U.S. Geological Survey

Understanding the Earth

1995

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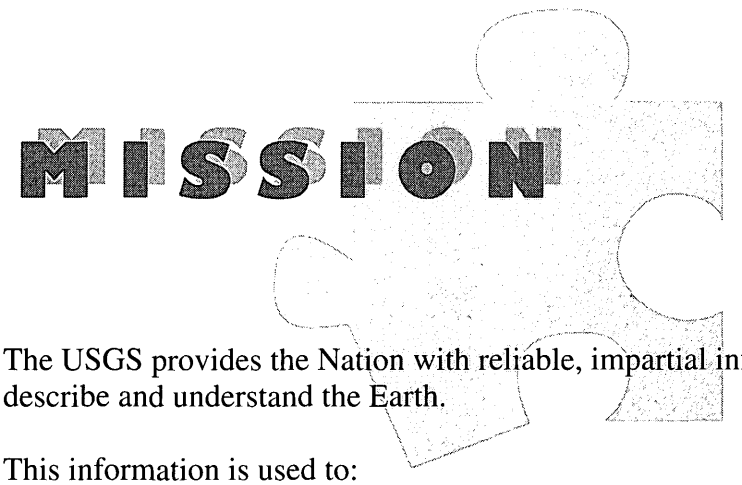
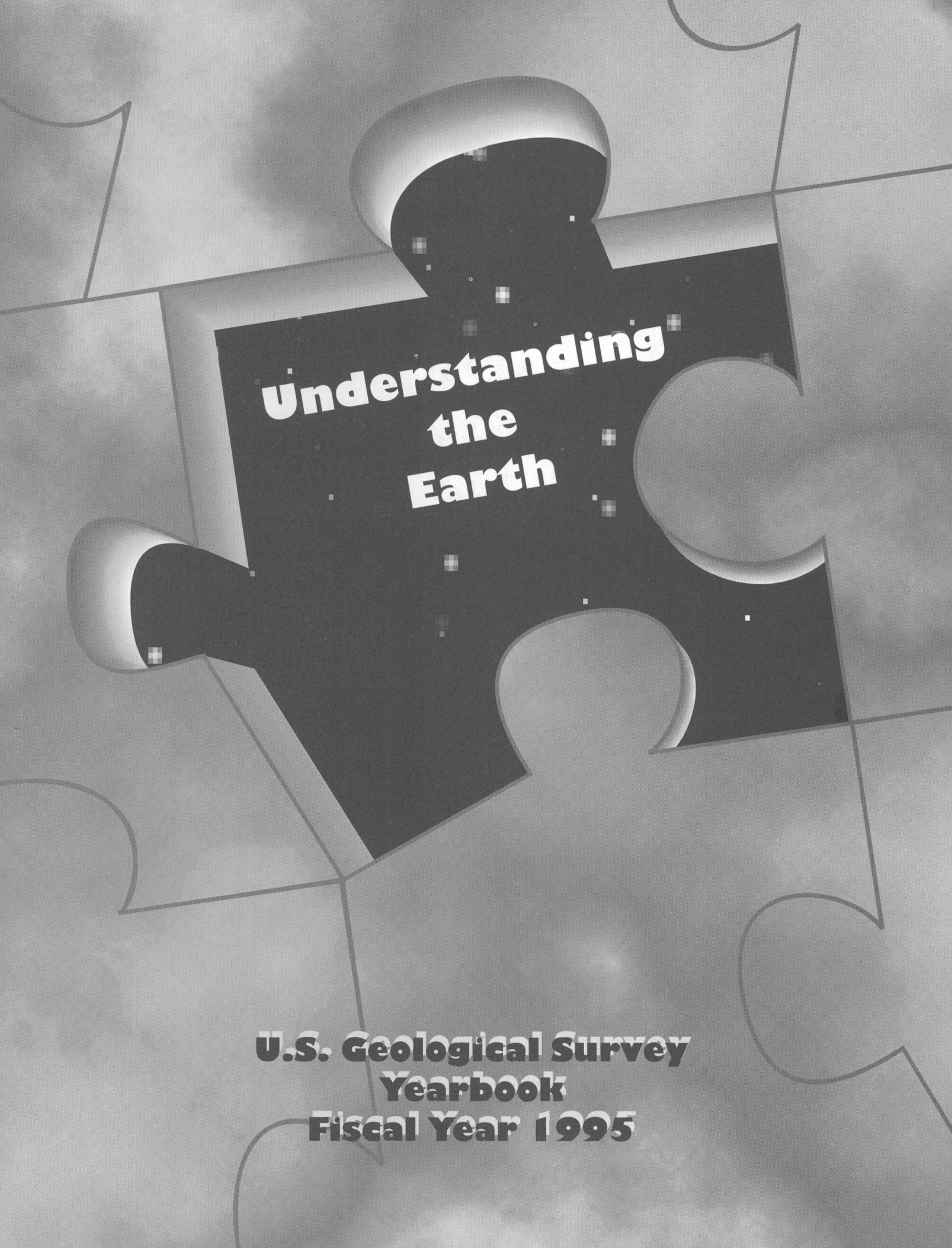


The USGS provides the Nation with reliable, impartial information to describe and understand the Earth.

This information is used to:

- minimize loss of life and property from natural disasters;
- manage water, biological, energy, and mineral resources;
- enhance and protect the quality of life;
- contribute to wise economic and physical development of natural resources.

The 1995 Yearbook is available electronically on the Internet at http://yearbook.usgs.gov



U.S. Geological Survey Yearbook Fiscal Year 1995

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, *Secretary*

U.S. GEOLOGICAL SURVEY
Gordon P. Eaton, *Director*

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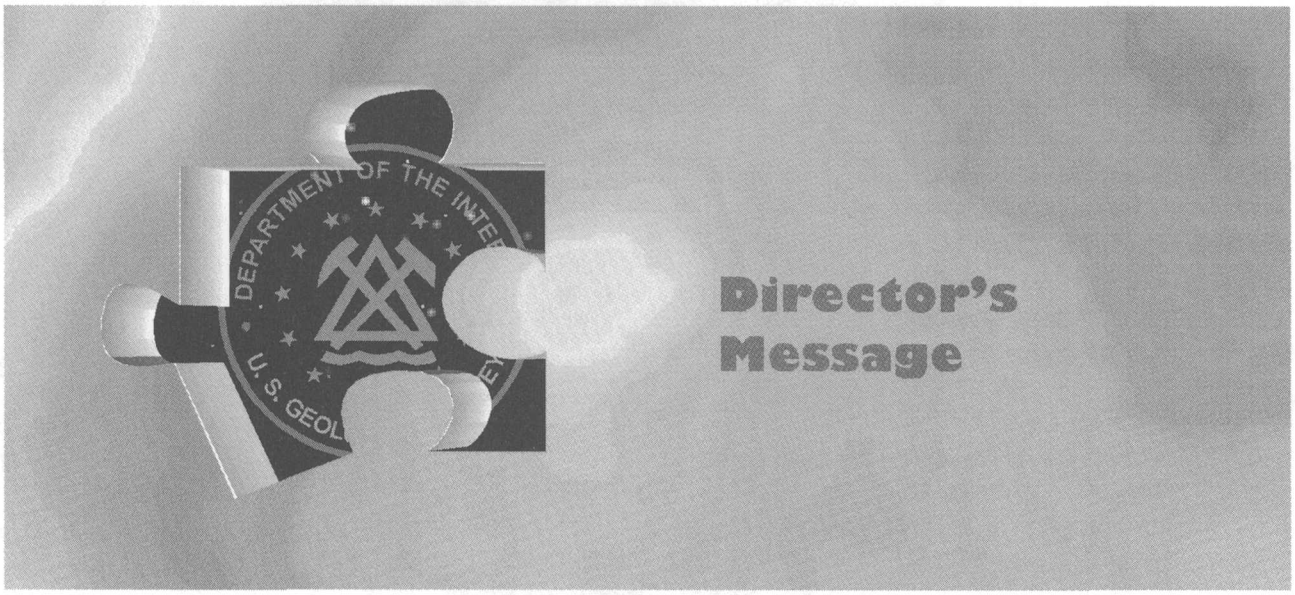


The "New" USGS: Progress in the Midst of Change

Let me introduce you to this volume by noting that, in fiscal year 1995, the U.S. Geological Survey made great strides toward reinventing and redirecting itself in some very fundamental ways. Through hard work and a significant dose of progress in the midst of profound change, the bureau has more than met the challenge that I issued last year to do better. That it has done so effectively is revealingly illustrated by the articles in this yearbook.

Fostering the cross-fertilization of ideas and information between and among employees in all parts of the organization is critically important to the restructuring of the USGS. Formation of three management councils—Policy, Program, and Operations—has helped us make significant progress toward increased openness and participation in the bureau's decisionmaking processes. Benchmark teams consisting of employees from all areas of the organization were formed and were charged with examining some of the bureau's most basic systems and structures. Three regions were established—Eastern, Central, and Western—and regional directors were appointed and charged with integrating and coordinating programs in the field.

The role of the new USGS State Representatives—to provide a bureauwide focus at the State level and to seek out mutually beneficial opportunities for further work—continues to grow stronger. "Commonality" is a key word where the State Representative concept is concerned, in that our broad expertise in geology, hydrology, and cartography provides the multidisciplinary approach to problem-solving that these complex times require.

Both outreach and inreach are key aspects of the State Representatives' charge to increase the awareness of clients, partners, and others of the USGS mission and programs. Carried out in conjunction with all USGS employees, the job of the State Representative is, simply stated, to help spread the USGS message across the land.

Definition, coordination, and communication of our work according to four broad themes—hazards, environment, resources, and information management and analysis—ensure a renewed bureau-level perspective in the development of programs. These crosscutting themes

integrate our expertise and better communicate the complex, integral nature of earth science processes. The theme definitions that begin each chapter in this yearbook establish a base for coordination across scientific disciplines. As we continue to study and understand the earth in terms of these four themes, I believe that the "new" USGS will be better positioned than ever to contribute to the Nation in a way that is both understood and valued by many, nonscientist and scientist alike.

Like many other organizations, we are being challenged to produce more results with fewer resources. In both the present and the future, the value of earth science must be understood and must be just as relevant to the taxpayer as it is to our professional colleagues. For this reason alone, it is crucial that we explain our science in language that everyone can understand.

Communicating with the people of America is on everyone's "short list," whether it means volunteers staffing a USGS exhibit at the county fair in Fairfax, Va., taking part in the Ground Water Festival in Grand Island, Nebr., or hosting an Earth Science Day Open House in Albuquerque, N. Mex. All are examples of hard work on the part of many USGS employees in the midst of change .

We are getting better at letting the world know exactly what we do and why we do it, and we are playing a significant role in reducing the indirect "disaster tax," the financial burden that all taxpayers share when rebuilding and repairing take place following calamitous natural disasters.

For much of the Nation, 1995 will be remembered as the "Year of the Floods," floods that devastated parts of the Pacific Northwest, the Northeast, the Gulf of Mexico, and the Caribbean. Measuring the flood stages of rivers as part of a warning system was key to the USGS role of responding to these natural disasters. USGS streamflow data were used by water-resource managers to warn downstream communities about the potential impact of impending disasters. The data provided significant assistance to water managers, who were better able to make decisions that resulted in saving billions of dollars in flood losses. And these data will also be used in making improvements to community disaster response plans and in the construction of flood-control structures.

As the Nation's need for water information continues to grow, the importance of USGS water-resources investigations also continues to increase. More than 1100 cooperators look to the USGS for information that will help them solve water problems in every State and at local, regional, and national scales. Read about a few of these projects, including the carbon dioxide hazard at Mammoth Mountain in California and the link between nutrients in the water and land use nationwide, in this yearbook.

Good progress in research has been made in the past year, even in the midst of ongoing internal changes. Evaluation of the landslides that occurred in Madison County, Va., in the summer of 1995 has greatly assisted local land use planners and emergency managers.

Managing the vast amount of data and information that the USGS and other earth-science agencies gather on the physical characteristics and processes of the Earth is an area of ever-increasing importance. USGS participation in the National Spatial Data Infrastructure is a step toward achieving this goal. One of our first priorities is to work with the Bureau of the Census to establish a national framework of geospatial data to support the decennial census that will take place in 2000. The progress of this project is also described in this yearbook.

Measuring historical changes in the Everglades and Florida Bay and analyzing the geologic framework of the Florida ecosystem are two ways that the USGS is addressing the environmental theme in south Florida. Through the cooperation of local, State, and other Federal

organizations, the investigations in south Florida demonstrate the multidisciplinary approach to science that the USGS has adopted and will continue to use in the future.

The quest toward understanding our Nation's resources focuses in part on cooperative efforts in Washington State to design a groundwater monitoring system will protect drinking water while saving water suppliers some $6 million annually in the process. The database of human-induced land use changes in the Washington D.C/Baltimore urban corridor reveals how we use and change the natural resources that surround us on a continuing basis.

Although conducting fundamental scientific investigations is a proud tradition of the USGS, it is only one part of our job as a mission-oriented agency. We must also understand the needs of our customers and respond accordingly. Connections with our customers take on many forms, from formal surveys of professional USGS data users to interaction with thousands of visitors to the USGS in Reston and at some of the field offices for Earth Science Day Open Houses in 1995. Informing residents about the potential volcanic hazards of Mount. Rainier and Mount Baker is another example of the essential communications link we must have and maintain with our customers and audiences.

New products and services are the result of understanding customer needs and responding to them. Any-day any-time access to USGS news and information is now available through EarthFax, the new USGS fax-on-demand system. Direct contact with USGS scientists is provided through the innovative Ask-A-Geologist service on the Internet. Customers download some 300,000 USGS digital products from the Internet each month.

Yes, 1995 was a year of profound change for the USGS. From organizational structure to how we conduct scientific investigations to how we communicate with our customers, the USGS has responded to the demands of the day. In doing so, we have created a solid foundation on which to build a future of new strategic directions while continuing to make great progress in the midst of significant change.

Gordon P. Eaton
Director, U.S. Geological Survey

HAZARDS

Hazards are unpreventable natural events that, by their nature, may expose our Nation's population to the risk of death or injury and may damage or destroy private property, societal infrastructure, and agricultural or other developed land. USGS activities in the hazards area include describing, documenting, and understanding natural hazards and their risks and consequences. These activities include long-term monitoringand forecasting, short-term prediction, real-time monitoring, and communication with civil authorities and others during a crisis. Other significant activities are post-crisis analysis and scenario formulation to develop strategies to mitigate the impact of future events and preparation of coordinated risk assessments for regions vulnerable to natural hazards. USGS hazards covered in the FY 95 yearbook include the flooding in Madison County, Va., the 1995 hurricane season, and wildland fire management. Internationally, USGS hazards work includes cooperative volcano disaster assistance through the Volcano Disaster Assistance Program in cooperation with the Department of State's Agency for International Development and international seismic monitoring via the Global Seismic Network.

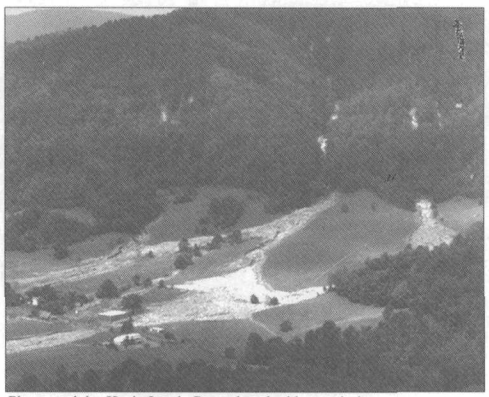
For more information on USGS hazards activities, visit www.usgs.gov/themes/themes.html on the World Wide Web.

Landslides and Floods in Madison County, Virginia

A severe storm on June 27, 1995, triggered hundreds of landslides on the steep hillsides of Madison County, Va. The landslides became debris flows—highly fluid masses of soil, rock, water, and vegetation that moved extremely rapidly and damaged buildings, roads, utilities, crops, and livestock. The debris flows also reached streams and rivers and contributed to the severe flooding.

Although Madison County and adjacent Orange County experienced catastrophic floods in April 1937, October 1942, and June 1972, none of them induced the abundant landslides and debris flows observed in the June 27, 1995, storm.

The geology of the area contributed to the extreme flooding and development of debris flows. Prolonged exposure of bedrock at the surface has produced soils that break or pulverize easily. These weathered materials are quite thick (as much as 30 feet) near the base of steep slopes. Stream erosion has, over geologic time, moved sand and clay materials onto the floodplains of the Robinson, Rapidan, and Conway Rivers. Much of the area's population lives on or adjacent to these floodplains, which support extensive farming of corn, hay, and livestock.



Scars of numerous soil slips-debris flows on forested hillsides from the storm of June 27, 1995, in Madison County, Va. Debris flows emerged from canyons, coalesced, and deposited bouldery debris on alluvial fans.

Photograph by Kevin Lamb. Reproduced with permission.

A debris flow, carrying logs and bouldery debris, overtopped a small channel and destroyed this house. The occupants narrowly escaped as the debris flow crashed into the rear of the house.

Photograph by Kevin Lamb. Reproduced with permission.

How much rain fell and where it fell also contributed to the broad geographic extent and severity of landslides, debris flows, and flooding in Madison County. The heaviest rainfall occurred over a 16-hour period, the heaviest falling during a 5-hour period on June 27. Estimates are that nearly 24 inches of rain fell, sometimes at a rate of 4 inches per hour. The meteorologic conditions leading to this storm are similar to those that led to other stationary thunderstorms that caused a rapid onset of flooding, such as the 1972 Rapid City flood in South Dakota and the 1976 Big Thompson River flood in Colorado.

Because some drainage channels were altered as a result of the flooding and subsequent debris flows, the risk of flooding in the drainage basins affected by the June 27 storm—the Robinson, Rapidan, and Conway Rivers—has increased slightly. Although these areas can probably expect greater erosion and larger accumulations of cobbles, gravel, sand, and silt in stream channels than they would normally experience during large annual storms, this slightly increased potential for flooding will be reduced gradually as mountain slopes and channels are revegetated.

Given another storm similar to the June 1995 storm, extensive landslides and debris flows could occur again in any part of the southern and central Appalachian Mountains chain. However, it is possible to plan for such hazards and to avoid the most hazardous areas. In Madison County, debris flows caused the most damage just beyond the mouths of channels, where the flows deposited large volumes of debris. By requiring that structures be built away from these channel mouths and ephemeral channels (those that are only infrequently filled with water), local planners and officials can significantly reduce the risk of debris flows.

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***Paula Gori** acts as a liaison between USGS scientists and Federal, State, and local governments on issues relating to natural hazards mitigation.*

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Under a Presidential declaration of disaster, the Federal Emergency Management Agency (FEMA) funded the USGS to conduct a reconnaissance of and map the extent of landslides and debris flows resulting from the June 27, 1995, flooding in Madison County, Va. This phase of the project has been completed; determining the potential for hazards during future storms and suggesting options for mitigating future damage are still underway. USGS scientists presented their preliminary findings at the FEMA Lynchburg Disaster Field Office on July 13, 1995. Members of the U.S. Congress were in attendance at the presentation, as were Virginia Governor George Allen, State and local officials, and representatives from Federal agencies such as the USGS and the National Park Service.

Potential debris-flow hazards are being evaluated during the final stage of this cooperative project. A final open-file report will contain a map showing high-, moderate-, and low-hazard areas that can be used by Madison County and by other local agencies.

Hazard Mitigation Grows in Importance

Direct losses from rapid-onset natural hazards within the United States (for example, floods, severe storms, earthquakes, landslides, volcanic eruptions, wildfires, tsunamis, and droughts) now reach approximately $52 billion per year. Three large recent natural disasters in the United States, for example, moved tax dollars from every Congressional District to aid the stricken areas: California, nine Midwestern States, Florida, and Louisiana, disrupting or delaying high-priority investments in infrastructure, health care, environmental protection, and education. The Federal Emergency Management Agency (FEMA) has developed a national strategy for mitigation involving public/private partnerships at local, State, regional, and Federal levels. A natural disaster affects the entire Nation in the form of a "hidden tax." A catastrophe can affect the entire world.

The first biennial national conference on mitigation, which was held in Alexandria, Va., in December 1995 and was attended by over 900 people from every State and Territory in the United States, unveiled a wide variety of strategies for mitigation.The long-term goal of mitigation as stated at the conference is to reduce direct losses by one-half by 2010 in order to stop the unacceptable economic hemorrhage brought on by rapid-onset natural hazards. Mitigation, the only way to reduce or eliminate the losses resulting from natural hazards, is based on science and technology, but it requires political commitment and economic investment to devise, implement, and sustain a mix of public policies and professional practices. These policies and practices must be designed and enforced by individual communities at risk in order tc achieve the following objectives:

- •Stop increasing the risk posed by new development.
- •Start decreasing the risk from existing development.
- •Continue advance planning for response and recovery from the inevitable occurrence of and socioeconomic and environmental consequences of a natural hazard.

The first biennial national conference on mitigation was a success technically and politically because of the support provided by ongoing activities of the USGS and the 14 science and disaster reduction agencies comprising the National Science and Technology Council's (NSTC) Subcommittee on Natural Disaster Reduction (SNDR) and Subcommittee on Risk Assessment (SRA).

***Walter Hays** is an engineering seismologist who has led research applications activities in the Earthquake Hazards Program since 1977.*

The USGS's ongoing contributions in support of FEMA and the National Mitigation Strategy began long before the December 1995 meeting. Current activities include:

• Participation in 11 town meetings convened by FEMA, one in each of the 10 Federal regions and one in Hawaii, to provide a forum for potential partners and end users in the public and private sector to articulate their ideas and needs.

• Establishment of a FEMA/USGS Coordination Committee on Seismic Zonation to provide coordination for earthquake hazard mapping underway in California, Oregon, and seven Midwestern States in the central Mississippi River valley.

• Leadership in the post-earthquake investigations of the January 17, 1994, Northridge, Calif., earthquake and in the California University Researchers in Earthquake Engineering (CUREe) program, funded by FEMA, to coordinate the urgent research supported by Congressional and Presidential Dire Emergency supplemental funds following the Northridge earthquake. The objectives of this activity, which are still being realized, are (1) to facilitate the recovery process, (2) to learn from the "scientific laboratory" created by the earthquake disaster, (3) to communicate the lessons to policymakers in California and other earthquake-prone regions of the Nation, and (4) to utilize this new scientific and technical knowledge in making policy decisions on mitigation.

• Provision of national probabilistic ground-shaking hazard maps and support for the new engineering design value map for the National Earthquake Hazards Reduction Program (NEHRP) model building code, which is being developed under the auspices of the Building Seismic Safety Council (BSSC), with

funding from FEMA, as a national reference for all model building codes.

• Development and implementation of Executive Orders 12699 (which dealt with the seismic safety of new structures) and 12941 (which dealt with the seismic safety of existing structures) through the Interagency Committee on Seismic Safety in Construction (ICSSC), which is comprised of Government scientists, engineers, and planners representing 32 agencies and bureaus responsible for the seismic safety of new and existing federally owned, constructed, funded, regulated, and leased buildings. The existing building stock being evaluated under Executive Order 12941 consists of over 700,000 buildings valued at the planning stage at over $50 trillion.

• Provision of national and regional ground-shaking hazard maps and technical support to the National Institute of Building Sciences (NIBS) and others in the development and validation of a loss estimation model.

• Participation in workshops on earthquake mitigation convened by the Central United States Earthquake Consortium (CUSEC), a regional consortium supported by FEMA to foster the use of science and technology in policy decisions concerning earthquakes in the 14 Midwestern States that would be adversely affected by an earthquake in the New Madrid seismic zone.

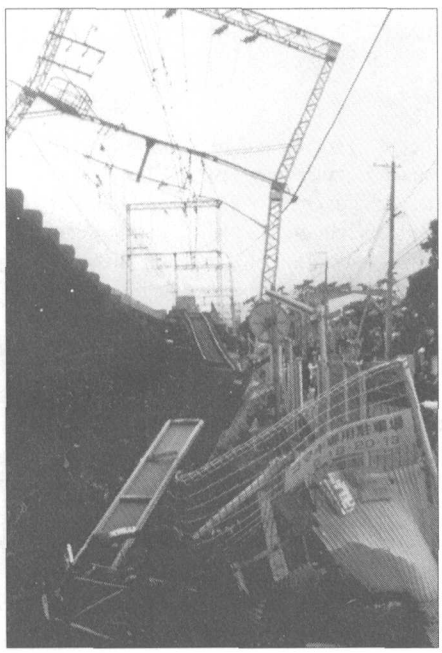
• Provision of adjunct faculty for the annual summer institute on "Multihazard Protective Design" and the bimonthly short courses on "Earthquakes" convened at the National Emergency Management Center in Emmitsburg, Md.

• Contributing to the formation of the Department of the Interior's All Hazards Task Force in November 1995.

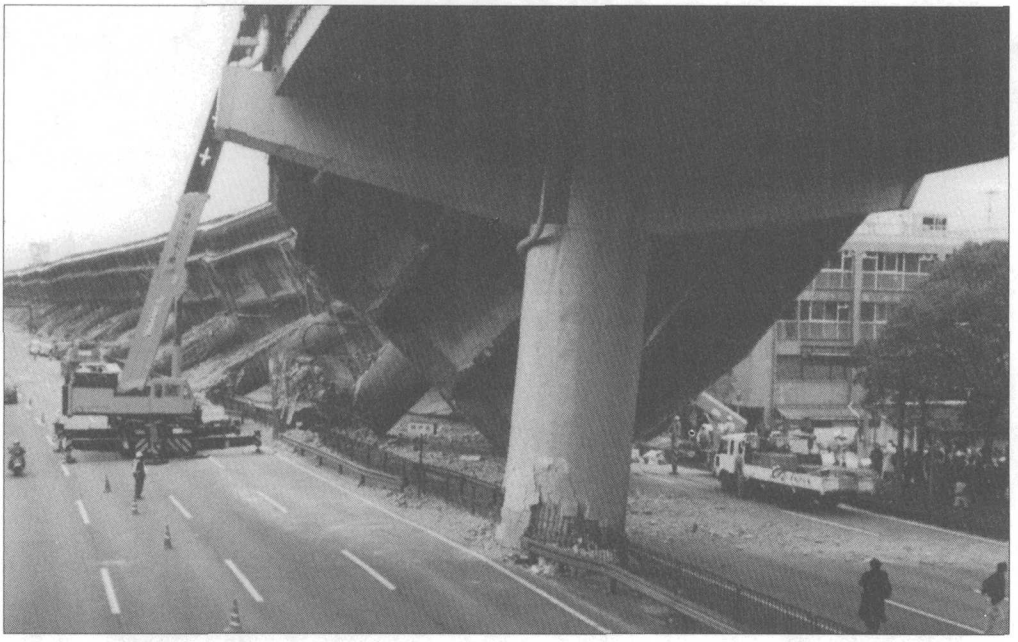
The Kobe Earthquake: Portrait of a Disaster

The January 17, 1995, Kobe earthquake, a moment magnitude 6.9 earthquake, was the worst earthquake disaster to hit Japan since the 1923 Kanto-Tokyo earthquake. Causing direct losses of $140 billion, it set a new world record in terms of monetary loss and drew dramatic attention to the catastrophic loss potential of moderate- to great-magnitude earthquakes in metropolitan areas like Tokyo, Los Angeles, San Francisco, Oakland, and Memphis. It also gave further credibility to economic theories indicating that the world economy will suffer as a result of an earthquake catastrophe in the Tokyo-Yokohama area, which would be expected to sustain direct losses exceeding $1 trillion.

The Kobe earthquake struck at 5:46 a.m., leaving a devastated city of 1,400,000 people, a surprised nation, and a concerned world. Japanese officials learned what their counterparts in Northridge, Calif., had learned earlier—that design and construction codes had underestimated the forces that were unleashed in the vicinity of the earthquake. The rupture started 20 km from Kobe at a depth of 10 km and moved toward the city. The close proximity and shallowness of the earthquake produced strong ground shaking that reached 80 percent of the force of gravity. The earthquake caused direct economic losses of over $140 billion U.S. with insured losses reaching $3 billion and indirect losses of at least as much owing to loss



The January 17, 1995, Kobe earthquake damaged powerlines and disrupted power distribution in the area.



Strong ground shaking from the magnitude 6.9 Kobe earthquake caused a 600-meter portion of the Hanshin Expressway to collapse.

of production and loss of supply. It also disrupted the flow of goods from the port of Kobe—Japan's second largest port facility and the world's sixth largest—for over a year because of damage from ground shaking, subsidence, liquefaction, lateral spreading, and flooding. Immediate consequences of the earthquake included:

- 5,480 dead.
- 34,665 injured.
- 300,000 temporarily homeless.
- More than 600 fires, which burned out of control because of ruptured water lines.
- Extensive utility outages.

Experts from the USGS, the National Institute of Standards and Technology, the Earthquake Engineering Research Institute (EERI), the University of California, Berkeley, the Applied Technology Council, the Structural Engineers Association of California, the National Center for Earthquake Engineering Research, and other organizations joined together to form multidisciplinary post-earthquake investigation teams. The goal of these teams was to acquire perishable data and perform scientific and technical reconnaissance investigations to determine the nature and extent of the damage caused by the Kobe quake and to deepen understanding of the causative mechanisms. The reconnaissance investigations were performed cooperatively under the protocol of the United States-Japan Natural Resources Panel on Wind and Seismic Effects. Forty Americans who were in Osaka, Japan, at the time of the earthquake, participating with Japanese colleagues in a conference on "Urban Earthquake Hazards" organized jointly by EERI and Japanese agency counterparts, were able to conduct reconnaissance studies within hours of the earthquake and to establish an interim information clearinghouse.

The President of the United States and the Premier of Japan agreed in 1995 to make earthquake loss prevention, mitigation, and preparedness a part of the Common Agenda on Global Perspectives. The Kobe earthquake disaster is now being compared with the January 17, 1994, Northridge, Calif., and the October 17, 1989, Loma Prieta, Calif., earthquake disasters and is being used to evaluate the state of the art and the state of practice of earthquake loss prevention, mitigation, and preparedness in Japan and the United States. The answers supplied by the cooperative post-earthquake investigations and long-range studies conducted under the Common Agenda will provide a scientific and technical basis for making policy decisions on prevention, mitigation, and preparedness measures in the United States and Japan and in other earthquake-prone regions of the world.

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A Whirlwind of Activity: The USGS Responds to Hurricanes

What happens when a hurricane threatens? Homeowners in the path of the storm check their insurance policies and their shutters, vacationers decide to head inland or take their chances at the beach—and all over the USGS, people get busy.

What does the USGS do when a hurricane approaches U.S. territory? The answer is "plenty"—before the hurricane hits, immediately afterwards, and in the long-term preparation for future events.

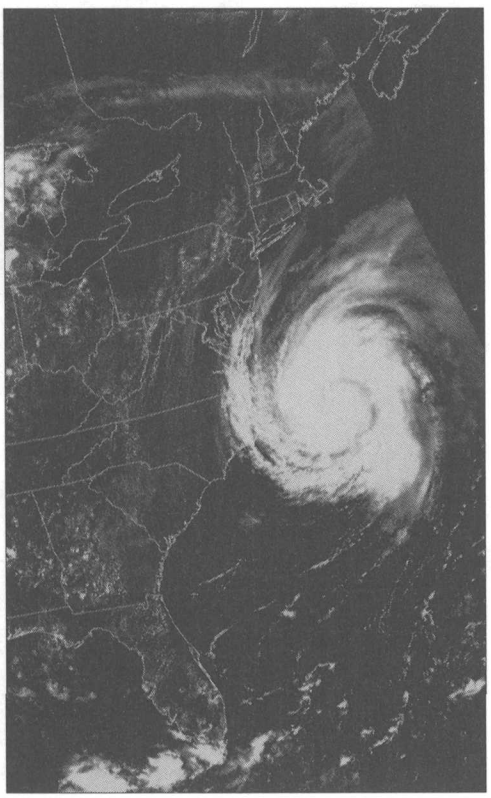
As a hurricane develops and moves toward the United States, USGS mapping professionals go on alert in order to provide maps of affected areas to emergency response personnel from local, State, and Federal agencies. The task can be challenging—it takes roughly 55,000 quadrangle maps to cover the United States and its Territories, not including Alaska. Just finding adequate supplies of the right maps for "Hurricane Alley" along the East and Gulf Coasts, Puerto Rico, and the Virgin Islands can be hard enough.

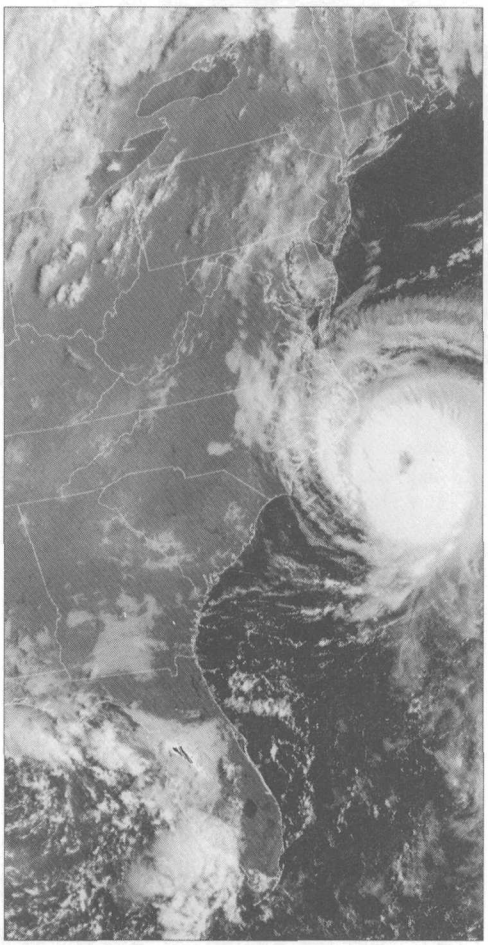
When a hurricanes strikes, the USGS provides maps to the Federal Emergency Management Agency (FEMA), the American Red Cross, the U.S. Army Corps of Engineers, and the Defense Mapping Agency. During Hurricane Andrew in 1992—one of the costliest disasters on record, with losses estimated at $30 billion—the USGS distributed 5,000 individual topographic maps of Florida and Louisiana, at various scales, and 200,000 maps in bulk shipments. These maps are vital to rescue efforts because they are the only ones that show streams, buildings, and topography in addition to roads. Rescue crews on the scene use these maps to plan their efforts and to get the supplies to where they are needed most. The USGS also provides aerial photography and digital map data when needed.

In October 1995, Hurricane Opal devastated a 150-mile stretch of beachfront on the Florida panhandle, leveling sand dunes as much as 20 to 30 feet high. Estimates of damage run as high as $2.8 billion, making it Florida's second most damaging storm on record. USGS aerial photography and videos indicated that most of the damage was caused by storm surge, which rose to 15 feet above normal around Pensacola Beach. USGS hydrologists are working with FEMA and the U.S. Army Corps of Engineers (USACE) to document the extent of the surge and flooding.

One lasting legacy of hurricanes is vastly accelerated coastal erosion, which USGS geologists have been studying for a number of years. As part of the cooperative Louisiana Barrier Island Erosion Study, the USGS and the Coastal Studies Institute at Louisiana State University have published two atlases that track shoreline and sea-floor changes along the Louisiana coast for more than a century. The shoreline atlas was finished before Andrew swept into the State and provided invaluable baseline data for determining the hurricane's impact. Andrew stripped sand from 70 percent of Louisiana's barrier islands, and more than 80 percent of the oyster reefs behind the islands were smothered by a blanket of sediment 1 to 3 feet thick. In Florida, Andrew completely stripped vegetation from the northernmost Florida Keys and destroyed many large, old stands of mangrove trees along the shoreline. Damage also can occur far from the actual landfall; Opal devastated barrier islands in Louisiana 300 miles from its point of landfall.

Coordinated crews from USACE and the USGS arrived in the affected area to document levels of storm surge immediately following Hurricane Opal. Storm-surge levels were measured at as much as 10 to 12 feet above mean sea level. Other USGS personnel took aerial photographs and videos indicating that most damage from this storm was due to surge rather than wind, although wind gusts were more than 135 miles per hour. River stage and discharge data collected by USGS personnel at about 45





Hurricane Emily approaches the East Coast of the United States on August 31, 1993 (satellite image from the USGS EROS Data Center, Sioux Falls, S.Dak.)

stream-gaging stations in northern Alabama and west-central Georgia showed that maximum rainfall amounts in the heavily affected areas were as much as 12 inches, although most totals were 8 to 10 inches for the 2-day period. This heavy rainfall on already saturated soils caused significant flooding in parts of the Altamaha, Chattahoochee, Flint, Mobile, Savannah, and Tennessee River basins.

Data-collection activities such as these provide vital information for coastal planners and managers. USGS studies in the Pacific Ocean have shown that overwash damage to coasts depends on the shape of the offshore area. When a particular coastal profile is known, shoreline cities can establish a reasonable construction setback to prevent unnecessary property losses. Nothing can prevent hurricanes, but geologic mapping in areas where storms are frequent can help minimize losses by identifying locations that are most likely to suffer.

Hurricane Marilyn, a Category 2 hurricane (Saffir-Simpson scale), made landfall on the islands of St. Croix and St. Thomas, in the U.S. Virgin Islands, on September 15 and 16, 1995, and devastated the islands. At least nine people died, and thousands were left homeless as a result of the storm, one of the most destructive of the nine major hurricanes to hit the area since the late 1800's. Relief agencies provided emergency housing, medical attention, and clothing for thousands of people. FEMA estimated damages of $2 billion. More than $1 billion of this amount was related to damage to private and public housing.

Although one USGS rain gage on St. Croix showed almost 13 inches of rain during September 15 and 16, riverine flooding in the interior of the island did nearly as much damage as tidal flooding. High-water levels—resulting from a combination of normal tide, storm surge, and wave action—ranged from 11.4 feet above mean sea level on Estate La Grande Princesse, St. Croix, to 3.1 feet on Limetree Bay, Estate Krausses Lagune, St. Croix. USGS personnel in Puerto Rico collected and processed a large amount of data related to Hurricane Marilyn. Meteorological and hydrological data were obtained during the event by means of remote telemetry, although many of the stations where these data are recorded were damaged by the passing of the hurricane.

In the aftermath of the hurricanes, USGS personnel assisted FEMA and USACE by obtaining levels of tidal flooding. The USGS uses this information to prepare maps of the areas inundated during the storm, which planners and managers then can use to mitigate damages from similar future storms.

In spite of devastating storms like Andrew and Hugo, the past 25 years have seen a lull in the number of major hurricanes making landfall along the East and Gulf Coasts of the United States. Researchers at Colorado State University, however, are projecting a return to the hurricane patterns seen earlier this century, and the events of 1995 would seem to support that prediction. Whether the hurricanes are few or many, the USGS will be ready to respond to the hurricane disasters of the future.

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Hurricanes are among the Nation's most costly disasters. A 1993 study by the Property Claims Services Division of the American Insurance Services Group showed that hurricanes account for two-thirds of the insured property losses in the 13 most costly insured catastrophes in U.S. history. Insurance, however, typically covers less than 20 percent of the losses resulting from natural disasters; the remainder of the dollar losses are covered by the Federal Government. This "disaster tax" costs the American taxpayer roughly $52 billion per year.

To assist the Federal Government in reducing the public cost of natural disasters, Christopher Barton and his colleagues at the USGS have developed a method that allows scientists and managers to forecast more accurately the size and number of natural disasters such as hurricanes, earthquakes, and floods and their consequent losses. According to Barton, such disasters are "complex phenomena whose size and frequency show mathematically self-similar behavior." This discovery allows planners and forecasters to use a database of small, frequent events to estimate the probability of occurrence of larger, less frequent events.

Analyzing storm data from the National Oceanic and Atmospheric Administration, Barton and his colleagues observed two fractal-scaling populations: tropical storms and minor hurricanes with sustained wind speeds of less than 98 miles per hour and more severe hurricanes with wind speeds at or above 98 miles per hour. Using the mathematics of self-similar behavior, they can now make probabilistic forecasts of the frequency of hurricanes of any given wind speed for any city or region over time windows ranging from 1 to 100 years. Barton and his colleagues are using their method to prepare a hurricane risk map for the Florida coast. Their probabilistic forecasts of property and life loss caused by U.S. hurricanes have provided a basis for comparing expected losses from hurricanes, earthquakes, and floods. This aspect of the USGS response to hurricanes is proving extremely useful to Federal, State, and local land use planners, disaster response planners, and the insurance industry.

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The USGS has produced two videos documenting the devastating impact of hurricanes on the Earth's surface.

Ann Tihansky and **Dan Duerr**, in cooperation with WTSP-TV in St. Petersburg, Fla,. have produced a dramatic 15-minute videotape, *Exploring Storm Surge*, about the destructiveness of storm surges. Animated segments show how local conditions affect flooding, and the storm history of Florida's Gulf Coast is reviewed.

A 29-minute video entitled *Hurricane Force: A Coastal Perspective*, produced by **Steve Wessells**, includes photographs of wetlands before and after hurricanes, historical footage of storm damage, and interviews with USGS coastal geologists. The film focuses on Hugo, Iniki, and Andrew but gives a nationwide perspective on hurricane damage.

Exploring Storm Surge (VHS 137) and *Hurricane Force: A Coastal Perspective* (VHS 133) can be borrowed from:

USGS Videotape Library
345 Middlefield Road
Menlo Park, CA 94025
(415) 329-5009
(415) 329-5132) fax

To purchase *Exploring Storm Surge* (Open-File Report 95-295), send $22.75 plus $3.50 shipping fee per order to:

USGS Information Services
Box 25286
Building 810, Mail Stop 517
Denver Federal Center
Denver, CO 80225

Bridge Scour and Flooding

The USGS has collected data and monitored bridge scour through cooperative projects with Departments of Transportation in Alabama, Arkansas, California, Colorado, Delaware, Indiana, Kansas, Maryland, Mississippi, Missouri, Montana, New York, North Dakota, Ohio, South Dakota, and Virginia.

The Federal Highway Administration (FHA) has funded several projects at the national level to develop instrumentation and data-collection techniques, collect detailed data sets at some sites, provide quality assurance and technical support to other investigations of scour processes, provide a national bridge scour data repository, and analyze field measurements of scour to develop a better understanding of the processes that cause scour. The USGS has worked with the FHA to develop, modify, and test different geophysical techniques and their appropriate applications in scour studies.

There are more than 580,000 bridges in the United States; of that number, about 84 percent span waterways. Channel scour—the eroding of a channel bottom—around bridge foundations is the leading cause of bridge failure, exceeding all other causes combined. Nationally, the annual cost for repairing scour-related failures is about $30 million; in comparison, repairing flood damage on federally aided highways runs about $50 million.

River channels scour and aggrade as a result of complex, interrelated natural processes. Bridge crossings frequently disrupt and intensify natural river processes by constricting the flow area of the stream at flood stage and by disturbing the flow with local obstructions such as piers and highway embankments, which constrict and redirect the flow. Because so little is known about the complex dynamics of river channels during rare flood events, it is difficult to assess the accuracy of the channel scour estimates on which bridge foundation design is based. Accurate estimates of potential scour at bridge sites are essential for designing new bridges and for evaluating the safety and reliability of existing ones.

The need for improved scour-design techniques has long been recognized, and scour has been extensively researched by many investigators, who have developed numerous equations to predict contraction scour and local scour at bridges. Applying these laboratory-based equations to field measurements of local scour at bridge piers produced results that ranged from gross overprediction to some underprediction of the observed scour. These fluctuations probably result from the range of deterministic scour variables in the field, which are difficult to reproduce or measure in the laboratory, and of the dynamic dissimilarity between field conditions and laboratory investigations. Many investigators have recommended measuring scour at bridges during floods to improve both the understanding of scour processes and bridge scour prediction methods.

The USGS has developed, modified, and tested surface geophysical techniques that can be used after a flood to detect and measure maximum scour depths that occurred during the flood's peak and the thickness of sediment redeposited in scour holes shortly after peak flow. Surface geophysical techniques generally operate by repeatedly transmitting a signal from the water surface into the water. The signal penetrates layers of materials having different physical properties, and part of that signal is then reflected back to the water surface by interfaces between the layers. Information about the type of and depth to interfaces can be interpreted from the reflected signals. Surface geophysical records collected near bridge piers provide a continuous profile of the water bottom and, at some sites, can delineate interfaces in the subbottom that can be correlated with previous scour surfaces, pier foundations, old channel beds, or geologic layers. Collecting sample cores and (or) analyzing subsurface lithologic logs from bridge plans provides additional data to help determine the lithology of the materials detected by the geophysical technique.

Several types of surface geophysical techniques have been used in bridge scour studies. Depth sounders and continuous seismic-reflection profiling systems use seismic (sound) signals. Reflections are caused by interfaces between materials that have differing acoustic properties. High-frequency chart-recording depth sounders are portable and provide clear, accurate information on water depth, existing scour holes, and the tops of submerged debris and exposed pier footings. Continuous seismic-reflection profiling systems produce high-resolution records of existing scour holes, infilled holes, and geologic layers in the subbottom.

Ground-penetrating radar systems use electromagnetic signals. Reflections are caused by interfaces between materials that have differing electrical properties. Ground-penetrating radar systems produce high-resolution records of existing scour holes, infilled holes, and geologic layers in the subbottom. Seismic and electromagnetic signals behave differently as they travel through the same material. The choice of technique is directly related to the type of site being studied. For example, a clear record of an infilled scour hole may be obtained by using the continuous seismic-reflection technique in saltwater, whereas ground-penetrating radar may fail at the same site because the high conductivity of the water quickly attenuates the signal.

Surface geophysical techniques have been used in scour studies in 12 States, including Alaska, Connecticut, Indiana,

Louisiana, Ohio, Oregon, and South Carolina. At the Baldwin Bridge, which crosses the Connecticut River near Old Saybrook, Conn., existing and infilled scour holes were detected. At one pier, a 20-foot-deep scour hole developed without any significant flood event having occurred within 3 years of the start of construction. Continuous seismic-reflection profiling showed evidence of no infilling in that scour hole, but 5 feet of infilled material was detected in a hole at an adjacent pier. At the Bulkeley Bridge, which is located near Hartford, infilled scour holes were detected at four of eight piers. Ground-penetrating radar showed 5 feet of infilled material at the bottom of a 10-foot-deep scour hole.

Qualitative and quantitative data also can be used to assess the underlying causes of bridge failure. On March 10, 1995, the I-5 bridge over Arroyo Pasajero near Coalinga, Calif., collapsed owing to scour during a severe flood. Of the eight people who plunged into the flood waters, seven died. At the request of the California Department of Transportation, the USGS headed up an effort to document the hydraulic and geomorphic conditions that led to the collapse of the bridge. The research team consisted of USGS personnel from the California District and the national bridge scour project in the Kentucky District, the regional hydraulic engineer for the Federal Highway Administration's California regional office, and the chief of the hydraulics laboratory at the Turner-Fairbank Highway Research Laboratory in McLean, Va.

The research team gathered both qualitative and quantitative data from the Arroyo Pasajero and its tributaries both upstream and downstream of the failure. Cross sections and high-water marks were surveyed near the failed bridge for hydraulic modeling of the bridge opening. Numerous pictures and measurements taken throughout the area documented potential geomorphic instabilities in the stream. Qualitative observations documented the amount of stream bed lowering, bank erosion, deposition of material on the floodplain, and potential for woody debris. Rapid and severe channel instabilities were observed, and a condition of severe degradation was identified less than a mile downstream of the bridge, moving in an upstream direction. The channel upstream of the bridge changed dramatically overnight when a small rainstorm passed through the area.

The USGS is currently preparing a report for the California Department of Transportation documenting the conditions observed and estimating the conditions that may have been present at the time of the failure. This report will contain a complete geomorphic, hydraulic, and sediment transport analysis of the conditions leading to the bridge collapse.

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Measurements of riverbed scour and deposition near bridge piers are essential not only to maintain bridges safely but also to understand the scour process, so that improved construction techniques and scour countermeasures can be developed. Maximum scour depths near a bridge pier usually occur at the peak of a flood when measurements are difficult, dangerous, or even impossible to collect. Sediment in alluvial channels is redeposited shortly after the peak flow but long before the flood has receded, so scour holes often are infilled. Detecting infilled material in scour holes is essential because that material is more susceptible to erosion during a subsequent flood than the natural riverbed is. If a scour hole has been infilled, then data collected after the flood's peak by using sounding weights or high-frequency depth sounders will not represent maximum scour depth.

The lack of and consequent need for reliable, complete field data on scour at bridges have been noted repeatedly by many researchers. Field measurements of bridge scour remain limited because focused scour-measurement investigations have been infrequent and because it is difficult to measure bridge scour during floods. However, awareness of bridge scour has grown in the last decade as a result of several catastrophic scour-related bridge failures. To help minimize such failures, the USGS has been instrumental in collecting data on scour at bridges during floods. At the national level, the USGS has developed and continues to improve instrumentation and data-collection techniques, collected detailed data sets at some sites, set up quality assurance and technical support for other investigations, provided a national bridge scour data repository, and analyzed field measurements of scour to develop a better understanding of the processes that cause it.

More bridge scour measurements are underway in the United States now than at any other time; more than 380 local scour measurements have been entered into the national bridge scour data-management system recently. These measurements, made through USGS District projects, consist of cross sections measured along the edges of bridges and velocities measured by using standard discharge-measurement techniques. These measurements were collected at 56 bridge sites in Alaska, Arkansas, Colorado, Delaware, Georgia, Illinois, Indiana, Louisiana, Maryland, Mississippi, Montana, New York, Ohio, and Virginia. Additional data have been collected in some of these States and in others and will be included in the national database as they are analyzed and reviewed. These data represent the results of studies funded by many State highway agencies and the creative, professional efforts of many hydrologists to develop programs, chase floods, and measure scour to provide bridge designers with the information they need to reduce the risk of bridge failure due to scour.

By determining the extent of existing and infilled scour holes, the USGS has prevented potentially dangerous scour conditions. In specific cases, the USGS may be able to provide information after a bridge fails to help a State agency understand the reasons for the failure. The geophysical data also are used to help develop, calibrate, and test scour-prediction equations used in bridge construction and scour-monitoring techniques.

Wildland Fire Danger Assessment

The USGS plays an important role in assessing wildland fire danger conditions nationwide. Over the past 7 years, the USGS has been working jointly with the land management agencies of the Department of Interior and the U.S. Forest Service (USFS) to integrate near-realtime satellite observations and land cover information to provide up-to-date information on the condition of vegetation as it relates to potential fire hazards.

Since 1989, the USGS has produced weekly updates on vegetation conditions (the greenness or dryness that either impedes or enhances fire ignition and burning) across the United States for use in the USFS national fire danger assessment program. The information is derived from satellite observations acquired and processed at the EROS Data Center in Sioux Falls, S. Dak. Digital maps showing vegetation conditions and departures from normal are produced at a spatial resolution of 1 kilometer. The information is transferred electronically to the USDA National Computing Center in Kansas City, Mo., and the National Interagency Fire Center in Boise, Idaho, where the USFS uses the data to produce additional maps showing percentages of maximum potential vegetation conditions and vegetation moisture information.

The USFS has recently begun using USGS data on land cover characteristics in conjunction with data on vegetation conditions and daily weather to improve its spatial and temporal assessments of fire danger conditions. In 1992, the USGS produced a conterminous U.S. land characteristics database and has worked with the USFS to tailor the database to represent fire fuel types. The fuel types are used to represent important aspects of fire danger and behavior, such as ignition potential, rate of spread, and fire intensity.

The integration of timely updates of vegetation condition and knowledge of vegetation types and seasonal characteristics in the fire danger assessment assists fire management agencies in accurately and objectively assessing regional fire danger conditions and making comparisons with historical data. The objective and consistent data provided by the USGS allow the USFS to determine when conditions are severe in specific regions, allocate fire-fighting resources to the appropriate State and local fire management agencies, and advise the public about fire hazards.

Jeffery C. Eidenshink *is a remote sensing scientist at the EROS Data Center and is responsible for operational production of regional, continental, and global vegetation condition data.*

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Use of Geographic Information Systems Before, During, and After Natural Disasters

The USGS works closely with others in scientific studies, spatial depictions of geographic and earth science data, and response to disasters. It maintains cooperative ties with State geological surveys to prepare for and make hazards assessments, and its partnership with regional FEMA offices facilitates interagency information management for improved disaster response. Such cooperation will permit more effective application of current data and research results to critical emergency management problems.

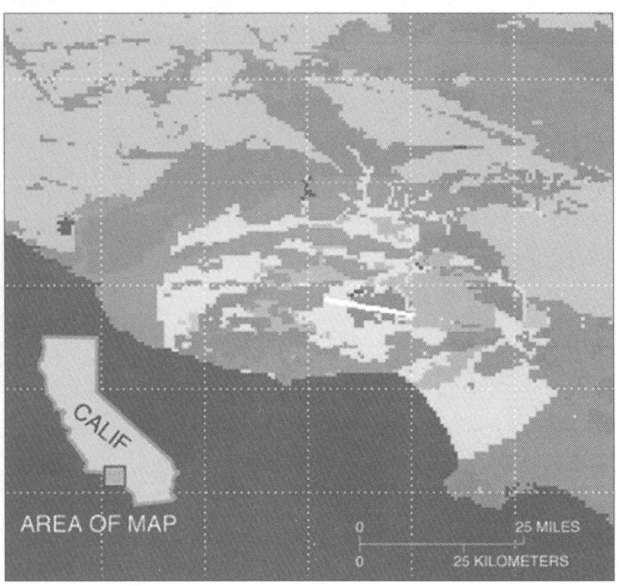
A powerful new tool for studying natural hazards has become available over the past decade as the capacity of desktop computers has increased to match that of the supercomputers of the recent past. Geographic information systems (generally shortened to GIS) are computer programs that store map information in a way that allows various kinds of manipulation, analysis, and graphic presentation of the data. Instead of having various paper maps on which roads, cities, schools, and earth science features such as flood plains, geologic formations, or earthquakes are shown, we now can have the same information encoded for use in a computer. Because the map elements (points, lines, areas) are stored according to their locations in a common coordinate system (*x,y* addresses), their spatial interrelations can be determined and used in computer-based analysis together with their topical attributes (city named San Francisco, fault named San Andreas).

Before a natural disaster actually happens, we can compile information in digital form that relates to the potential occurrence of the triggering event (rainstorm, earthquake), its effect on the natural environment (flooding, shaking of the ground), and the vulnerability of houses, people, and critical structures to the resulting hazard. These data, together with quantitative models of the hazardous processes, allow predictive analysis of the hazard posed by various natural processes and the risk to which society is exposed. The results are always estimates because of our incomplete understanding of the processes, the actual complexities of nature, and the practical limitations of the datasets.

Predictive modeling of the expected shaking from a repeat of the great 1906 San Francisco earthquake provides an example of the procedure. In 1975, Roger Borcherdt and his colleagues at the USGS published a paper map compiled carefully by hand that showed expected shaking in the San Francisco region in terms of broad categories of shaking severity. With the advent of GIS, Borcherdt, Carl Wentworth, and colleagues reexamined the problem for a presentation at the Fourth International Conference on Seismic Zonation at Stanford University in 1991. Once the needed data have been compiled digitally, the analysis can be done quickly, alternative physical models can be tested, and the results can be portrayed at various levels of detail, depending on the intended purpose.

The components of the analysis begin with the physical model, which in this example describes where the earthquake occurs (along the San Andreas fault), how the seismic energy travels and decays outward from the fault source in the Earth's crust (attenuation equation), and how the local ground conditions amplify that base motion as it reaches various parts of the region (geologic units and their capability to amplify seismic waves). Digital databases representing the location of the fault and the distribution of geologic units of different amplification capability are compiled. The spatial distribution of base shaking from the earthquake is computed by using the location of the fault source and the attenuation equation That result is then combined with the amplification capability map to produce the analytic result, a shaking potential map that provides an estimate of the distribution of shaking that can be expected from a repeat of the 1906 earthquake. Similar analyses for various earthquake sources can be combined into a single estimate of the distribution of maximum expected shaking, and the estimated likelihood of occurrence of the various earthquakes can be used to cast the results in probabilistic terms.

The preventive actions that can be taken on the basis of such hazard analyses are facilitated by GIS. Informed planning can prevent or minimize the creation of new risk by guiding development away from high-hazard areas and insuring that engineering and construction incorporate techniques that defend effectively against the anticipated hazard, and existing risk can be reduced by structural reinforcements and modifications of land use. Economic incentives such as

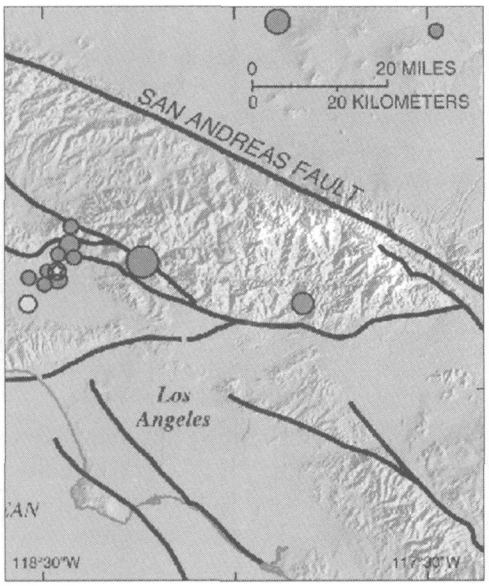


bank loans and insurance coverage can help to encourage the adoption of defensive measures. Hazard analyses also provide a basis for informed preparation in advance of a disaster, allowing disaster response to be as effective as possible.

When a disaster strikes, emergency response teams mobilize to provide aid to the victims, to help guide recovery, and to mitigate the continuing effects of the disaster. Emergency managers gather information that will help them decide how to respond and what resources are needed. GIS is an effective tool in this process, bringing previously compiled datasets such as zip code boundaries and population distribution together with new datasets compiled during the response that describe the extent and character of the disaster and the response actions. The questions that must be answered immediately are daunting: where are the affected areas, how serious is the damage, who requires help, what kinds of help are needed and with what urgency? The sooner there are at least preliminary estimates, the sooner the right aid can be applied where it is most needed. GIS datasets and procedures help speed this response and tailor it to the specific needs of the situation.

Following a disaster, informed planning for reconstructing damaged structures and reinforcing others can decrease the future vulnerability of the region, and scientific study of the event can improve the process models on which predictive modeling is based. GIS is a valuable tool for both. One of the most effective ways to reduce our vulnerability to natural hazards is to encourage the investment of Federal resources in reducing future risk in disaster areas. Federal law requires that 15 percent of all funds allocated for a declared disaster must be spent on mitigation. Emergency managers seeking to apply these funds in the most cost-effective way can use the results of GIS hazards analyses, compilations of disaster effects, and associated data on roads, buildings, and other societal factors to help them estimate the value of various mitigation strategies and thus prioritize mitigation actions and investments to achieve the most effective use of available funds.

Ongoing scientific inquiry treats disasters as natural experiments from which we can learn. The details of the Northridge earthquake, still under study 2 years after the event, are being used to improve our understanding of earthquake sources, the propagation of seismic energy, controls on local amplification, and liquefaction failures, as well as fundamental issues in structural engineering and emergency response itself.



GIS has been a valuable tool in this process and will be even more important as improved process models are tested and used to prepare better predictive hazard and risk assessments.

Carl M. Wentworth *is a research geologist who uses GIS in the compilation of areal geology and its application to analysis of geologic hazards.*

Carl Mortensen *is a geophysicist who utilizes GIS to summarize and transfer post-earthquake observations and research results to emergency management agencies after damaging earthquakes.*

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Response to the Northridge earthquake, which devastated parts of the Los Angeles area of southern California in January 1994, included assigning USGS scientists to aid the Emergency Response Team of the Federal Emergency Management Agency (FEMA) . This liaison provided FEMA quick access to past and emerging scientific information, summaries of the technical data being gathered about the disaster, and help in bridging from the technical data to its practical application. Within 48 hours, a preliminary map of the severity of shaking and damage from the earthquake had been created by combining predictive analyses made by EQE International and Science Applications Corporation (using techniques pioneered by the USGS) with information about the earthquake source derived by the USGS and the California Institute of Technology from seismological data obtained from the 350-station seismographic network operating in southern California. This intensity map was then combined in a GIS with zip code areas to create a basis for dispatching community outreach personnel to the most heavily affected areas to assure emergency shelter for victims. GIS data were also used to locate FEMA's Disaster Application Centers and to provide immediate financial assistance to victims living in the most severely affected areas. As the response effort progressed, GIS representation of the specifics of the damage and the corresponding response, recovery, and mitigation actions was compiled to assist in making further decisions.

Future improvements in GIS-assisted hazards mitigation are already underway. The Northridge earthquake reemphasized the importance of having digital datasets ready in advance. Work is now underway to compile geologic data in digital form for the Los Angeles area and for other metropolitan regions at risk from earthquakes. The ability to obtain precise locations for points on the ground with GPS receivers, which use signals from earth-circling satellites, now allows locations to be determined in the field and fed directly into GIS databases. The use of satellite images of disaster areas will increase now that GIS programs support work with such imagery and as new high-resolution images become available over the next several years. The USGS is now working to provide predictive assessments in digital map form quickly and automatically following the seismographic recording of any large earthquake.

The role of the USGS ranges from basic research on hazardous processes, their occurrence, and their effects to providing expert information and advice when disasters strike. USGS activities of particular importance for earthquake safety are scientific understanding and development of procedures for hazards analysis, the participation of USGS experts on various official committees charged with preparing advisory and regulatory codes for land use and engineering design, and the preparation of national maps showing probabilistic ground motion and other hazards assessments to be used by the engineering community in developing earthquake-resistant design.

CO_2 Emissions at Mammoth Mountain, California

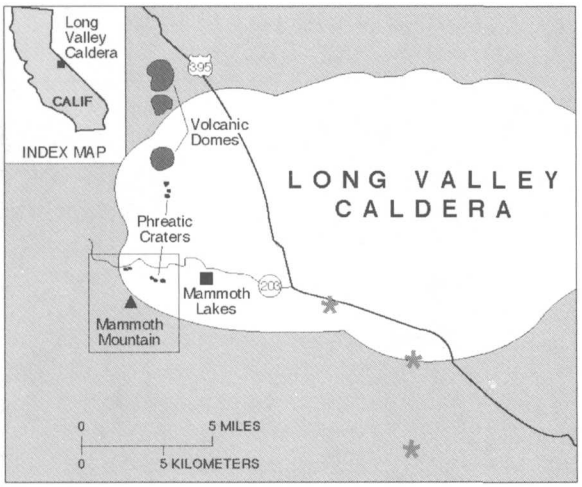
Mammoth Mountain is a young volcano that sits on the edge of the Long Valley caldera in eastern California. The mountain and the adjacent town of Mammoth Lakes are popular destinations for skiing, hiking, camping, and other vacation activities. This area is also geologically active; volcanic eruptions have occurred intermittently over the past million years or so, most recently about 600 years ago. Because of the potential for damaging earthquakes and volcanic eruptions in the area, the USGS maintains an extensive monitoring program to assist in assessing the significance of ongoing geologic activity and in providing warnings of hazardous conditions.

A recent period of crustal unrest was initiated by four magnitude 6 earthquakes and uplift of the central part of the caldera in 1980. Since then, anomalous seismicity and ground deformation have continued to occur in the region. In 1989, earthquake swarms occurred beneath Mammoth Mountain for a period of 6 months in response to an intrusion of magma beneath the edifice of the volcano. Although seismicity beneath Mammoth Mountain has subsequently fallen to lower levels, areas of dead and dying coniferous trees began appearing on the flanks of the mountain in 1990. Since then, the extent of these tree-kill areas has grown to approximately 100 acres. Measurements made by the USGS in the summer of 1994 showed that the trees are dying in areas where carbon dioxide (CO_2) has accumulated in the root zone in concentrations ranging from 30 to 90 percent.

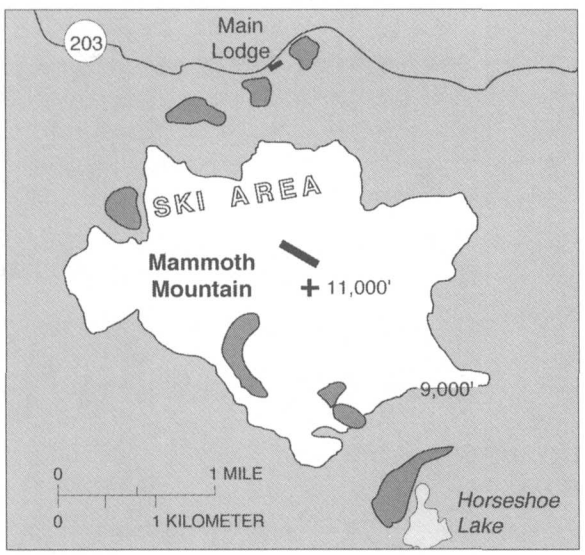
The timing of the onset of the tree kills and the isotopic characteristics of the CO_2 indicate that the gas is being derived from magmatic sources. Furthermore, there is a remarkable similarity in the chemical makeup of the soil gas from each tree-kill area and that of the gas from steam vents higher up on the flanks of the mountain; this similarity suggests that a large reservoir of magmatic gas may exist beneath the mountain. Studies of the attenuation of earthquake signals passing through the mountain also show evidence of such a reservoir. Our initial estimate of the rate at which CO_2 is escaping from the surface of Mammoth Mountain—1200 tons per day—is comparable to the gas flux from the summit regions of Kilauea Volcano in Hawaii and Mount St. Helens in Washington.

Further increases in the rate of gas emission, along with increased earthquake activity and ground deformation, could signal the onset of a new period of volcanic activity in the area. During past eruptive periods, the magnitude of individual eruptions has varied widely, from the catastrophic caldera-forming eruption 760,000 years ago to relatively small eruptions of steam and mud. However, emissions of hot volcanic ash such as those that occurred during the last eruptive period could cause significant damage and loss of life on Mammoth Mountain and in the town of Mammoth Lakes.

The presence of high concentrations of CO_2 in the soils on Mammoth Mountain also poses a threat to public health. Although CO_2, which is released as a cool, diffuse gas from broad areas of soil, dissipates quickly when it



Location of Mammoth Mountain, a young volcano, on the southwestern edge of the Long Valley caldera, that contains volcanic domes and craters that erupted 600 years ago and experienced magnitude 6 earthquakes in 1980.



Areas on Mammoth Mountain where carbon dioxide gas is killing trees and collecting in subsurface structures, as delineated in 1995.

leaves the ground, its toxicity at concentrations above about 10 percent poses a hazard of asphyxia in poorly ventilated areas and subsurface structures, where it can collect at high concentrations. A U.S. Forest Service (USFS) worker almost died from CO_2 inhalation after entering a cabin in the Horseshoe Lake tree-kill area in the spring of 1990; the USFS closed the Horseshoe Lake campground to overnight camping during the summer of 1995.

Michael Sorey *serves as the coordinator for the Water Resources Division Geothermal Program and conducts research on geothermal and volcanic processes.*

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Bill Evans, Chris Farrar, Dave Hill

View of tree-kill area adjacent to Horseshoe Lake showing tree kill caused by high concentrations of carbon dioxide in the root zone.

View from Horseshoe Lake (with Mammoth Mountain in the background) showing healthy forest conditions.

The role of the USGS at Mammoth Mountain is to monitor and interpret signs of crustal unrest, including earthquakes, ground deformation, and changes in the locations and rates of CO_2 discharge. Interpreting this information allows the USGS to advise other agencies and municipalities concerned with public health and emergency planning about the possibilities of future volcanic eruptions, large earthquakes, and threats posed by CO_2 inhalation.

The USFS and Mammoth Mountain Ski Area use USGS findings to develop safety procedures for personnel working on the mountain, especially for activities involving entry to buildings and subsurface structures. Local authorities (fire department and police) and the State Office of Emergency Services are advised when signs of crustal unrest are detected that indicate a heightened possibility of large earthquakes or volcanic eruptions.

In addition to continuing its gas monitoring program, the USGS will be preparing a hazards report that documents (1) the areas and rates of anomalous CO_2 discharge, (2) present conditions under which dangerous levels of CO_2 could be encountered, and (3) areas where sudden releases of CO_2 in the future could cause hazardous conditions to develop. It also plans to test for anomalous levels of CO_2 within the snowpack that covers the mountain during the winter months.

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ENVIRONMENT

Our Nation's environment—the air, water, soil, and plant and animal life—is constantly changing as it is impacted by natural processes and human actions. USGS activities in the environmental area include studies of natural processes and the results of human actions, the goal being to provide the understanding and scientific information needed to recognize and mitigate adverse impacts and to sustain the environment. Activities include data collection, long-term assessments, ecosystem analysis, predictive modeling, and process research on the occurrence, distribution, transport, and fate of contaminants. The article on MTBE, a gasoline additive that has been found in the Nation's shallow ground water, is one example of such a study. Another is the nationwide study of the connection between nutrients in water and land use. At the international level, the USGS is conducting water-resource studies in the People's Republic of China, France, India, Japan, Hungary, Poland, Russia, Slovakia, and Sweden. In Russia, an environmental database for the Lake Baikal drainage basin is being designed in cooperation with Russian colleagues. Increasing the scientific understanding of the environmental systems that sustain and improve the quality of human life continues to be a central concern of USGS environmental studies.

For more information on USGS environment activities, visit www.usgs.gov/themes/themes.html on the World Wide Web.

Stellwagen Bank National Marine Sanctuary Mapping Project

Environmental mapping requires a multidisciplinary approach. This project is being conducted with the cooperation and support of three National Oceanic and Atmospheric Administration agencies (Sanctuaries and Reserves Division, National Marine Fisheries Service, National Ocean Service), the Environmental Protection Agency, the Canadian Hydrographic Service, the University of Connecticut, and the University of New Brunswick, who provide ships, equipment, and expertise in the collection and interpretation of sea-bed imagery and biological observations.

National Marine Sanctuaries are marine and coastal areas of special biological significance that support unique ecosystems, commercial fisheries, and (or) habitats of endangered species and are valued for their recreational and aesthetic resources. Many sanctuaries are located adjacent to large population centers, and some are near offshore waste-disposal sites.

Stellwagen Bank National Marine Sanctuary (NMS) lies off the Massachusetts coast north of Cape Cod. It supports active commercial and recreational fisheries, serves as a habitat for marine mammals, including endangered species of whales, and draws 1.5 million visitors a year, many of whom come to whale watch.

The sanctuary abuts the Massachusetts Bay Disposal Site, which serves Boston and surrounding cities and towns, and is near Boston's new sewage outfall in Massachusetts Bay. Sanctuary habitats are disturbed by systematic dredging of bottom sediments, by trawling by fishing gear, and by periodic large storms.

Because they are poorly understood, sea-floor environments and resources are difficult to manage. Maps produced by the Stellwagen Bank National Marine Sanctuary Mapping Project provide information essential for:

- Determining the distribution of biological habitats and living resources.
- Assessing natural and human disturbance of habitats and living resources.
- Identifying areas where sediment-borne contaminants are deposited.
- Guiding management of commercial and recreational fisheries, marine mammals, tourism, and waste disposal.

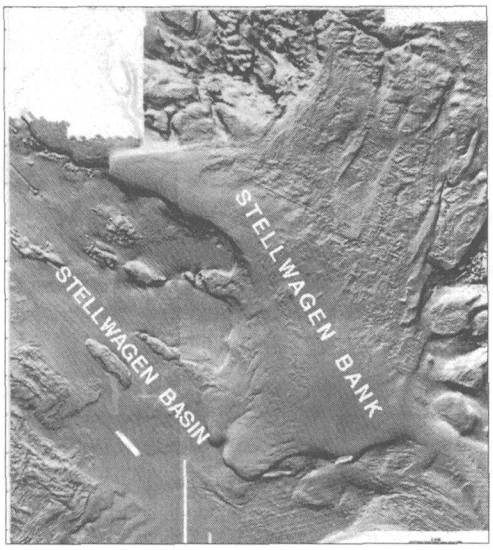
In 1995, the project completed the second phase of a three-stage effort to map the entire sanctuary region (1,000 square miles) using an efficient, high-speed vessel equipped with a digital multibeam mapping system. This vessel collects, processes, and maps topographic and sea-bed character data while still at sea. Interpretation of this sea-bed imagery is aided by the collection of sediment samples, video and still photographs, and biological observations of the sea bed.

Visit the Stellwagen Bank National Marine Sanctuary Mapping Project on the World Wide Web at:
http://vineyard.er.usgs.gov

Results to date show that the sanctuary is comprised of many habitats, each of which supports a distinctive sea-floor community that includes valuable commercial fishery species. These habitats include boulder and cobble assemblages on the flanks of Stellwagen Bank, highly mobile sand on the bank crest, and depositional basins of mud adjacent to the bank. Most of the habitats are heavily impacted by major northeastern storms and by continual disturbance from towed bottom-fishing gear. The information collected by the project is now being used by managers in deciding whether to close some areas to fishing so that important fishery habitats can undergo recovery.

A new map showing the sea-floor topography of Massachusetts Bay, Cape Cod Bay, and the sanctuary was published in 1995 as USGS Open-File Report 95-73 and currently is being used by State and Federal agencies and academic institutions that manage and study the region. This map is based on existing data and will provide a basis for work in the region until the more advanced maps produced by the project are compiled.

The first detailed map of the Massachusetts Bay Disposal Site, a major dumping ground off Boston that is adjacent to the Stellwagen Bank NMS, is now being compiled and will show bathymetry, bottom character, and



Sun-illuminated sea-floor topography of the southern part of the study region. Sun illumination is from the upper left of the image. The smooth sea bed in the basins is mud, the relatively smooth sea bed on the bank crests is sand, and the rough sea bed is boulders, cobbles, and large sand features. This image illustrates dramatically the scouring of the sea bed by prehistoric glaciers, the partial burial of knolls by mud deposited in deep basins, and surficial sand features formed by modern storm currents. The variability shown here in the surface of the sea bed reflects the diversity of environments and biological (for example, fishery) habitats that occur in the region.

the locations of materials that have been disposed of since the 1940's in a 14-square-mile area. This information will be utilized by both the Environmental Protection Agency and the U.S. Army Corps of Engineers, who jointly manage the disposal site.

The Stellwagen Bank NMS project will produce imagery and interpretive maps showing the entire study region as well as a series of quadrangle maps showing detailed sedimentary environments and biological habitats at a scale of 1:20,000 (1 centimeter= 200 meters). Final maps, images, and supporting data will be disseminated in published form and on CD-ROM and the Internet.

The USGS is mapping the entire sanctuary sea bed by means of modern digital sidescan sonar imagery in conjuction with video and photographic surveys, bottom-sediment analyses, and biological observations. Final maps will depict detailed sea-bed topography, sedimentary environments, biological habitats, and processes that alter the sea bed and will provide a basis for making decisions about monitoring, managing, and conducting research in the region. The USGS serves as the repository for information utilized by the project and makes it available to the public in digital format.

The final one-third of the study region will be surveyed in 1996, after which regional maps showing sea-bed topography and character will be completed. Additional sea-bed observations will be collected over the next 2 years to provide the information required for producing individual map quadrangles showing high-resolution interpretations of the sea-bed environment.

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Acknowledgments

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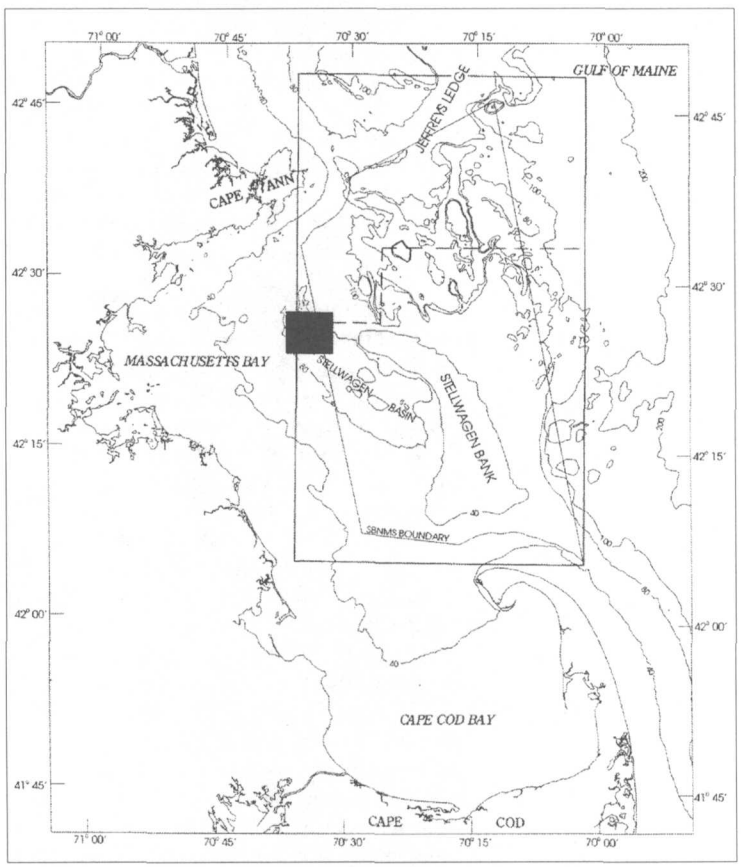

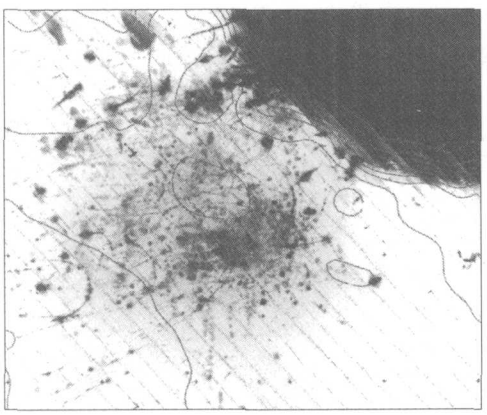

Sidescan sonar image showing the sea-bed character of the Massachusetts Bay Disposal Site in Stellwagen Basin. The light area is mud in the basin, and the dark area is gravelly sand on the edge of Stellwagen Bank. Gray dots and lines represent deposits of dredged material and debris from coastal harbors. The highest concentration of deposits is located at the present site of the marker buoy. Large black deposits are rock debris blasted out of Boston Harbor during excavation of the Third Harbor Tunnel from 1992 to 1993. Mapped area is 3.7x3.8 nautical miles.

Location of Stellwagen Bank National Marine Sanctuary and the region being mapped, which measures 26x43 nautical miles. The area south of the dashed line has been imaged, and the remaining part will be completed in 1996. The shaded box shows the Massachusetts Bay Disposal Site region, where dredged material from coastal harbors is being dumped outside the sanctuary boundary.

Studies in South Florida

Geologists taking a core in a cypress stand.

Ecosystem History: Measuring Historical Change in South Florida

The south Florida ecosystem—including the historic Everglades wetland, Florida Bay, and Biscayne Bay—has undergone striking changes in plant and animal composition and distribution over the last century. These changes have been attributed largely to increasing urban and agricultural activity in the region. However, because the range of natural variability of the ecosystem over time is unknown, it is premature to ascribe cause-and-effect relationships to human activities.

A complex canal and levee system constructed to control flooding and manage freshwater resources for the growing population of southern Florida has drained over half of the Everglades wetland and altered the flow of freshwater into Florida Bay and Biscayne Bay to an unknown extent. In the Everglades, these changes have been blamed for declines in populations of wading birds, decreases in biodiversity, and changes in plant communities as nonnative species invade the wetlands. In Florida Bay, die-off of seagrass populations, declining numbers of shellfish, and frequent algal blooms may be related to onshore drainage changes. In Biscayne Bay, fisheries are declining, pollution is increasing, and the nearshore vegetation has changed dramatically.

In response to these environmental changes, new management strategies are being developed to restore the Everglades to its original pristine state. An understanding of past plant and animal communities and their response to environmental change is critical in the formulation of these plans. Ecosystem history projects at the USGS are providing needed data to modelers at various State and Federal agencies to help develop a sustainable management plan for the Everglades.

USGS scientists are conducting studies to quantify the modern variability in water levels and water chemistry (salinity, nutrients, and dissolved oxygen) as well as the historical changes that may have occurred over the last century. Integrating modern floral, faunal, and sedimentologic distributions with hydrologic data allows scientists to use the biotic record from short sediment cores (<2 m) collected throughout the region to interpret environmental changes over the last 150 years. Comparing modern records with down-core records enables scientists to interpret the effects of changing rates of freshwater flow, nutrient levels, sedimentation patterns, and fire frequency in the south Florida ecosystem. This research requires careful dating of samples by several techniques. Dating by using radioactive isotopes provides particularly good chronological control.

USGS scientists also are analyzing the biotic record over the last few millennia to determine the amount of natural variability in plant and animal communities. This information is crucial to establish baseline levels of variability within the ecosystem and to guide resource managers in selecting goals for restoring plant and animal communities in the Everglades ecosystem.

Reconstructing vegetational communities at selected time intervals over the last 150 years allows scientists to determine how broad an area was affected by various environmental changes. Such information is critical to the modeling efforts of the South Florida Water Management District, the National Oceanic and Atmospheric Administration, and the USGS.

Biotic records from both Florida Bay and the Everglades indicate floral and faunal changes over the last 150 years, several of which appear to be synchronous across the region. Around 1960 (plus or minus 10 years), Florida Bay sediments show decreases in submerged aquatic vegetation and decreases in benthic faunal abundance and diversity. Pollen assemblages indicate a contemporaneous decrease in sawgrass abundance in near-shore peats and an increased abundance of mangroves and hardwoods. Farther inland, at a cattail-affected site in the water conservation areas, a change to vegetation having a greater abundance of cattails also is recorded at about the same time. This vegeta-

USGS projects in south Florida are funded by the Ecosystem Initiative, with added support from the U.S. Army Corps of Engineers, and have been carried out in coordination with other USGS projects. Other agencies involved in site selection, field support, and other aspects of the projects include the South Florida Water Management District, Big Cypress National Preserve, Everglades National Park, the Dade County Department of Environmental Resource Management, the National Oceanic and Atmospheric Administration, the Florida Geological Survey, and the Florida Institute of Oceanography.

tional change corresponds to other changes in the geochemical record, including increases in phosphorous, nitrogen, and other elements.

Extensive sampling of modern sediments in Florida Bay, Biscayne Bay, the Everglades, and Water Conservation Areas is planned for FY 96. Coring of transects from Florida Bay through the mangrove fringe into sawgrass marshes is being undertaken in FY 96, and additional coring will be done in the Everglades, Florida Bay, and Biscayne Bay in FY 97. Processing and analysis of cores collected in FY 94 and FY 95 also are being completed in FY 96. Analysis and interpretation of data from all cores collected will show the degree and rate of change in floral and faunal communities over the last 150 years and will help to interpret the driving forces behind biotic changes in the Everglades ecosystem.

Debra Willard *is a palynologist studying past vegetational responses to environmental and climatic change.*

Acknowledgments:
Lynn Brewster-Wingard (U.S. Geological Survey)
Scott Ishman (U.S.Geological Survey)
Chuck Holmes (U.S. Geological Survey)
Jim Herring (U.S.Geological Survey)

Mud banks in Florida Bay.

Wading birds in a sawgrass marsh.

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Florida Cooperative Mapping Project

A multitude of water-related societal issues face south Florida in the 1990s. Among the more pressing of these issues are the irrigation demands of sugar cane growers and other agricultural businesses, the increasing domestic demands of a rapidly growing population in the Naples and Miami areas, and the recently mandated restoration of natural sheet flow through the Everglades ecosystem.

Eighty-seven percent of the freshwater used in south Florida for commercial, agricultural, and private needs comes from shallow subsurface aquifers. However, because surface exposures of these rocks are rare, access to essential geologic and hydrologic information is severely limited. As a result, the interpretation of geologic history and the prediction of hydrologic properties are difficult and require the collaboration of State and Federal geologists and hydrogeologists.

Ongoing core analyses indicate that the sedimentary units of the shallow aquifer system in south Florida are characterized by carbonate rocks and quartz sand that have undergone a complex series of changes over time. To use this valuable resource efficiently calls for an integrated study of the geologic and biologic framework of the entire aquifer system.

In addition to the demands posed by conflicting-use needs and a rapidly growing population, the freshwater supply is threatened by pollution and saltwater incursion along the coasts. The surficial aquifer is quite thin in southeastern Florida and vulnerable to surface-derived pollution from many sources. Knowledge of the quantity, quality, and flow characteristics of the ground water is essential in order to address and eventually solve these problems and to provide a scientific basis on which land and water managers can make responsible decisions.

Managing the restoration of sheet flow through the wetlands requires an understanding of the complex interaction between surface (overland and channelized) and shallow

This project is jointly funded by the Ecosystem Initiative and the National Cooperative Geologic Mapping Program. The USGS has a cooperative agreement with the Florida Geological Survey through a signed Memorandum of Understanding and a Project Implementation Plan. Site location and project modification are closely coordinated with the South Florida Water Management District, the National Park Service, and local State parks. The Southwest Florida Water Management District, the Florida Museum of Natural History, and the University of Florida are actively involved in the mapping aspects of the project.

In addition, the project interfaces with the U.S. Army Corp of Engineers, the National Oceanic and Atmospheric Administration, the U.S. Department of Agriculture, the U.S. Fish and Wildlife Service, and the Environmental Protection Agency (largely in the ecosystem history aspects).

ground-water flow throughout the year. In the tropical climate of south Florida, summer is wet summer and winter is dry. During the long dry winter, the water table moves into the subsurface in many parts of the wetlands. Flow during the dry season is controlled, in part, by the presence of a dense cap rock that occurs within 20 feet of the surface in much of southwestern Florida. Knowledge of the spatial distribution of this cap rock is essential to understand the complex seasonal interaction of surface and shallow ground-water flows.

Bruce Wardlaw *is a geologist who has studied carbonate rocks for 22 years.*

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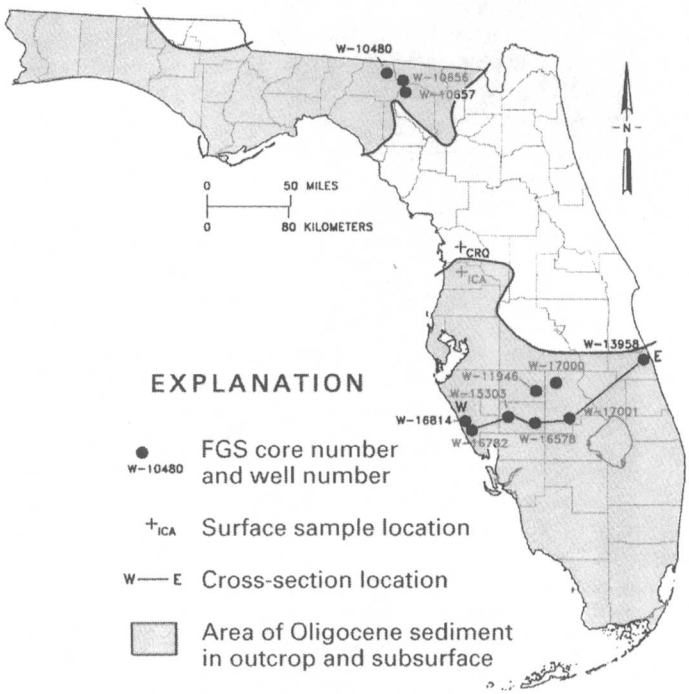
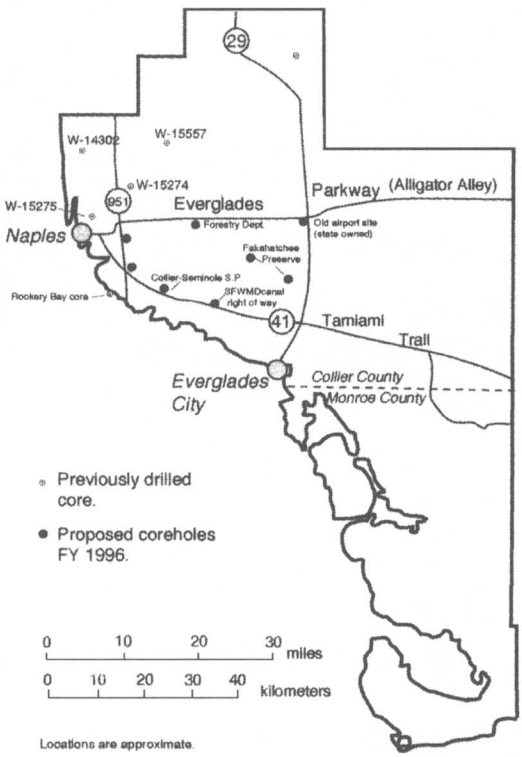


Core and surface sample locations and the distribution of Oligocene sediments in the Florida peninsula and eastern panhandle. Areas of Oligocene deposition are shown in gray (modified from work conducted by Tom Scott in 1988).



Proposed corehole sites in Collier and Monroe Counties and the hydrogeology of the surficial aquifer system of southwestern Florida.

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To streamline the USGS's paleontological and geologic framework activities in Florida, the Florida Cooperative Mapping Project was organized. The project covers ecosystem history (see "Ecosystem History: Measuring Historical Change in South Florida"), the geologic framework for the Florida ecosystem, and SUPPORTMAP for mapping activities of the Florida Geological Survey (FGS).

The FGS and the USGS have initiated a drilling project in southwestern Florida to investigate the surficial subsurface aquifer system. Coreholes will be jointly drilled by the FGS and the USGS, geophysically logged and monitored by the USGS, and jointly described by the FGS and the USGS. Refined stratigraphic analysis will be performed by the USGS. The USGS will then use the data acquired from the project to produce a more detailed surficial material/bedrock map of southwestern Florida to better understand surface and shallow ground-water flow.

The USGS will provide refined biostratigraphic, lithostratigraphic, and sequence stratigraphic support to the mapping activities of the Geological Investigations Projects of the Florida Geological Survey (SUPPORTMAP) which include:

- Revision of the State geologic map and the State geomorphic map.
- Surficial sediments and bedrock mapping of the western half of the Homestead 1:100,000-scale quadrangle and surficial sediments and bedrock geology mapping of the Sarasota 1:100,000-scale quadrangle.
- Lithostratigraphic and biostratigraphic investigations of the proposed Okeechobee Formation.
- Study of the siliciclastic-carbonate transition in south Florida and the Keys.
- Hydrostratigraphic and lithostratigraphic characterization of the Cenozoic sediments of the Southwest Florida Water Management District.
- Characterization studies of western Florida coastal estuarine sediments.

The project was initiated in FY 95 by combining ecosystem history studies, small preliminary subsurface stratigraphic studies, and a geohydrology study. The very active drilling program in southern Florida should continue, along with the descriptions and analyses of core and the monitoring of sample sites. The analysis of a north-south transect of coreholes in combination with the recently completed east-west transect are near-term priorities.

Global Warming: Role of Recovering North American Forests in Offsetting Greenhouse Gas Emissions from the Burning of Fossil Fuels

The forests of North America (as well as those of northern Europe and northern Asia) are now recognized as important carbon dioxide sinks. Much of these forest lands—which were substantially depleted in carbon inventories when they were used for agriculture—are now recovering and acting as net sinks for carbon dioxide in both soil and vegetation. The existence of these "sinks" explains some of the often cited "missing carbon sink" associated with global carbon budgets.

Several ongoing USGS projects currently include investigations into various aspects of carbon cycling. At the Panola Mountain Research Watershed, near Atlanta, Ga., scientists with the Water Energy and Biogeochemical Budgets (WEBB) initiative of the Global Change Program have estimated the rate of carbon accumulation in vegetation and soils and offered an hypothesis of how this rate may be changing over time.

Emerging scientific consensus holds that:

- Anthropogenic emissions of greenhouse gases (primarily carbon dioxide resulting from the burning of fossil fuels) have caused a chronic increase in the atmospheric concentrations of theses gases.

- The accumulation of these gases in the atmosphere has resulted in a "greenhouse effect" that in turn has caused gradual warming as measured in air and ocean temperatures and a corresponding sea-level rise.

- The Intergovernmental Panel on Climate Change (IPCC) estimated recently that increases in atmospheric concentrations of greenhouse gases may have raised global mean temperatures by 0.45 °C during the last century and predicted an increase of about 2.5 °C during the next century if emissions are not significantly reduced. The IPCC also forecast a corresponding average sea-level rise of 6 centimeters per decade (with an uncertainty range of 3 to 10 centimeters).

Importance of Forests

Forest ecosystems comprise the largest terrestrial carbon stores, between 1.3 and 1.6 trillion tons of carbon, representing 82 to 86 percent of above-ground carbon and 70 to 73 percent of all soil carbon. The rate of carbon losses (emissions of CO_2 to the atmosphere between 1980 and 1989) attributed to tropical deforestation has been estimated to be 1.8 billion tons of carbon per year. Mitigation strategies that have been proposed include large-scale reforestation as a means of augmenting global carbon sequestration. Understanding the role of forests in the global carbon cycle is very important, because small changes in forest response will translate into large effects on the global carbon budget.

Forests are likely to respond to climate change in complex ways, all of which will have an impact on the role of forests as carbon sinks. Increasing carbon dioxide concentrations may increase phostosynthesis and growth where nutrients or water are not already limiting. Increased photosynthesis will result in higher rates of carbon from decomposing plant material to soils. There is evidence that increasing carbon dioxide may alter water and nutrient use efficiency. There is also speculation that increasing carbon dioxide may alter the chemical composition of the decompsing plant materials and, hence, change the rate of decomposition. Forest species composition may be altered. The occurrence and severity of forest insect and pathogen pests are likely to be influenced by a changing climate. The occurrence and competitive pressure of exotic plant species may be influenced by a changing climate. An increase in the frequency of severe weather (hurricanes, ice storms, severe drought), which is thought to be a likely consequence of climate change, also may affect forests.

In this specific study, USGS scientists have collaborated with scientists from Syracuse University and Emory University and with scientists from the National Resource Conservation Service (formerly the Soil Conservation Service).

More information can be obtained from these publications:

T.G. Huntington and J. Bremner, 1995, Soil respiration in relation to environmental factors in a Georgia Piedmont forest [abs.]: Annual Meeting of the Soil Science Society of America, St. Louis, Mo., Agronomy Abstracts, p 308.

T.G. Huntington, 1995, Carbon sequestration in an aggrading forest ecosystem in the southeastern USA: Soil Science Society of America Journal, v. 59, p. 1459-1467.

Summary of Results at Panola

- Carbon is accumulating in the soil at Panola at an estimated rate of 0.25 ton per acre per year.
- Carbon is accumulating in vegetation at Panola at an estimated rate of 0.66 ton per acre per year.
- When comparable rates of vegetation and soil carbon accumulations are applied to large forested areas of northern temperate latitudes, they can explain a substantial part (approximately 2 billion tons per acre per year) of the "missing sink" in the global carbon budget.
- A comparison with a nearby "undisturbed" forest (the Fernbank Forest in Atlanta, Ga.) indicates that there is a large potential for further carbon accumulation in Southeastern U.S. forest soils.
- On the basis of this analysis and the finite "carrying capacity" for a given site's soil carbon storage, it is estimated that the rate of soil carbon accumulation is currently near maximum or declining; thus, the rate of accumulation in the sink will continue to diminish if the land remains under forest cover.
- Because of the larger soil carbon inventories in more northerly latitudes, it is likely that the rate of carbon accumulation is greater in those forests, assuming that comparable percentages of soil carbon were lost during periods of disturbance.
- Carbon accumulation in soils is likely to be directly influenced by changes in the temporal or spatial patterns of deposition of nitrogen and possibly of phosphorus and base cations where these nutrients limit forest growth.
- Carbon accumulation in soils will undoubtedly be influenced by changing climate, because the rate of carbon mineralization (decomposition) is dependent, in part, on soil temperature. The USGS has demonstrated a marked and highly significant temperature dependence for soil respiration (CO_2 flux from the soil to the atmosphere) has been found during the dormant season at Panola Mountain. On the basis of this relationship, a 1.6 °C increase in soil temperature would lead to a 40-percent increase in soil respiration.

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The USGS conducts research into controls on basic carbon transformations and investigates carbon cycling in forest ecosystems and how carbon cycling may both influence and be influenced by changing climate. At Panola, the USGS has studied carbon pools and fluxes to develop a budget for carbon at the site. The USGS has estimated carbon transport in suspended and bed sediment and has estimated the amount of carbon buried in alluvial sediments within the small forested watershed to determine what proportion of carbon (which had been eroded from hillslopes during the period of agricultural disturbance) might have been retained in buried sediments. Currently, the USGS is studying the dependence of soil respiration on temperature and moisture. Study results will provide ecosystem managers with information that can be used to make decisions regarding resource management and will provide global climate modelers with data for making predictions of ecosystem response to potential climate change.

GIS-Baikal: An Environmental Geographic Information System of the Lake Baikal Region

Lake Baikal, a rift lake in southeastern Siberia, is the largest (23,000 cubic kilometers of water), deepest (~1,640 meters), and one of the oldest (20-25 million years) lake systems in the world. Baikal receives drainage from more than 300 rivers and streams and has a combined watershed area of 579,000 square kilometers. This area is home to over 2300 species of plants and animals, 70 percent of which occur nowhere else in the world. The Baikal area also contains abundant resources of timber, minerals, coal, and petroleum.

Because of its unique ecology and rich endowment of resources, the Lake Baikal area has been the focus of efforts to develop new approaches for environmental management and the sustainable development of natural resources.

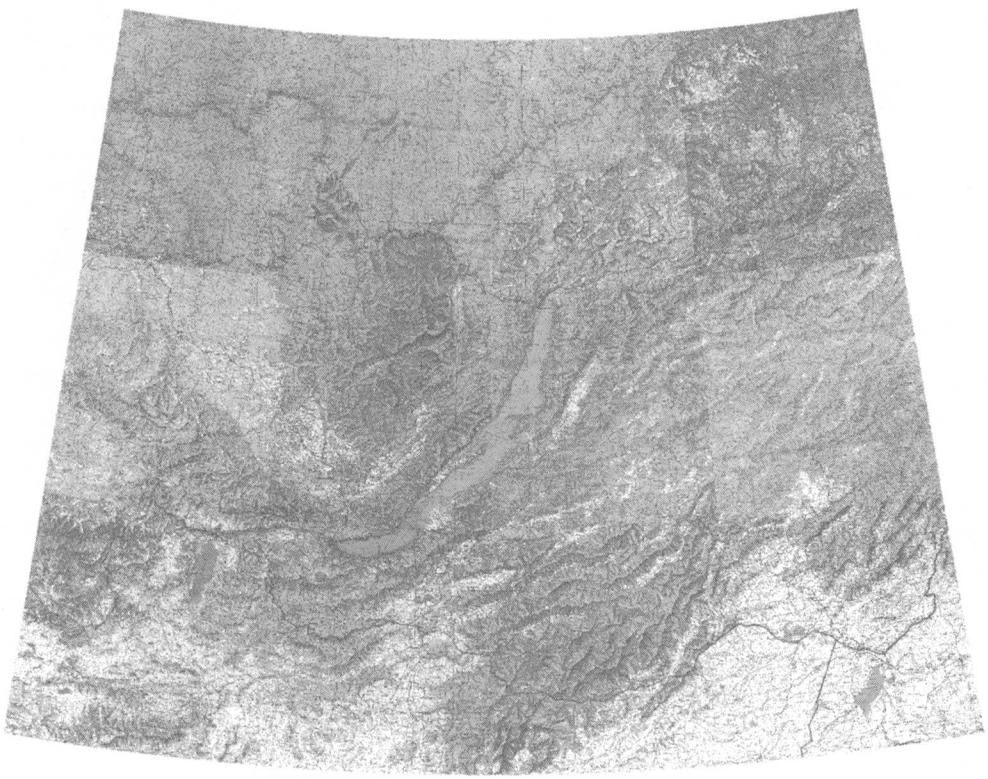
On June 17, 1992, U.S. President George Bush and Russian President Boris Yeltsin issued a joint statement declaring the determination of the United States and the Russian Federation "...to conserve the unique ecosystem of Lake Baikal and to utilize its potential for research in limnology, geology, and global climate change."

In 1993, the U.S. Department of State provided funding for a number of joint projects in the Baikal area involving U.S. Government and private-sector organizations and their Russian counterparts. These projects were intended to provide technical resources and expertise to support the development of sound land management and environmental protection policies in the Baikal region.

A key requirement of all these projects was the availability of a geographic information system, or GIS, to provide data management, geographic analysis, and information dissemination. A GIS consists of computer hardware and software, data, technical specialists, and procedures assembled for a specific task.

In 1994, the USGS began a joint project with Russian counterparts to compile an environmental GIS of the Lake Baikal drainage basin. In the first stage of this program, modern UNIX-based GIS facilities were established at Russian centers in Moscow and Irkutsk. The three regional environmental committees in the Lake Baikal area (Irkutsk, Chita, and Ulan-Ude) were also equipped with PC-based GIS systems.

The components of the Lake Baikal environmental GIS are designed to accommodate the large datasets, multiscale sources, and varied output requirements of the project. This GIS will allow scientists, analysts, and policymakers from all of the Russian and U.S. cooperating



Digital raster graphic base-map mosaic of the Lake Baikal region, produced from12 1:1,000,000-scale Russian topographic maps.

organizations, including Federal, State, and local (both public and private), to contribute and share geographic information.

The main part of the GIS is now being compiled in ARC/INFO format at a scale of 1:1,000,000 and will cover an area of approximately 2.5 million square kilometers. Additional coverages will be prepared at larger scales for selected areas. Among the layers to be included in the 1:1,000,000-scale coverages are:

- Topography
- Vegetation type
- Political boundaries
- Geology
- Wildlife distribution
- Population density
- Engineering geology
- Forest classification
- Economic development
- Soil type
- Historical climate data
- Health statistics
- Hydrology
- Snow cover
- Digital raster graphic
- Images of base maps
- Seismicity
- Agricultural zones
- Tectonics
- Satellite imagery

The USGS provided technical expertise in the design of UNIX-based GIS computer hardware and software systems and helped install these systems at Russian facilities in Moscow and Irkutsk. PC-based systems were designed and shipped to regional environmental committees in the Baikal area. The USGS is also providing assistance in the design of the Baikal GIS and is now working with Russian specialists to complete preliminary segments of the GIS for demonstration to the U.S and Russian governments.

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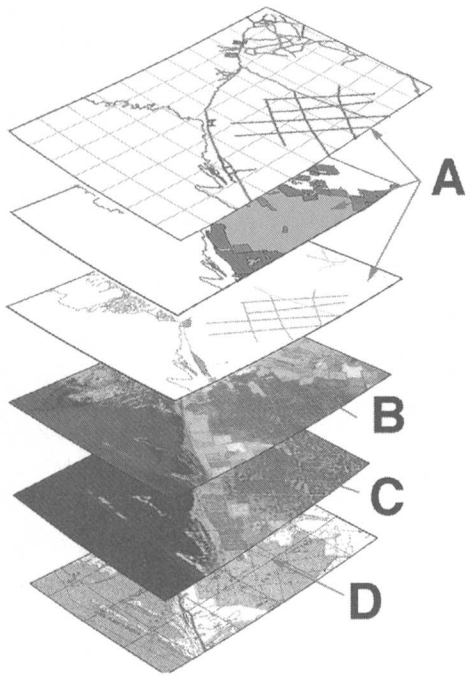


Schematic showing examples of layers that will be contained in the Lake Baikal GIS. A represents Russian thematic maps showing agricultural zones, protected areas, and other land-use data; B shows Russian KFA-1000 satellite imagery with three spectral bands at 5-meter resolution; C shows U.S. landsat TM satellite imagery with seven spectral bands at 30-meter resolution; D is a Russian topographic base map at 1:200,000 scale.

The Russian Federal Service for Geodesy and Cartography (ROSKARTOGRAFIA) is the Russian agency responsible for all topographic mapping in the Russian Federation. ROSKARTOGRAFIA manages the Russian civilian satellite imagery program and is also charged with developing technology and expertise in GIS applications. The technical facilities to develop and produce the Lake Baikal GIS were established at ROSKARTOGRAFIA institutes in Moscow and Irkutsk. ROSKARTOGRAFIA is providing the topographic base maps and satellite imagery for the GIS and will combine these components with thematic data provided by other participants to produce the final GIS.

Environmental committees of the Buryat Autonomous Republic and the Irkutsk and Chita Oblasts, together with the Siberian Branch of the Academy of Sciences, are gathering and compiling thematic data for the GIS. Specialists with these groups have already compiled several GIS coverages of selected areas within the Lake Baikal region.

Ecologically Sustainable Development, Inc. (ESD), is a U.S. nonprofit organization that has worked extensively with Russian government agencies and local environmental committees to develop a comprehensive land use plan for the Lake Baikal drainage basin. ESD has also played a key role by working with the regional environmental committees to gather, compile, and digitize land use data and other thematic data for use in the Lake Baikal GIS and other GIS applications.

Land Information Technology, Ltd. (Land Info), a U.S. company that specializes in the digitization of maps and other cartographic products, worked with USGS and ROSKARTOGRAFIA specialists to produce the digital mosaic of 12 1:1,000,000-scale topographic maps covering approximately 2.5 million square kilometers around Lake Baikal.

Occurrence of MTBE in Shallow Ground Water

MTBE, or methyl tert-butyl ether, is a volatile organic compound (VOC) that is added to gasoline in many parts of the United States to increase the octane level and to reduce carbon monoxide and ozone levels in the air. MTBE is currently classified by the Environmental Protection Agency (EPA) as a possible human carcinogen. Health complaints related to MTBE in air have been reported since 1992 at some locations around the country. It is estimated that 109 million Americans live in counties where MTBE is believed to be used.

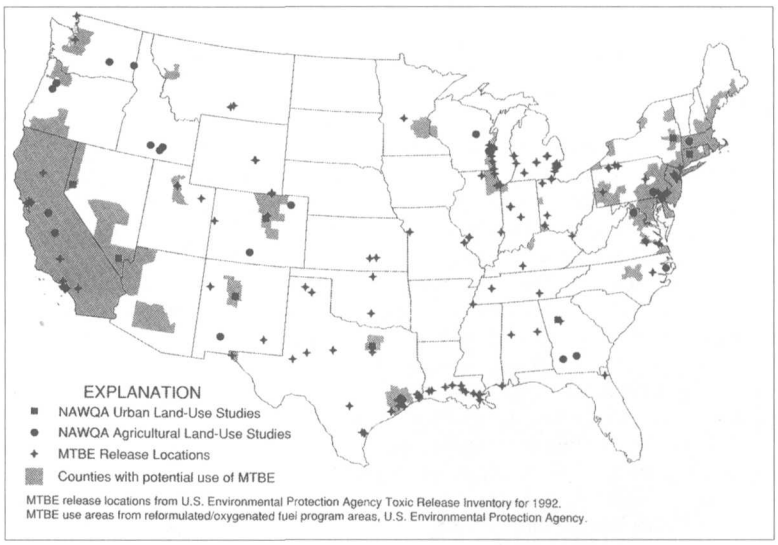
The Clean Air Act of 1990 mandates that oxygenates be added to gasoline in parts of the country where ozone levels in the summer or carbon monoxide levels in the winter exceed established air-quality standards. Because of its low cost, ease of production, and favorable transfer and blending characteristics, MTBE is a commonly used oxygenate. Domestic use and production of MTBE decreases the Nation's need for foreign oil.

The USGS National Water Quality Assessment (NAWQA) Program collected samples from wells, tested them for the presence of MTBE and other VOCs, and summarized the results. MTBE was detected in water samples from wells in 210 shallow wells and springs (27 percent) in 8 urban areas and 549 shallow wells (1.3 percent) in 21 agricultural areas. It was found most frequently in shallow ground water in Denver, Colo.,where 79 percent of the samples from shallow urban wells had detectable concentrations of MTBE, and in urban areas of New England, where 37 percent of the samples from urban wells had detectable concentrations. Only 3 percent of the wells sampled in urban areas had concentrations of MTBE that exceeded 20 micrograms per liter, the estimated lower limit of the EPA draft drinking water health advisory level.

USGS scientists sampled ground water that was located near the top of the water table and was most likely to show contamination from sources at the land surface. Five of the urban wells sampled were being used as a source of drinking water, but none contained MTBE. In general, public water supplies draw water from deeper parts of the ground water system, and there are few data showing concentrations of MTBE at these deeper depths.

Ongoing NAWQA studies will continue to investigate the occurrence of MTBE in ground water. Additional sampling for MTBE in shallow ground water in about a dozen metropolitan areas throughout the country in 1997-98 will attempt to establish a connection between the occurrence of MTBE and residential and commercial land use. At some urban sampling sites, water will be tested in all phases of the hydrologic cycle to better understand the sources, transport, and fate of MTBE in the hydrologic cycle.

In addition, about 30 aquifers representing "deeper ground water" will be sampled for MTBE and other VOCs.



Location of urban and agricultural areas studied and locations where MTBE may be released and used.

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Are Nutrients in the Nation's Water "Too Much of a Good Thing"?

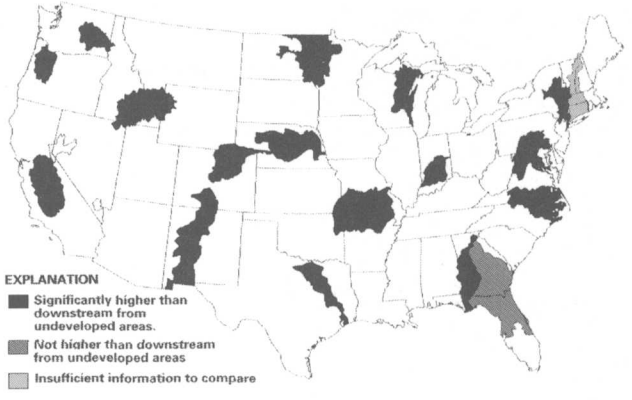
The USGS has conducted one of the most extensive studies ever of nutrients ("plant food"), documenting what is known about their concentrations in the Nation's surface and ground waters and where, when, and why concentrations differ. The results provide insight into cost-effective methods for managing and protecting pure water resources.

Contamination of water by nutrients has been a national concern for several decades. Nutrients in water are necessary for productive aquatic ecosystems, but, in high concentrations, they can adversely affect both aquatic ecosystems and human health. The major inputs of nutrients to streams and ground water are from nonpoint or diffuse sources, such as commercial fertilizer and manure applications to land, as well as precipitation. Point sources, such as sewage treatment plants, are a smaller but more direct source.

The study, done by the USGS National Water Quality Assessment (NAWQA) Program, indicates that patterns of nutrient concentrations in water generally follow patterns in land use. Nitrate concentrations in shallow ground water are higher in agricultural areas than they are in urban or undeveloped areas. Nitrate concentrations in surface water are highest downstream from both agricultural or urban areas but are not as high as those in ground water. Ammonia and phosphorus concentrations are highest downstream from urban areas and sometimes are high enough to exceed criteria intended to protect aquatic life.

Recent improvements in sewage treatment mandated by the Clean Water Act have decreased ammonia concentrations downstream from many urban areas by converting the ammonia to nitrate. This conversion process has decreased the incidences of fish kills and odor problems in comparison with the 1970s. However, because of what appears to be a widespread shift from ammonia to nitrate nationwide, total amounts of nitrogen entering downstream reservoirs and estuaries have not decreased. Elevated concentrations of nitrate in streams of the Northeastern States follow elevated concentrations in precipitation in the Northeast (nitric acid is one of the acids in acid rain). High nitrate concentrations in Midwestern streams are likely accentuated by tile drainage of agricultural fields.

Drinking water from public supply wells and domestic supply wells outside of agricultural areas is not likely to contains high levels of nitrate. Concentrations in only 1 percent of the sampled public supply wells exceeded the Environmental Protection Agency's drinking-water standard for nitrate. For domestic supply wells in agricultural areas, where sources of nitrate are often nearby and more prevalent, concentrations in 12 percent of wells exceeded the standard. Nitrate concentrations in ground water generally are higher in parts of the Northeast, the Midwest, and West Coast and generally lower in parts of the Southeast.



Nitrate concentrations in surface water downstream from agricultural areas.

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Mirror Lake Site: How Methods Developed There Are Being Used at Other Sites

This project was conducted by the USGS, in cooperation with the U.S. Air Force Conversion Agency, the U.S. Environmental Protection Agency, the Maine Department of Environmental Protection, and Mitretek Systems.

Because of the ground-water contamination that exists in shallow, unconsolidated formations in many areas of the Nation, increasing quantities of water are being withdrawn from deep bedrock formations. Cracks, joints, and faults (collectively referred to as "fractures") are the principal pathways for ground-water flow in bedrock. Because rocks do not fracture uniformly and rates of ground-water flow through fractures can range over more than 10 orders of magnitude, methods that have been used successfully to evaluate the physical and chemical processes affecting ground water in shallow, unconsolidated formations may not be applicable to the complex hydrology and geology of fractured rocks. New or modified methods of characterizing the location of fractures and their ability to transmit fluids and dissolved chemicals are needed to evalute ground water in fractured rock areas.

In 1990, the USGS's Toxic Substances Hydrology Program began studying fractured bedrock in the Mirror Lake watershed in Grafton County, New Hampshire, in order to develop methods of evaluating the ability of fractures to transmit water and dissolved chemicals or contaminants. A broad range of techniques, including geologic, geochemical, geophysical, and hydrologic methods, are being developed and applied at the Mirror Lake site. About 25 research scientists from the USGS, universities, and research institutes are involved in the study.

Studies related to ground-water flow and transport of dissolved chemicals in fractured rock areas throughout the Nation have benefited from the investigation at Mirror Lake. In particular, the innovative geophysical methods developed there for detecting fractures have been applied to a contamination problem at the former Loring Air Force Base in Aroostook County, Maine. For many years, jet fuel, waste oil, and flammable solvents were dumped into a pit and set on fire, so fire-fighting crews could practice extinguishing the fires. Although the site is no longer used, the petroleum products are still in the soil and ground water and have contaminated a fractured bedrock aquifer. After evaluating new technologies for cleaning up the site and recovering the contaminants in an efficient and economical manner, the U.S. Air Force decided to blast an area of bedrock near the contaminated site to increase hydraulic conductivity and create a "recovery trench" to collect the waste products. Such an approach was necessary because not all fractures were well connected, a situation that could have slowed or prevented contaminant recovery.

Because Air Force technical consultants wanted to be certain that the effects of the planned blast fracturing were well understood, the USGS was asked to use the state-of-the-art borehole and surface-geophysical techniques it had developed at the Mirror Lake site to characterize the orientation and hydrologic properties of fractures in the bedrock aquifer. The geophysical data collected by the USGS before blasting the recovery trench were used to orient the trench; additional surveys conducted by the USGS after the blasting evaluated the effectiveness of the blast containment and the extent of fracturing in the recovery zone.

***F.P. Haeni** is Chief of the Branch of Geophysical Applications and Support in the Office of Ground Water.*

Acknowlegments:
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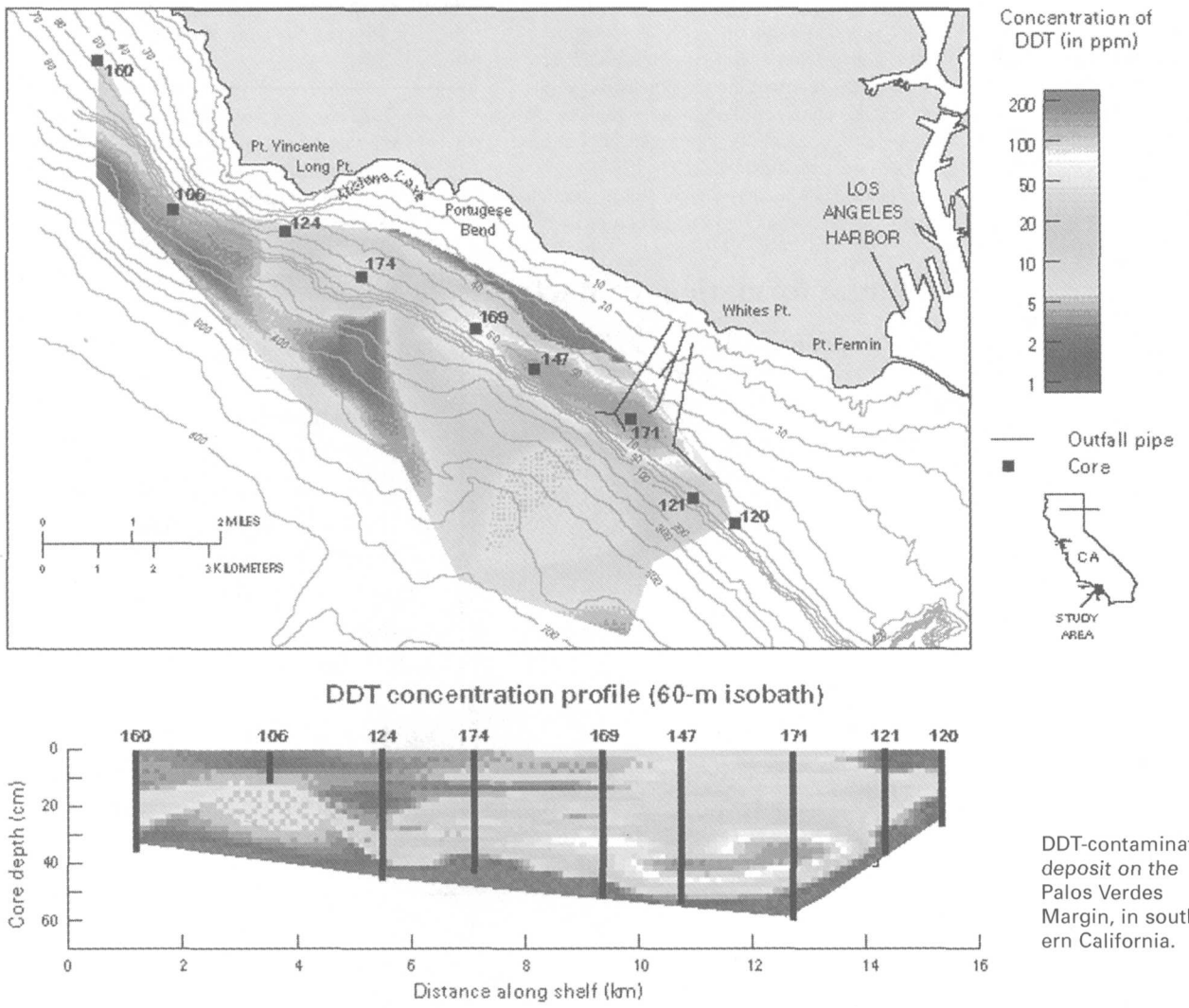
Distribution and Fate of Contaminated Sea-Floor Sediment on the Shelf Offshore Los Angeles

During the 1950's and 1960's, when the world's largest producer of DDT was connected to the Los Angeles County sewer system, a significant quantity of DDT passed through the sewer system and out the Whites Point outfall into the ocean off the Palos Verdes Peninsula. Several other industries allowed PCBs to pass into the same sewer system, and these substances were also discharged into the marine environment near Palos Verdes.

These contaminants—DDT and PCBs—became associated with organic matter and other solids in the effluent, as well as with ordinary sediment particles, to form an effluent-affected sediment deposit on the continental shelf and slope. These contaminants seriously impacted—and continue to impact—sediment-dwelling organisms, fish, and birds.

The DDT producer was disconnected from the sewer system in the early 1970's, and sediment deposited since then is less contaminated with DDT. However, biological and physical mixing processes continue to transfer older, highly contaminated sediment to the sea-floor surface and thus maintain a risk to the environment.

As part of several environmental lawsuits brought against the allegedly responsible parties, the USGS was asked to map and characterize the effluent-affected sediment body and to predict the fate of contaminants over the foreseeable future if no remedial action were to be taken (natural recovery). To that end, a major research project was undertaken that included acoustic and photographic surveys, sediment sampling, physical and chemical analysis of sediment cores, and state-of-the-art modeling of



DDT-contaminated *deposit on the* Palos Verdes Margin, in southern California.

The contaminant mapping and natural recovery modeling were part of a collaborative effort that included scientists from the University of Virginia, the Woods Hole Oceanographic Institution, the University of Southern California, the Battelle Organization, and the Arthur D. Little Company.

sediment transport processes extending far into the future.

Acoustic profiling clearly showed a 20- to 60-centimeter-thick low-density sediment layer extending over much of the 3x10-km continental shelf. Testing of the physical properties of cores confirmed the presence of this layer on the shelf and also showed that the layer extends well down the 3x10-km continental slope. This low-density sediment layer constitutes the effluent-affected sediment deposit, which chemical analyses have confirmed is almost all contaminated with DDT and PCBs. Over 100 tons of DDT are present in the effluent-affected deposit, which covers an area greater than 40 square kilometers. The volume of the contaminated sediment exceeds 9 million cubic meters.

The natural recovery model predicted that surface DDT concentration will drop near the outfall until about 2010 while new deposition of less contaminated sediment remains dominant. In later years, as erosional processes become more dominant and as presently buried, more contaminated sediment undergoes partial exposure, surface concentrations will rise and continue to be environmentally significant until at least 2040 and possibly through 2100.

The USGS coordinates all studies related to mapping and predicting the natural recovery of contaminated sediment on the Los Angeles County continental shelf near Palos Verdes. This effort includes conducting acoustic, photographic, and sampling surveys, installing environmental monitoring equipment, conducting geologic and physical property analysis of cores, and interpreting resulting data.

In addition to providing continuing information for the lawsuits, the USGS is using this unique and extensive data set to begin a systematic regional investigation of sediment and pollutant transport processes in the greater Los Angeles area. One goal of this investigation is to describe the sediment transport processes that were active in the area before any significant human impact was felt and to define the important changes in these processes that have occurred since the intense development of the Los Angeles metropolitan area. The USGS will provide regional information that can be used by local organizations in planning for specific projects that impact the coast and continental margin.

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These environmental lawsuits are being pursued by the U.S. Department of Justice on behalf of the natural resource trustees, consisting of the U.S. National Park Service, the U.S. Fish and Wildlife Service, the National Oceanic and Atmospheric Administration (NOAA), the California Department of Fish and Game, the California State Lands Commission, and the California Department of Parks and Recreation. The lead natural resource trustee and sponsor of the USGS work was NOAA.

NATURAL RESOURCES

The natural resources of our Nation are its land, water, minerals, plant and animal life, and energy. These resources are needed to sustain life and to maintain and enhance our economic strength. In order to assess the quantity, quality, and distribution of the Nation's natural resources, the USGS monitors current conditions, documents changes, describes and interprets the processes that form and affect resources, and forecasts changes that can be expected in the future. USGS activities related to natural resources range from assessing the quantity and quality of the Nation's coal resources to determining the availability, quality, and effects of development on the water resources of the middle Rio Grande area of New Mexico. Mineral resources studies —although focused on the United States—include some activity on nearly every continent. For example, USGS scientists are working to assess the thickness, extent, and quality of U.S. mineral resources (such as sand, gravel, and crushed stone) in support of efforts to build and repair the Nation's infrastructure. USGS research into the migration of salmon may allow managers to design strategies that accommodate both the hydropower needs of the region and the need to protect salmon fisheries.

For more information on USGS natural resources activities, visit www.usgs.gov/themes/themes.html on the World Wide Web.

Pesticides in Public Supply Wells of Washington State

The USGS, together with the Washington State Department of Health (WDOH), saved the taxpayers of Washington $6 million per year by completing a study of the pesticide levels found in Washington's public supply wells.

The Safe Drinking Water Act requires quarterly pesticide monitoring of Washington State's 4,300 Class A (15 or more connections) public water systems. In 1994, the State Legislature passed a bill allowing water systems to waive this quarterly inspection if it could be shown that a source well's risk of pesticide contamination was low. Because data on groundwater quality in Washington State were insufficient to assess vulnerability to contamination, the USGS was asked to cooperate with the WDOH in designing and developing a method for assessing the vulnerability of public water systems Statewide to pesticide contamination.

The USGS selected 1,326 Class A public supply wells for sampling using geographic information systems software. Three contract laboratories collected and analyzed samples from across the State, and the USGS National Water Quality Laboratory analyzed 220 duplicate samples from two areas to provide comparisons with USGS low-level detection procedures.

The study found that all pesticides detected were at low levels, less than 10 percent of the levels that constitute safe drinking-water standards. Factors found to correlate with pesticide detection were land use, well depth, and nitrate concentration.

Seventy-four percent of wells were designated low risk and were granted a full waiver from quarterly sampling. An additional 20 percent were granted partial wavers. The cost of sampling public supply wells was thus reduced at 94 percent of all sites, and the citizens of Washington State recognized a savings of about $6 million annually without sacrificing protection of their water supplies.

Dennis Helsel *is the chief of the Nutrient National Synthesis for the National Water Quality Assessment Program.*

Alex K. (Sandy) Williamson *is the project chief of the Central Columbia National Water Quality Assessment Program study and has worked on Gulf Coast and Central Valley RASA Studies.*

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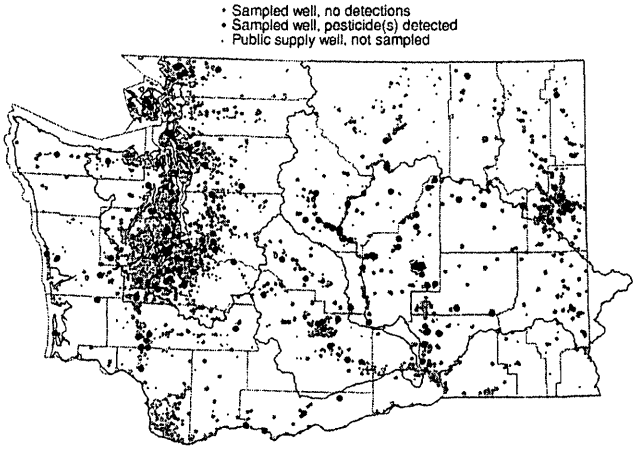

Map showing hits and nonhits across Washington State. Grey circles represent sampled wells with no detections; large solid circles represent sampled wells where pesticide(s) were detected; small solid circles indicate public supply wells that were not sampled.

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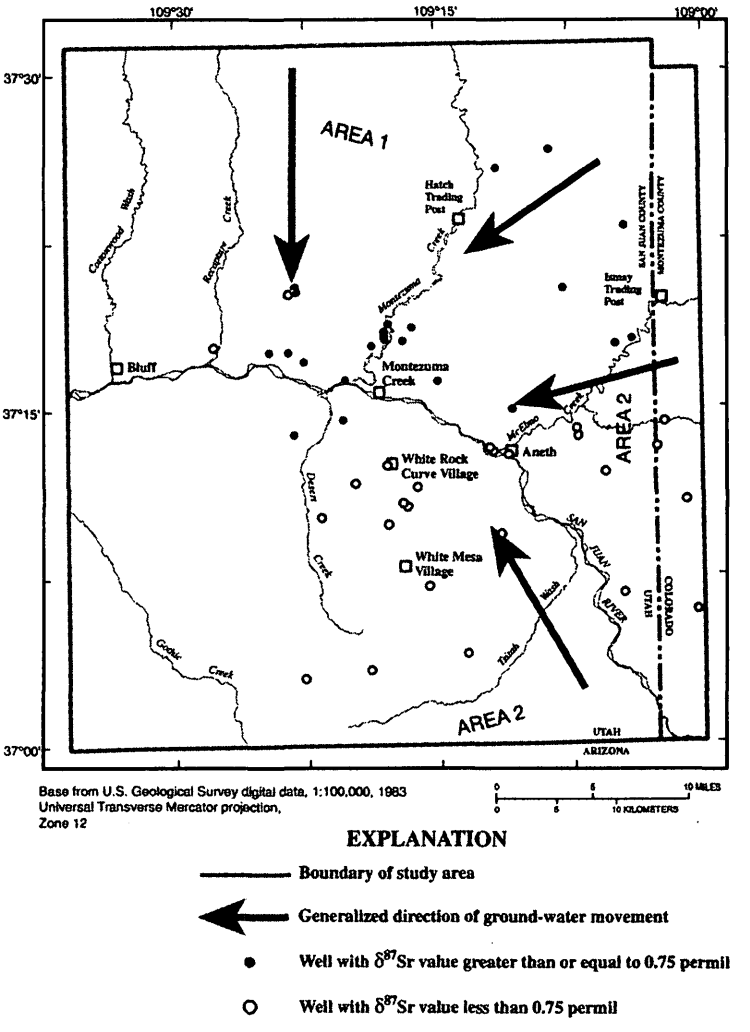
Ground-Water Resources and Sources of Salinity in the Aneth Area, Southeastern Utah

A project using geohydrologic data in combination with geochemical fingerprinting techniques was conducted by the USGS to investigate the source(s) of and process(es) that have caused the observed salinity increases in the freshwater Navajo aquifer in the vicinity of the Greater Aneth Oil Field in southeastern Utah.

Results from previous studies and the proximity of oil-field operations in the Aneth area strongly suggested that oil-field brines (saline water reinjected into the subsurface to enhance the recovery of oil) were causing salinity increases in the Navajo aquifer. Geochemical results from this study conclusively proved that oil-field brines and associated injection processes were not sources of the salinity increases. Instead, the study results pointed to another salinity source (water from the upper Paleozoic aquifer) that is not associated with oil-field brines. If the study had not been done, considerable time and money would have been wasted trying to remediate a salinity source (oil-field brines) that was clearly not the problem. Future study and remediation efforts will be able to focus on the correct salinity source.

Regulatory agencies will be examining records of abandoned oil wells in the Aneth area to determine the number and locations of improperly abandoned wells that might be providing a vertical conduit for movement of saline water from the upper Paleozoic aquifer through a 1000-foot confining layer into the Navajo aquifer. A follow-on study that will use geochemical fingerprinting techniques to quantify salinity contributions from the Greater Aneth Oil Field to the San Juan River is currently in the developmental stage.

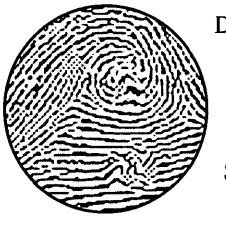


David Naftz is a geochemist with the Utah District in Salt Lake City who has worked on a variety of environmental geochemistry projects since joining the USGS in 1984.

The Aneth project was directed by the Aneth Technical Committee, a liaison group comprised of Federal, State, and Tribal agencies and private oil companies. Represented on the Committee are:

- U.S. Geological Survey
- Bureau of Reclamation
- Bureau of Land Management
- U.S. Environmental Protection Agency
- Bureau of Indian Affairs
- Texaco Exploration and Production, Inc.
- Mobil Exploration and Producing U.S., Inc.
- Phillips Petroleum, Inc.
- Utah Division of Oil, Gas, and Mining
- Navajo Environmental Protection Agency
- Navajo Water Resources Management

For more information, contact:



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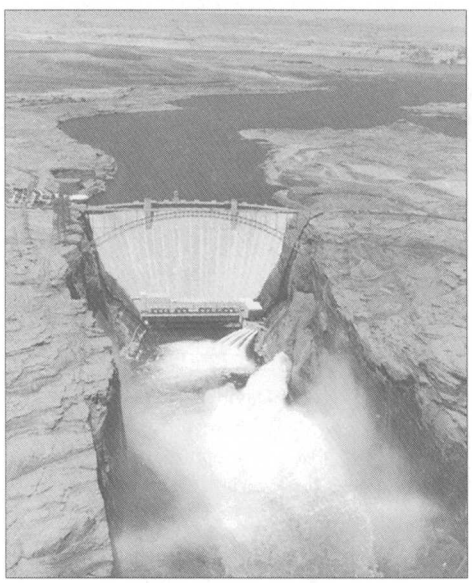
Glen Canyon Environmental Study: Resources and Multiple-Use Aspects

The Grand Canyon is the centerpiece of one of the most visited national parks in the world. Carved by the Colorado River as the Colorado Plateau rose 4 to 6 million year ago, the Grand Canyon exposes rock formations that span a large fraction of the Earth's history. The river itself was a sediment-laden, steep-gradient stream with great erosive power, especially in the spring when annual floods were caused by melting snow in the headwaters. The largest flood in the USGS gage record is 127,000 cubic feet per second, but inference from high-water marks suggests that the largest floods approached 400,000 cubic feet per second. The average annual high flow for the period during which the USGS has been keeping records on the free-flowing river (1922-57) is about 80,000 cubic feet per second.

These high flows transported large amounts of sand, silt, and clay through the canyon. During the period 1925 to 1957, nearly 100 million tons of sediment were carried through the Grand Canyon by the Colorado River every year. In most places where a tributary enters the main Colorado River, the flow of the Colorado is constricted in such a way that large eddies are formed on the downstream side. These eddies trap sediment that would otherwise be transported to the sea. Bar-building processes operated at high water each year. When the water level dropped, these bars were exposed, producing the camping beaches that are so popular with river runners.

The conditions for supporting life that resulted from this array of physical characteristics were extraordinary. Not many plants could live in the river because it was so often too turbid for light to penetrate. At low light intensity, photosynthesis and plant life were limited. Without plants, grazing animals were few, probably existing only in the tributaries. The combination of high-velocity reaches, turbid water, and limited food supply led to the evolution of a unique group of fishes that existed nowhere else in the world.



High-flow release from Glen Canyon Dam in 1984.

The Colorado was the river that John Wesley Powell first traveled in 1869. Powell's 1878 "Lands of the Arid Regions of the United States" provided early wisdom about developing water resources to support irrigated agriculture in the West. Irrigation was developing rapidly in the late 18th century, especially in the Imperial Valley of California, where rainfall is less than 8 inches per year. However, because the valley is below sea level, it was relatively simple to deliver water from the Colorado to the Imperial Valley once the water was diverted into appropriate canals. In 1902, the river broke through these diversion works, causing extensive flooding for several years and forming the Salton Sea. The need for a major dam to control flooding was recognized, but the project was too expensive for local resources to finance.

After construction of Hoover Dam in 1935 and Glen Canyon Dam in 1963, the Colorado River's annual floods were controlled and the size of peak flows was significantly reduced.

A river that flooded annually was now controlled so that annual peak flows were much smaller. Sediment that was transported to and through the canyon was trapped in the upper reaches of Lake Powell. Water that was warm in summer was now cold all year long because it came through the dam from deep in Lake Powell. The dam, which was being used for hydropower production, altered the flow of the river on a daily schedule. In the absence of a sediment load to rebuild what was being eroded, sand deposits in the canyon were being lost, especially in the upper reaches of Marble Canyon.

Five of eight endemic species of fish disappeared from the canyon because the water was too cold. Also, introduced and invading species altered many competitive interactions among fishes, perhaps to the detriment of species native to the river in its original state.

Because recent increased awareness of the human influence on natural ecosystems (especially in the national park) has raised objections to the effects of the dam and its operation, the Bureau of Reclamation has begun studying these effects. The USGS participated in this work as

an agency partner.

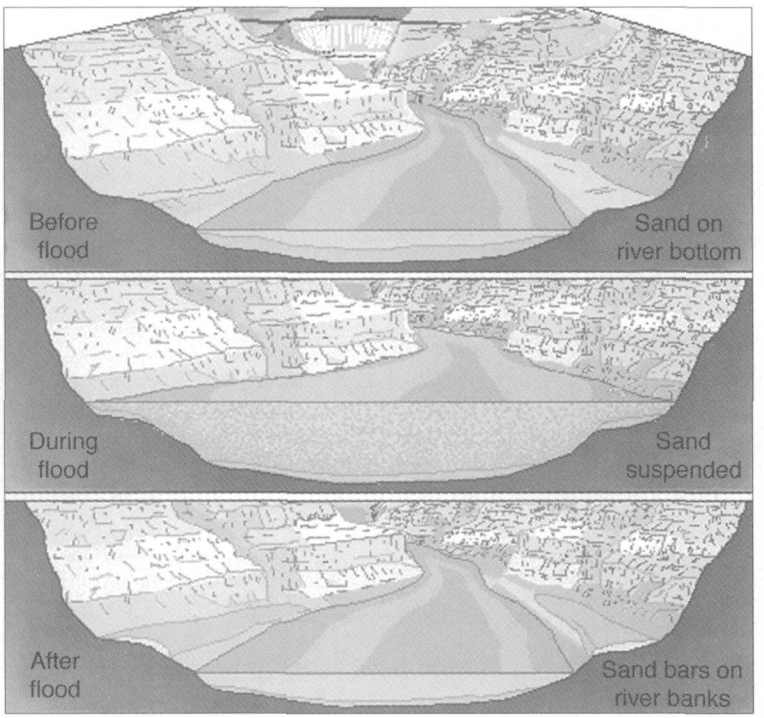
The Grand Canyon Protection Act passed by Congress in 1992 provides for use of Glen Canyon Dam to manage resources in the river corridor of the national park. The environmental impact statement that was required by the Act suggests several alternative ways of operating the dam. All of the alternatives that are being seriously considered for implementation call for periodic flood flows to restore sandbars to their pre-dam state.

The recommendation for periodic flooding is based on the conviction that the absence of floods (or steady flows) is a greater disturbance to this flood-adapted ecosystem than periodic floods themselves would be. Floods will redistribute sand-bar deposits, reestablish backwaters and riparian vegetation conditions, provide a greater competitive advantage to native fishes, and begin to meet the restoration and management goals of the Bureau of Reclamation, the National Park Service, and others.

Achieving both precision environmental management of national park resources and greater latitude for power production are the dual objectives of science-based adaptive management. In this way, minimizing lost power revenues will offset the cost of the research that supports restoration of the river according to national park objectives.

As the management of the dam and the river through the national park enters this new phase, the USGS has been given the responsibility for long-term monitoring of Lake Powell and the river resources in the Grand Canyon. The USGS will also administer the research program in support of continued management.

The National Park Service has the major responsibility for setting management goals in the Grand Canyon. The Bureau of Reclamation has primary responsibility for operating the dam. Additionally, the Native American tribes, which have reserved water rights, environmental groups, and trout anglers have their own distinctive points of view. Other constituent groups that have opinions include irrigators and municipal water users in the upper basin States of Colorado, Utah, Wyoming, and New Mexico and in the lower basin states of Arizona, Nevada, and California and the private and public utilities that purchase power from Glen Canyon Dam.



Sand on the river bed will be suspended by the controlled flood and deposited in sand bars along the banks.

G. Richard Marzolf *is a limnologist working on the Colorado River and Lake Powell. He is the coordinator of the USGS's National Research Program in the Grand Canyon.*

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National Assessment of U.S. Oil and Gas Resources

The USGS works with many Federal and State agencies and industry sources to gather relevant information. The USGS relies specifically on the Energy Information Administration for estimates of proved reserves and some of the cost factors used in economic analysis. The USGS and the MMS cooperate in those areas of responsibility that are geographically close, particularly subjoining State and Federal water areas. In particular areas, the Bureau of Land Management also contributes data.

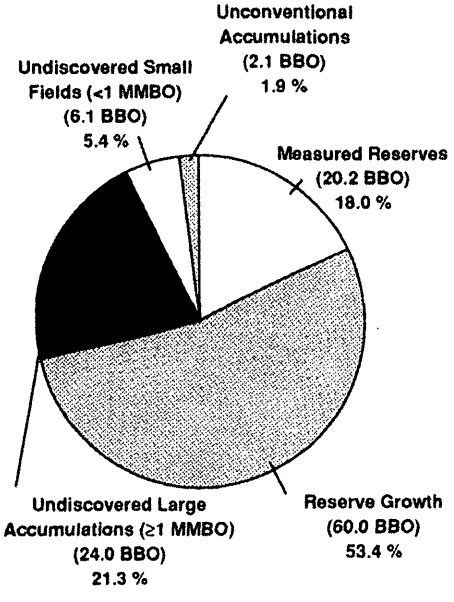
Since 1970, U.S. crude oil production has declined from approximately 9.6 million barrels per day to 6.9 million barrels. Today, over 50 percent of the Nation's crude oil needs are met by imports. Proved (measured) reserves of oil in the United States have also shown a long decline from over 39 billion barrels in 1970 to about 22 billion barrels at present. Domestic natural gas resources appear relatively abundant but are of uncertain quantity, partially because of economics.

Knowledge of remaining U.S. oil and gas resources is essential for carrying out strategic planning, formulating economic and energy policies, evaluating lands in the purview of the Federal Government, and developing sound land use and environmental policies.

The USGS maintains primary responsibility for assessing all onshore lands (including Federal, State, private, and Indian trust lands) and all State offshore waters; the Minerals Management Service (MMS) maintains primary responsibility for Federal offshore waters.

In 1995, the USGS completed an appraisal of the quantity of oil and gas yet to be discovered and recovered and of the future growth of reserves in existing fields of the continental United States and adjoining State waters.

The assessment considers three broad categories of resources (each requiring different techniques for evaluation): undiscovered conventional accumulations of oil and gas; future additions to reserves of known fields (reserve growth or field growth); and oil and gas in continuous-type accumulations (largely equivalent to the "unconventional" categories of other analysts). Resource estimates were based on a thorough geological and statistical analysis of available data and information; all resources were assessed on the basis of what was technically recoverable.



Technically recoverable oil resources of the United States, exclusive of Federal offshore. BBO, billions barrels of oil; MMBO, million barrels of oil.

The basic unit of the assessment is the play, a set of discovered or undiscovered oil and gas accumulations or prospects that exhibit similar geological characteristics (such as trapping style, type of reservoir, nature of the seal, or source rocks) that are responsible for hydrocarbon accumulations. It is a model for oil and gas occurrence.

About 700 plays are grouped into 72 provinces, which in turn are grouped into 8 regions. Each play is described in narrative form in detail sufficient to allow a complete and consistent analysis and to allow comparison among plays and provinces. Statistics of oil and gas exploration and development for each play are tied to geological expertise and interpretation.

The assessment of undiscovered conventional resources includes a sophisticated analysis that yields field-size distributions in addition to overall resource estimates, leading readily to economic analysis. The USGS assessment documented a general decline in the size of the fields being discovered through time, as other studies have suggested, and considered this issue significant in the economics of exploration and the availability of supply.

In this study, the USGS for the first time undertook a nationwide assessment of what have been termed "unconventional" resources of oil and gas. These resources are the continuous-type accumulations of the study and are largely equivalent to the "unconventional" categories of other analysts. They include such things as coalbed methane, gas shales, and many of the western "tight "gas sandstones and are typified by single accumulations of large extent, not separated or bounded by discrete water contacts. In-place resources are commonly very large; technically recoverable resources, although also large, are often shrouded by economic uncertainty.

The USGS attempted, through new assessment models, to estimate the amount of hydro-

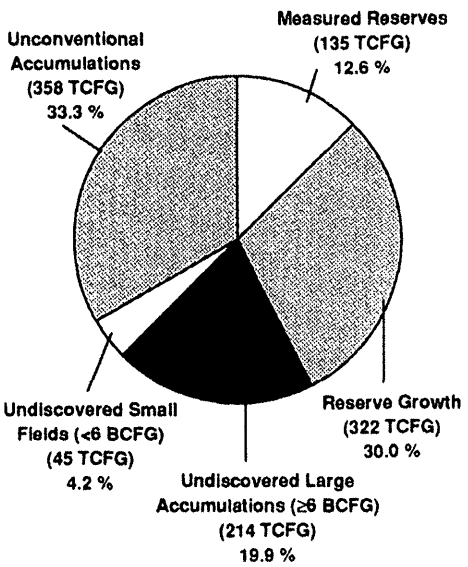
carbons that will be available from unconventional resources over the next few decades. Although a very large in-place gas resource had been identified previously in some of these settings, the USGS now estimates approximately 310 trillion cubic feet of technically recoverable gas in those plays assessed, exclusive of coalbed gas. Of that, it is estimated that approximately 10 percent can be commercially produced at $3 per million cubic feet or less, assuming current technology. Coal-bed gas appears to account for about 50 trillion cubic feet of undiscovered natural gas, technically recoverable, in the plays assessed.

Reserve growth in known fields was treated on a regional scale and found to be a major contributor to future resources. It is estimated that 60 billion barrels of oil will be added to known oil reserves and 322 trillion cubic feet to known gas reserves during the 80 years following 1991.

Additional economic analysis of the results of the national assessment is currently underway and will be reported. A follow-up national assessment of oil and gas resources on Federal lands is also currently underway.

Assessment results are available in a summary report in USGS Circular 1118 and in a full report on CD-ROM in USGS Digital Data Series DDS-30. Economic analyses are available in Open-File Reports 95-75A, 95-75F, and 95-75H.

Digital data CD-ROMs are being prepared for Government, academic, and private sector use and will appear as Digital Data Series DDS-35 and DDS-36.



Technically recoverable gas resources of the United States, exclusive of Federal offshore. TCFG, trillion cubic feet of gas; BCFG, billion cubic feet of gas.

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GIS Database Documenting Two Hundred Years of Human Impacts on the Baltimore-Washington Region

The USGS has developed a mapping project that will put urban development into historical perspective by combining information from a variety of data sources into an integrated, multi-scale, multi-resolution database. These data will provide the baseline information needed to model and predict regional patterns of urbanization. The project uses a geographic information system, remote sensing, and image-processing techniques to capture information from topographic maps and satellite images. The database highlights the profound changes in the landscape of the Baltimore-Washington region that have developed incrementally between 1792 and 1992. Types of data include urban development, principal transportation, hydrography, Census data, and legal/statistical boundaries.

Urban areas have a strong impact on local land use and land cover. Modern urban settlements are characterized by the proliferation of buildings, asphalt, concrete, and suburban gardens along with the displacement of agricultural and forest lands. Land cover changes associated with an urban area can be immense but difficult to grasp when they occur incrementally. The impact that urban land has on economic and environmental systems is quite significant in comparison with its spatial extent. It is imperative to understand the spatial dynamics of urban land use change so that future patterns of land use and land cover can be projected, planned, and managed under sustainable conditions.

Temporal urban mapping is used to reconstruct past landscapes by incorporating historical maps, Census statistics, and commerce records to generate a representation of land cover change in the region. Contemporary mapping focuses on the use of remotely sensed data, existing digital land use data, digital Census information, and a variety of earth science infrastructure data, such as digital line graphs, digital elevation models, and key ancillary demographic information.

Scientific visualization techniques are used to convey the land use changes documented by the temporal database. A time-series computer animation dramatically conveys the changes that have occurred in the Chesapeake Bay region over the last 200 years. Visualization of the database requires single-frame animation techniques. The urban datasets were output sequentially to a computer display to render a two-dimensional view of the study area, the urban boundaries of which move with time. Time-series visualization requires the creation of intermediate datasets to expand the single-frame animation database. Yearly images are derived by the linear interpolation of the reference urban boundary image maps. The final visualization blends the urban boundaries with various image maps as a background.

The Baltimore-Washington regional database provides a strong visual portrayal of recognized growth patterns and conveys strikingly how the progress of modern urbanization results in profound changes to the landscape. The extent of urban development highlights the need to understand the forces influencing the creation of the spatial patterns and corridors that have developed over time. The principal transportation data layer that is part of the datbase clearly demonstrates the influence that roads, railroads, and seaports have exerted on the region's urban development. The hydrography data layers contribute to historical understanding by indicating the loss of navigable rivers through siltation, the development of reservoirs for water supplies, and the changes in the shoreline resulting from harbor development and salt pond formation.

Historical overviews of urban development provide insights into future development and expansion trends. The data are useful to urban

and regional planners, policymakers and decisionmakers, earth scientists, and global change researchers for measuring trends in urban sprawl, monitoring impermeable urban surfaces, analyzing patterns of water pollution and sedimentation, understanding the impacts of development on ecosystems, and developing predictive modeling techniques to better forecast future areas of urban growth. The economic, environmental, and political consequences of informed growth decisions are vital to the millions of people living within and between large metropolitan areas.

The USGS first initiated urban mapping research activities as part of a project contributing to the U.S. Global Change Research Program. The Human-Induced Land Transformations project was undertaken to understand urban transitions from a historical and multi-scale perspective sufficient to model and predict regional patterns of urbanization. This research involved using the USGS's rich 100-year topographic map and 20-year Landsat satellite data archives to delineate urban land transformation parameters. This research also provided the regional geospatial information necessary for making informed decisions on urban growth and sustainable development.

An interdisciplinary team from the USGS and the University of Maryland Baltimore County (funded by NASA's Mission to Planet Earth) have joined forces to develop a temporal database reflecting 200 years of urban development. Other organizations, such as the Smithsonian Institution and the Bureau of Census, have entered into this partnership to enhance the scope of the database.

The project will continue to refine, edit, and verify the database in preparation for publication and release of the data. Additional map products are planned along with Internet access to the data. A follow-on research project will examine the application and correlation of the data to sedimentation and nutrient studies within the Chesapeake Bay ecosystem.

***Susan C. Clark** is a cartographer with 17 years of experience in a variety of production and research mapping activities.*

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Land Cover Mapping of NAWQA Study Units

Multi-Resolution Land Characteristics Consortium Members

National Water Quality Assessment Program (NAWQA) and EROS Data Center—U.S. Geological Survey

Coast Watch Change Analysis Program (C-CAP)—National Oceanic and Atmospheric Administration

Environmental Monitoring and Assessment Program (EMAP)—Environmental Protection Agency

United Nations Environment Programme (UNEP)—GAP Analysis Program

North American Landscape Characterization (NALC)—Landsat

An important element of the National Water Quality Assessment (NAWQA) Program is the development of an environmental framework in which to compare findings on water quality with causative factors, whether natural or manmade. These relationships are being developed within the 60 NAWQA study units and ultimately will be extended nationwide to develop inferences about water quality in areas that have not been sampled. A digital database of nationally consistent natural and human-related factors such as geology, soils, physiography, and land cover is being developed at several scales, including national, study unit, and local. These data will provide a unifying framework for making comparative assessments of water quality.

Current, detailed, and consistent land cover information is a critical data component of the environmental framework that is not available for all of the NAWQA study units. To fulfill this requirement, the NAWQA Program has teamed with the USGS EROS Data Center (EDC) and four other Federal programs to form the Multi-Resolution Land Characteristics Consortium. The primary goals of the Consortium were to acquire current Landsat Thematic Mapper (TM) data for the conterminous United States and to develop a protocol to process these data at the EDC. As a result of this cooperative effort, geometrically corrected and spectrally clustered Landsat TM data are being delivered to the NAWQA study units.

Each TM scene is clustered into 240 unique spectral classes, and each class is subsequently assigned to one of the land cover categories in a nationally consistent land cover classification system. The land cover information produced, in combination with the other natural and human-related land characteristics in the environmental framework, will be used by NAWQA to analyze the effects of land cover and land use on water quality.

In addition to producing regional-scale land cover information, the USGS is demonstrating methods of efficiently building land characteristics information on a very fine scale for specific localized studies. Digital orthophotoquadrangles with 1-meter resolution have been used to develop land use and land cover information in three urban areas (Tacoma, Wash., Sacramento, Calif., and Atlanta, Ga.). For these areas, land cover information is compiled in 5-acre minimum mapping units by using a new classification scheme intended to replace the one used for the nationwide 1:250,000-scale land cover mapping program conducted in the 1970's. NAWQA will use these detailed data to examine relations between land use and occurrence of specific compounds in ground water.

Over the next several years, NAWQA will be working with others at the USGS to complete the interpretation of over 300 TM scenes, providing a regional characterization of land cover information for over one-half of the conterminous United States. Digital orthophotoquads will continue to serve as high-resolution source material for mapping detailed land cover and land use for selected urban areas. All of these interpreted digital data sets will be incorporated into a multi-resolution database of land characteristics and archived at the EDC, where they will be made available to the public.

Susan Benjamin *is a remote sensing scientist specializing in land use and land cover mapping.*

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NAWQA NS — http://wwwrvares.er.usgs.gov/nawqa/natsyn.html
MRLC — http://www.epa.gov/docs/grd/mrlc/index.html
EDC — http://edcwww.cr.usgs.gov/eros-home.html

Mapping Marine Habitats and Mineral Resources

Puerto Rico, like many islands, has a pressing need for local sources of sand and gravel to use as aggregate in the construction industry and for beach replenishment projects. Sources on the island are limited, and the cost of importing this heavy and bulky resource is very high.

Past mining of beach sand has left residential areas exposed to storms and flooding, exacerbated coastal erosion problems, and destroyed coastal habitats. These things are especially important on an island where nearly everyone lives or works near the ocean and many depend on it for their livelihoods. Thus, in recent years, Puerto Rico has turned its attention to the possibility of mining sand and gravel from offshore deposits on the insular shelf.

The Puerto Rico Shelf Mapping Project was initiated several years ago in cooperation with the Commonwealth of Puerto Rico's Department of Environment and Natural Resources to provide reconnaissance-scale (1:40,000) maps of the surficial geology (including aggregate resources and bathymetry) of the entire insular shelf of Puerto Rico. The finished maps identify and characterize sedimentary deposits and further our understanding of the processes responsible for the deposition and redistribution of sediments between the beach and the shelf edge. They are useful in locating offshore sand and gravel deposits, in understanding coastal erosion, and in planning the use and protection of fragile marine environments.

Of the 15 map areas, 6 have been published. In FY 95, the following progress was made on the remaining maps:

- Three maps have been compiled and should be printed in FY 96 (Cabo Rojo, Luquillo, and Grappler Bank areas).

- Cruises were completed to collect seismic-reflection profiles and sediment samples for two maps (Vieques and Culebra areas).

- Laboratory analyses (grain size and percentage of calcium carbonate) were completed for four maps (Humacao, Fajardo, Vieques, and Culebra).

- Interpretation of seismic-reflection data was completed for two maps (Caja de Muertos and Salinas-Jobos).

Mapping off the eastern coast of Puerto Rico has revealed a thin biogenic carbonate sand cover over much of the area, with pockets of thicker sand. Preliminary results suggest that some of these thicker deposits may have economic potential. Sediments are more varied in composition off the southern coast, where terrigenous sediment input from rivers is more significant. Shallow subsurface faulting has been found in the Caja de Muertos area.

In addition to the Shelf Mapping project, three other projects on Puerto Rico's marine and coastal environment were completed:

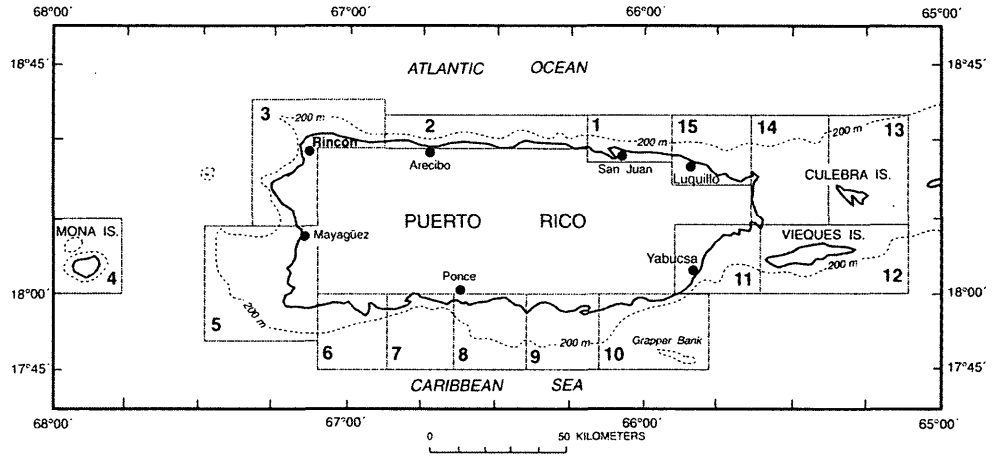
- Results of an investigation to determine the fate of sediment removed by natural processes from the coastal zone in the Luquillo area was published.

- An analysis of beach erosion and the impact of coastal development in the Rincon area was published.

- A series of coastal hazards maps, from San Juan east to Yabucoa, depicting coastal geology and geomorphology, beach and inner shelf characteristics, and hazard potential from flooding, overwash, erosion, earthquakes and landslides were completed and submitted for internal review.

USGS personnel collect, analyze, interpret, and map the sedimentologic and seismic-reflection data and produce a series of maps at 1:40,000 scale. The finished maps identify and

The Puerto Rico Shelf Mapping Project is planned cooperatively with and partially funded by the Commonwealth of Puerto Rico's Department of Environment and Natural Resources.



Locations of the 15 surficial marine geology maps of the Puerto Rico insular shelf:

1. Rio de Bayamon to Rio Grande de Loiza
2. Punta Peñón to Punta Salinas
3. Rio Grande de Añasco to Rio Camuy
4. Isla de Mona
5. Cabo Rojo
6. Parguera to Guánica
7. Guánica to Ponce
8. Caja de Muertos
9. Salinas-Jobos
10. Grappler Bank
11. Humacao
12. Vieques
13. Culebra
14. Fajardo
15. Luquillo

characterize sedimentary deposits and further our understanding of the processes responsible for the deposition and redistribution of sediments between the beach and the shelf edge. These maps also are useful in locating potential marine mineral resources (for example, sand and gravel), in understanding coastal erosion, and in planning the use and protection of fragile marine environments (for example, coral reefs). Data are stored in USGS facilities at Woods Hole, Mass.

In FY 96, nearshore and beach samples from the Culebra, Vieques, and Fajardo areas will be collected and analyzed, thus completing fieldwork for the Shelf Mapping project. By the end of FY 96, four maps should be in press and the remaining four in internal review.

When all data have been collected and analyses completed, work will resume on a digital synthesis of the geology and bathymetry of the entire Puerto Rico shelf, to be published as a CD-ROM.

***William Schwab** is a geophysicist with the Marine and Coastal Surveys Team specializing in sea-floor mapping and sedimentology.*

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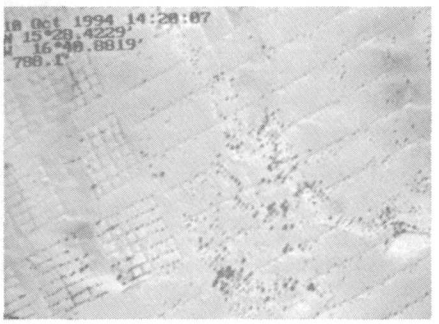
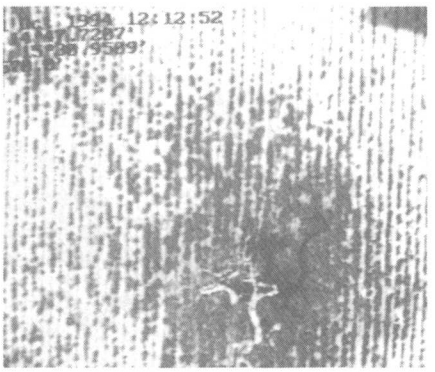
Long-Term Monitoring of Environmental Change in Senegal

In recent decades, there has been considerable evidence of land degradation throughout Africa, driven by the interplay of changing natural processes and unprecedented human pressures. A current USGS study, conducted by the EROS Data Center (EDC) in Sioux Falls, S. Dak., focuses on Senegal in West Africa's Sahel region. Buffeted by drought, economic hardship, and rapid population growth, Senegal's ecosystems are coming under increasing pressure. The USGS, in partnership with the U.S. Agency for International Development (USAID), has responded by developing a long-term monitoring framework for understanding the rapid changes occurring in Senegal's environment. The framework will be applicable to the Sahel and to other parts of the world as well, including the United States. The monitoring approach integrates the combined strengths of data collection at hundreds of field sites (established in an earlier USAID project from 1982 to 1984 and revisited by EDC scientists), aerial videography, and satellite remote sensing. Local socioeconomic studies and interviews with rural people add an extra dimension, a critical element in better explaining the human dimensions of change.

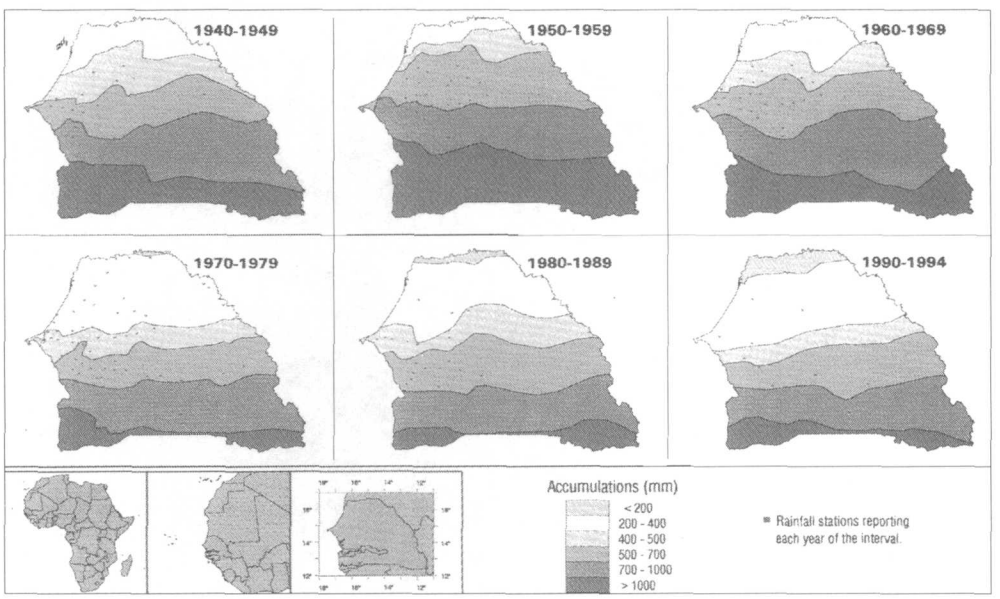
Many natural resource changes have occurred in Senegal since the collection of the original baseline data. The most striking of these changes, observed during the two major field campaigns conducted in FY 95, are (1) reduction and impoverishment of Senegal's southern woodlands, a result of local production of charcoal; (2) land degradation on upland plateaus related to overgrazing and subsequent soil erosion; (3) significant levels of tree mortality brought on by long-term drought; and (4) the expansion of areas under cultivation necessitated by increasing rural populations. However, the study also highlighted numerous cases in which local people are successfully conserving and man-



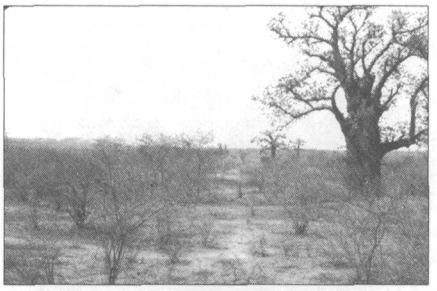
An example frame from an aerial video mission over Senegal, looking vertically from 1000 feet above ground, showing shifting sands from live coastal dunes that constantly threaten adjacent cropland.

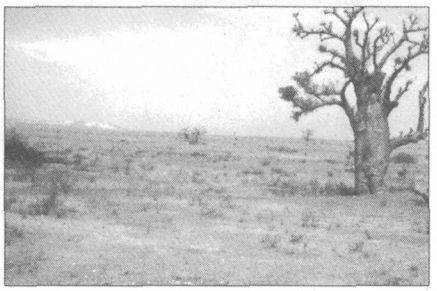


A detailed vertical video image showing the positive effect of an **Acacia albida** tree on the growth of a peanut crop. The tree is a legume used for enriching the soil with nitrogen. Local interventions like this one can be monitored over time with aerial videography.



Historical rainfall in Senegal and Gambia.





Photographic comparison of rapid change at a site west of Thies, Senegal, showing the sever loss of *Acacia seyal* trees and shrubs between 1983 and 1995. The loss of vegetation cover is a result of the site's proximity to an urban center where there is an acute demand for firewood.

aging natural resources, including the protection of trees that enhance soil fertility, reforestation, and the use of live hedges to slow erosion. This information is helping the Government of Senegal to formulate better environmental policies and take a more active role in managing natural resources.

During the past year, particular emphasis was placed on developing an aerial videography system to archive and analyze the wealth of data collected in 1994. The video data will serve as a permanent record of biophysical conditions and land use practices throughout Senegal. Flown repetitively with the aid of Global Positioning System technology, the videography represents the basis for future aerial missions to monitor environmental change at a large scale. A videotape recorder/PC system for rapid browse, retrieval, frame grabbing, analysis, and image processing has been developed and is a part of the program's technology transfer efforts to counterpart scientists at Senegals' Center for Ecological Monitoring.

Gray Tappan *is a physical geographer at the EROS Data Center who has worked in numerous African countries since 1982 and currently leads the effort to monitor long-term natural resource changes in Senegal.*

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INFORMATION MANAGEMENT

The Nation relies on the USGS for timely earth science information related to earthquakes, volcanic eruptions, floods, natural resources, and the environment. Information management is both a strategy driven by customer needs and an infrastructure shaped by technology for handling and distributing these data and information. USGS information management activities include collecting and cataloging quality-assured data in standard formats and archiving, maintaining, and disseminating an array of earth science data and information products. The main goal is to provide the broadest possible access to information in formats that suit customer needs. The USGS makes extensive use of the Internet and the World Wide Web to provide broad and immediate access to its information. Internet technology enables real-time data dissemination during an event such as a major flood and allows access to thousands of pages of earth science data with just a few keystrokes. The USGS is also developing a growing reference library of earth science CD-ROMs. Other information management activities include the long-term stewardship of large databases and leadership in the development of data standards and partnerships for data exchange. The articles in this section highlight USGS information technology, dissemination, data sharing, archiving, and coordination activities.

For more information on USGS information management activities, visit www.usgs.gov/themes/themes.html on the World Wide Web.

Alaska Geographic Data Committee

The Alaska Geographic Data Committee (AGDC) was organized in 1993 and held its first official meeting in conjunction with the annual Alaska Surveying and Mapping Conference on February 9, 1994. The AGDC was formally recognized as a cooperating group of the Federal Geographic Data Committee (FGDC) on January 23, 1996.

The AGDC provides a forum for coordinating spatial data development projects, developing coordinated methodologies for implementing standards and policies, and reviewing and responding to FGDC initiatives in Alaska.

The AGDC provides Statewide leadership in surveying, mapping, and related spatial data coordination. Member agencies provide leadership in coordinating this effort, including the facilitation of information exchange and data transfer and the coordination of spatial data collection to minimize duplication of effort where practical and economical.

The AGDC pursues its objective of building geographic information partnerships among government institutions through communication, investigation, and coordination. The AGDC recognizes that the development of Alaska's geographic data resources depends on all parties working together: Federal, State, and local governments, the Native Alaskan community, academia, and the private sector. The AGDC works with the non-Federal community through organizations such as the Alaska ARC/INFO User Group and the Alaska Survey and Mapping Conference.

Several subcommittees of the AGDC also have been established, including the Land Cover Subcommittee, the Hydrography Subcommittee, the Government-Owned/Contractor-Operated Subcommittee, and the Geographic Names Subcommittee. A Clearinghouse Subcommittee is developing an Alaska Geospatial Clearinghouse Home Page on the World Wide Web. The USGS office in Anchorage serves as chair and provides staff support for the activities of the AGDC.

Nineteen Federal Agencies and 5 Departments within the State of Alaska are active members of the AGDC. Several major mapping projects and initiatives are currently in progress. The Bureau of Land Management, the National Park Service, and the U. S. Fish and Wildlife Service all require updated hydrography in digital format at 1:63,360 scale over user-specified lands in Alaska. An innovative partnership—the Revised Hydrography Project—calls for the USGS to furnish film overlays of hydrography to the BLM, which oversees the revision of hydrography by using existing Alaska High-Altitude Aerial Photography or other data sources as deemed appropriate. The USGS then prepares revised files for digital production and quality control, provides Government-furnished materials to the contractor, and manages the digital contract. All four agencies share the cost of digitally producing the revised hydrography in digital line graph (DLG) format. A DLG is a digital representation of cartographic information. All DLG data distributed by the USGS are DLG-Level 3 (DLG-3), which means the data contain a full range of attribute codes, have full topological structuring, and have passed certain quality control checks. This workshare/costshare cooperative program is accelerating USGS production of revised national digital map products to populate the GIS databases of partner agencies and has resulted in the accelerated population of the National Digital Cartographic Data Base. Additional innovative, cooperative initiatives carried out under the auspices of the AGDC include the State of Alaska Census/Transportation Project and the Alaska Geospatial Data Program.

During the spring of 1995, the AGDC responded to the Department of the Interior (DOI) High-Priority Lands Initiative for FY 96. The AGDC membership, which includes non-DOI Federal agencies and the State of Alaska, submitted a proposal to the DOI Geographic Data Committee (IGDC) to complete revised digital hydrography and digital elevation model (DEM) projects throughout Alaska. A DEM is a sampled array of regularly spaced elevation values registered to a base map. The IGDC Digital Base Data Program team performed a cost-benefit

Visit the Alaska Geospatial Data Clearinghouse Home Page on the World Wide Web at:
http://www-eros-afo.wr.usgs.gov/agdc/

analysis for each project area proposed for digital data acquisition and developed a matrix to determine the maximum benefit for each requesting agency or agencies. Project areas that rated a benefit factor of 2.00 or higher were considered for funding. Due in part to the AGDC's unified response, the revised digital hydrography and DEM projects received a benefit factor of 7.00—the highest benefit factor for any proposed project work submitted for consideration for FY 96.

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Office of Environmental Policy and Compliance, Alaska

U.S. Department of Agriculture:
U.S. Forest Service:
Alaska Region Pacific, Northwest Research Station
National Resource Conservation Service, Alaska State Office

U.S. Department of Commerce:
National Oceanic and Atmospheric Administration,
Alaska Region
National Weather Service, Alaska Region

U.S. Department of Transportation:
Federal Aviation Administration
Federal Highway Administration
U.S. Coast Guard

U.S. Department of Defense:
U.S. Army Corps of Engineers, Alaska District
U.S. Air Force

U.S. Environmental Protection Agency,
Alaska Operations Office

State of Alaska:
Department of Community and Regional Affairs
Department of Fish and Game
Department of Labor
Department of Natural Resources
Department of Transportation and Public Utilities

Declassified Intelligence Satellite Photographs: A USGS-DOD Partnership

The U.S. intelligence community began gathering photographs of the Earth's surface from space in the early 1960's. Although these images were initially used to help set foreign policy during the Cold War era, they are valuable now as an historical record of the state of the environment.

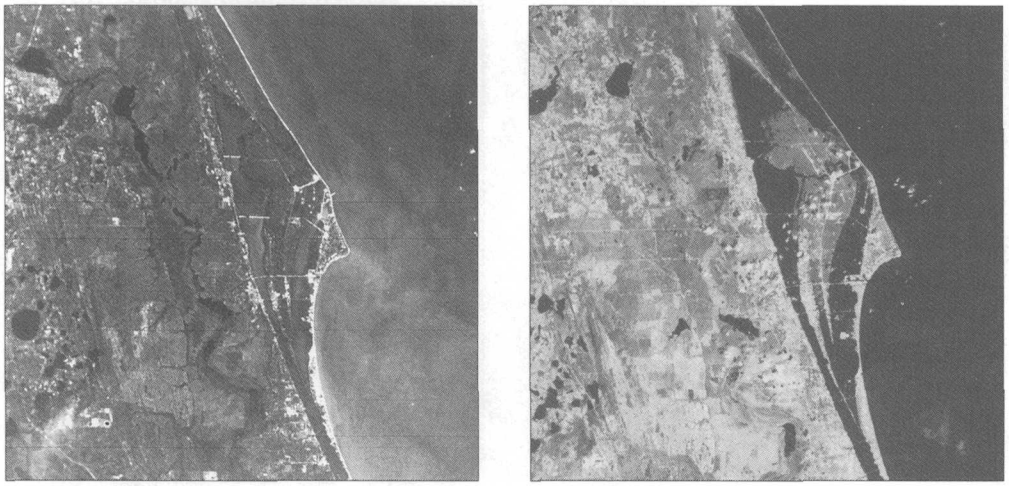
On February 23, 1996, President Clinton signed an Executive Order authorizing the declassification and release of these photographs. The availability of these images from space pushes back by 10 years the window for global environmental monitoring.

The declassification order specified that the USGS and the National Archives and Records Administration (NARA) would share the responsibility for making the space photographs available to the public. A working copy of the film was given to the USGS's Earth Resources Observation System (EROS) Data Center (EDC) in Sioux Falls, S. Dak., to be added to the National Land Remote Sensing Data Archive.

Because the USGS has a 26-year history of archiving and distributing both aerial and space imagery to the public at the cost of reproduction and delivery, it was able to incorporate this collection of over 800,000 photographs into its superb archive facility at the EDC, making use of both existing production systems for online Internet customer query and browse of the images and its photographic laboratory to create products for customers.

Researchers now have effective and timely access to photographs that enable them to monitor global environmental conditions and international land surface conditions further back in the past than ever before. Ground resolutions allow

The declassification and release of intelligence satellite photographs was a joint effort of several intelligence agencies, the Department of the Interior, and private contractors. Primary particpants were the Central Intelligence Agency in Washington, D.C., USGS Headquarters in Reston, Va., the USGS EROS Data Center in Sioux Falls, S. Dak., the Mitre Corporation, Eastman Kodak, and the Hughes Information Technology Corporation.



Two images of Cape Canaveral, Fla. Declassified image: KH-5, B&W, 460' ground resolution, April 1963. Current USGS image: Landsat satellite, color IR, 240' ground resolution, March 1992.

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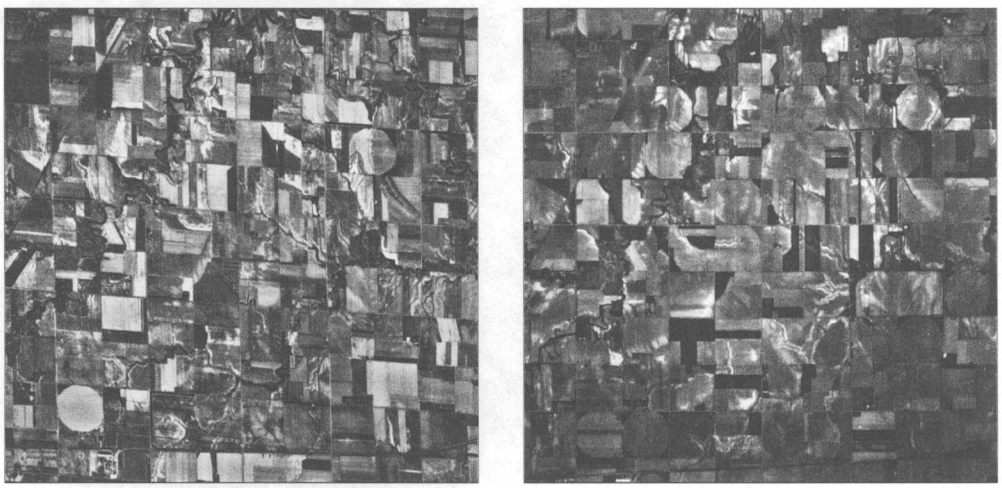
researchers and public consumers to see the Earth's land cover at a high level of detail during critical environmental and political periods in history.

Archiving and distributing these declassified intelligence satellite photographs to the public require making the online catalog and online browse for each photograph available over the Internet through the USGS' Global Land Information System (GLIS). Customers can conduct their own queries, make purchase decisions, and initiate a product order by using GLIS. This approach to self-service inquiry and ordering gives customers maximum control over product selection and involves USGS staff only when an order has been received, payment steps initiated, and production begun. USGS staff are available to assist those customers who do not have Internet access to GLIS and the services it offers.

The initial shipment of declassified film was received by the USGS on January 31, 1996. The final shipment of photographs was delivered to the USGS on May 22, 1996. The USGS is charged with processing and checking film into the National Land Remote Sensing Data Archive and completing the project by September 1996. Discussions are already underway with the intelligence community regarding other image data scheduled for declassification that should be added to the USGS public-access archives.

Donna K. Scholz *is responsible for the development and management of online customer query and order systems, product management, and distribution of*



Two images of central Nebraska. Declassified image: KH-4B, B&W, 6' ground resolution, 1962. Current USGS image: NAPP, B&W, 3' resolution, 1993.

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Digital Geospatial Data Framework

National geospatial data are becoming increasingly important in assisting resource managers and earth scientists in making informed decisions about land and resource development, natural disaster mitigation, pollution abatement, transportation planning, urban development, and recreational use.

In support of the National Information Infrastructure, in April 1994 President Clinton issued Executive Order 12906, "Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure (NSDI)." The NSDI encompasses the technologies, policies, standards, and human resources necessary to acquire, process, store, distribute, and improve the use and sharing of geospatial data throughout all levels of government, academia, and the private sector. One objective of the Executive Order is the development and implementation of a national digital geospatial data framework (Framework).

National geospatial framework data are the commonly recurring data elements applicable to most geographic information system (GIS) analyses and deemed most significant to the broadest user community. Specifically, these data pertain to elevation, hydrography, transportation, political and administrative boundary, cadastral, and orthoimagery themes.

For many parts of the Nation, geospatial data either are not available or are not useful to a broad spectrum of users because of differing standards, formats, and licensing restrictions or because of a lack of coordination.

The purpose of the framework concept is to organize the collection and maintenance of basic, consistent digital geospatial data that can be shared and to provide a base on which an organization can accurately register and compile other types of data. Shared collection and maintenance will reduce expenditures for data collection and integration, allow organizations to focus on their primary business, expand the user base for data being collected, and increase data availability over broader geographic areas.

The USGS has unique leadership qualifications and a core capability for the acquisition and integration of geospatial data. The USGS can serve as a catalyst to (1) help define, develop, and promote geospatial data standards and coordinate their use and (2) establish cooperative partnerships with other Federal, State, local, and private sector organizations to establish common approaches to data sharing, data acquisition, and data integration as well as enable the technologies to support the implementation and maintenance of Framework.

The USGS will serve as the theme manager for elevation and orthoimagery data themes and may also serve as a data producer and (or) data distributor. The USGS also will support the implementation and production of other Framework data themes through the establishment of data partnerships. The USGS thus will serve as an "area integrator" for Federal data requirements and will assist programs in making the tranisiton from primary data production to data production of last resort.

The USGS will integrate existing data from other Federal, State, local, and private sector organizations to meet customer requirements for nationally consistent data. Where data do not exist, the USGS will pursue partnerships with other organizations to acquire new data.

The USGS will continue research and systems development activities to improve its data sharing, data integration, and data dissemination operations. These activities will be augmented through the use of cooperative research and development agreements with academia and private industry.

Framework development and implementation are being managed by a consortium of representatives from Federal, State, and local governments, academia, and the private sector under the auspices of the Federal Geographic Data

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Committee (FGDC). The USGS is coordinating closely with the FGDC to ensure that national mapping data programs are consistent with FGDC-endorsed Framework guidelines.

The USGS is currently participating in cooperative agreements with the Environmental Protection Agency, the Bureau of the Census, and the Bureau of Land Management to establish common geospatial data for transportation, hydrography, boundary, and cadastral themes. Through these agreements, the USGS and their partners are pursuing other data partnerships at the State, local, and private levels to collaboratively develop geospatial data adhering to Framework guidelines. The primary goal is to respond to Executive Order 12906 establishing initial "framework" data for the transportation, hydrography, and boundary themes by January 1998.

The USGS will continue to take an active leadership role in advancing the goals of the NSDI, including support for the development and implementation of Framework. To facilitate these activities, the USGS will pursue cooperative agreements with other Federal, State, local, and private sector organizations to collaboratively develop common technological approaches and data standards that will permit more efficient data sharing, data acquisition, data maintenance, and data dissemination capabilities.

Mark Naftzger *is a cartographer with the National Mapping Division and is a staff advisor for USGS digital mapping programs.*

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Keven Roth (U.S. Geological Survey)
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Mike Domaratz (U.S. Geological Survey)

Base Mapping Working Group—Coordinating Digital Geospatial Base Data Among DOI Bureaus

Almost every Department of the Interior (DOI) bureau conducts geographic analyses in support of departmental policy initiatives. Sixty to 80 percent of the cost of these analyses are associated with data collection and management. DOI bureaus are compiling data to fit the needs of their individual analyses, such as habitat type, species diversity and counts, pollution point sources, water flow rates, emergency preparedness, and many others.

The Interior Geographic Data Committee (IGDC) established the Base Mapping Working Group in FY 93 to coordinate the identification and collection of high-priority digital geospatial base data requirements among DOI bureaus through the High-Priority Digital Base Data Program. The primary objective of the working group is to minimize redundancy in the collection and maintenance of digital geospatial base data; expedite the availability of nationally complete, accurate, and current data; and promote user awareness of data availability. The working group also serves as a forum for sharing information on data standards and new product development.

High-priority digital base data requirements for digital elevation, orthoimagery, raster graphic, and vector data are identified through an annual solicitation of more than 140 regional bureau offices in the January through March time frame. The Base Mapping Working Group then meets in May to analyze the results of the requirements solicitation and to identify high-priority areas for data collection through a three-step selection process: (1) only areas of overlapping multi-bureau requests are considered, (2) Department and bureau program priorities determine which areas are selected, and (3) selected areas are prioritized on the basis of the number of bureaus requesting the data. By the end of June, high-priority project areas are defined, and materials are being gathered in preparation for contracting by the beginning of the new fiscal year on October 1.

In FY 95, high-priority geospatial base data requirements were addressed in the following areas: the Pacific Northwest, the U.S./Mexico border, the Black Hills, Glen Canyon/Grand Canyon National Park sites, the Illinois River, the lower Colorado and Gila Rivers, Petrified Forest National Park, Federal lands in western Nevada, and the upper Mississippi River Valley.

The USGS chairs the Base Mapping Working Group and provides funding and staff support for the DOI High-Priority Digital Base Data Program. USGS headquarters staff con-

Digital geospatial base data:

Information about the location and type of base geographic features used as a foundation to support general-purpose applications, including digital elevation, orthoimagery, raster, and vector data.

duct the annual requirements solicitation, record and process solicitation responses, analyze the results, prepare a proposed data-collection plan for consideration by the Base Mapping Working Group, and provide information to the regional bureau offices on the disposition of their requests. USGS regional staff work with coordinating committees and ad hoc regional consortiums to coordinate the identification of data requirements for the annual solicitation.

BASE MAPPING WORKING GROUP
Kathryn Wortman, Chair
Richard Kleckner, Alternate Chair
Deborah Moreland, Executive Secretary
David Saghy, Technical Support

The average number of data requirements being satisfied for each product produced has increased steadily during the first three years of the program.

In some regions, bureau offices coordinate their responses to the requirements solicitation through coordinating committees such as the Alaska Geographic Data Committee, the California Desert Managers Group, and the U.S./Mexico Border Field Coordinating Committee.

Data that are selected for collection in many of the program priority areas reflect geospatial base data requirements of non-DOI Federal agencies and State and local government organizations. Once archived, all data collected under the program are available to any public or private sector organization that uses digital geospatial base data.

Beginning in FY 96, most data selected under the DOI High-Priority Digital Base Data Program are being collected by the private sector.

In FY 96, high-priority geospatial base data requirements will be addressed in the following areas: Alaska, the U.S./Mexico border, the California desert, Hawaii, the Pacific Northwest, the Great Plains Grasslands, the upper Mississippi and Missouri Rivers, and the southern Appalachian Mountains.

***Deborah K. Moreland** is executive secretary of the Interior Geographic Data Committee Base Mapping Working Group, an interagency group that leads a Departmentwide effort to establish priorities for mapping based on multi-bureau needs to ensure the best use of natural resources.*

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Scientific Contributions to the Middle East Peace Initiative

In an effort to achieve a just and lasting peace among Israelis, Palestinians, and Jordanians, U.S.-led bilateral negotiations on Middle East peace were convened in Madrid, Spain, in 1991. The talks, which were cosponsored by Russia, Canada, the European Union, and Japan, played a key role in making possible the historic Declaration of Principles on Interim Self-Government Arrangements signed by representatives of Israel and the Palestine Liberation Organization on the White House lawn in September 1993 and the Peace Treaty signed by Israeli and Jordanian representatives in October 1994 in Eilat on the Jordan-Israel border.

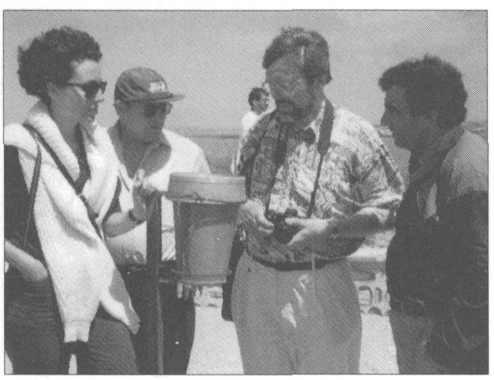
Multilateral working groups were formed in January 1992 to support the Middle East Peace Initiative bilateral talks, to build confidence among regional parties, and to seek solutions to critical problems directly related to the peace process. The Department of State asked several Federal agencies, including the USGS, to provide technical support and advice to the Multilateral Water Resources Working Group (WRWG). Water-data enhancement, water-supply technology, and water management were selected as topics of vital importance, and the USGS was designated as the lead Federal agency for water-data enhancement.

Since 1992, the USGS has sent one or more technical experts to each of the WRWG meetings as members of the U.S. delegation. In addition, the USGS has been involved in successful efforts to use science as a catalyst to build confidence and friendship among Palestinian, Israeli, and Jordanian scientists and political leaders while advancing awareness of the need for cooperation in the field of water resources. Assisted by other Federal water agencies and the Department of State, the USGS conducted a study tour of the Colorado River Basin to demonstrate to Middle Eastern water managers and officials the benefits to be gained by managing scarce water resources on a regional rather than a national basis. A water-data questionnaire designed by USGS scientists and distributed to all parties in the region advanced USGS understanding of water data in the Middle East while providing another opportunity for cooperation among Middle Eastern water agencies.

On the basis of responses to the questionnaire, USGS scientists and water experts from the European Union and Canada visited Palestinian, Israeli, Jordanian, and Egyptian water agencies to assess the availability and adequacy of water data and to develop recommendations for improving existing water-data collection systems.

Following the mission to the region, the USGS developed and hosted a workshop for regional parties to devise plans for standardizing methods for water-data collection and analysis. This highly successful workshop resulted in a request from the Department of State for the development of a Middle East Water Data Banks Implementation Plan. The plan, which was written by the USGS, received consensus approval from 45 nations and international organizations convened at the sixth meeting of the WRWG in Athens, Greece, in November 1994. Implementation of the plan began in 1995. The USGS is playing a key role as facilitator, advisor, and mentor as well as being an advocate of U.S. interests.

The Implementation Plan is designed to establish standardized water-data collection, storage, and analysis capabilities to a level at which appropriate sharing and exchange of data and information can take place. The plan is comprised of 39 recommendations, plus Work Package A, which is dedicated to the establishment of a Palestinian water-data collection capability. Successful implementation of the plan will allow the exchange of consistent, compatible, and scientifically defensible water data and information to support decisionmaking at both local and regional scales. On behalf of the Department of State, the USGS is leading implementation of the plan. In January 1995, the Executive Action Team (EXACT), composed of two representatives from each Core Party plus representatives from the United States, Canada, France, and the European Union,



Israeli, Palestinian, and Norwegian representatives inspect a rainfall measuring device.

was formed to provide a mechanism by which Core Party water agencies can become active partners in the management and coordination of Water Data Banks Implementation Plan. Two USGS employees are the U.S. representatives, one of whom serves as the gavel holder and the other as the Secretariat.

The EXACT met in May and December 1995 and in May 1996 to plan and coordinate ongoing implementation. U.S. contributions during 1995 include beginning to prepare specifications for mobile laboratories and compiling a bibliography of water-resources publications, a directory of the major water-resources professionals in the region, and a directory of major ongoing water-resources projects.

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USGS scientists are working closely with the Department of State to support the water-resources activities of the Middle East Peace Process. These activities require close interaction with representatives of Israeli, Palestinian, and Jordanian water-resources agencies as well as with donor countries. which include Canada, France, the European Union, Australia, and Norway.

Subsequent activities within this program will include completing the projects started in FY 95 and beginning some of the other 35 recommendations described in the Water Data Banks Implementation Plan. These recommendations are designed to establish or upgrade and strengthen current water-data programs while maintaining data-collection standards that will enable the parties to exchange water data. Implementation of the plan will be shared by donor nations throughout the world through contributions of technical expertise, equipment, and funding.

Anna Lenox, *chief of the International Water Resources Program, coordinates the USGS contributions and is the U.S. representative to the Water Resources Working Group of the Middle East Peace Initiative.*

Information Management through CD-ROM Technology

One of the primary missions of the USGS is collecting, interpreting, disseminating, and archiving earth science data. One of the major databases developed by the USGS consists of approximately 600 tapes of seismic data collected from Cape Hatteras to the Mid-Atlantic Ridge. These data are invaluable to geologic analyses of the evolution of the continental margin and the western North Atlantic.

This archive of 600 tapes presented several problems. First, because of the nature of magnetic storage, the tapes themselves were beginning to deteriorate and lose data. Second, access to this archive was very limited, because the master copy of these tapes resides at the USGS in Denver, Colo. A duplicate set of tapes would cost approximately $80,000.

Over the past year, data managers and scientists at the Denver facility decided to transfer this entire archive of data to CD-ROM media. The transfer was accomplished in a relatively short time by reducing the 600 tapes to a set of 39 CD-Recordable (CD-R) discs, which were then duplicated and made available to seismic researchers around the world. The cost to acquire a copy of this entire database was reduced from $80,000 to $475 due to the extraordinary economies inherent in CD-ROM technology. Also, the CD-ROM version of this archive included visualization software as well as a variety of descriptive image and text files that allow researchers to better understand the data.

This project demonstrated the use of CD-R and CD-ROM technology to not only preserve a priceless archive of earth science data but also to make that same archive affordable and accessible to a much larger audience of researchers. Now, the data will never be lost because hundreds of copies of the entire database now exist. Equally as important, the USGS has made a valuable breakthrough in fulfilling its mission of providing earth science information to the public.

Jerry McFaul, *a computer scientist in the Information Resources Management Group, is an expert on electronic publishing specializing in CD-ROM and CD-Recordable technologies.*

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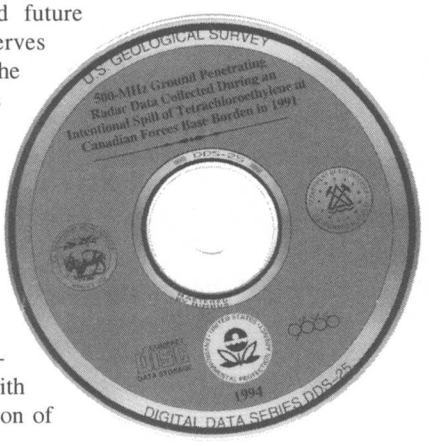
USGS Digital Data Series 30 (DDS-030) summarizes the results of USGS investigations into the oil and gas resources of the onshore and State waters of the United States. A parallel study of the Federal offshore is being conducted by the Minerals Management Service. Assuming existing technology, there are approximately 110 billion barrels of technically recoverable oil onshore and in State waters. The interactive nature of the National Assessment CD-ROM allows the user to browse through the documents and presentations, choosing items of interest in user-selectable order.

The USGS National Assessment is an unbiased and scientifically based estimate of the quantity of oil and gas yet to be discovered and of the past and future growth in hydrocarbon reserves onshore and in State waters. The National Assessment describes the sources of oil and gas, where they are, what technology may be needed to recover them and at what price, and at what rate they can be withdrawn. Knowledge of oil and gas resources is necessary for strategic planning, evaluation of Federal lands, and development of sound economic, energy, and environmental policies.



USGS Digital Data Series 25 (DDS-025) presents detailed environmental data demonstrating the usefulness of ground-penetrating radar in examining the interaction of different subsurface heterogeneous geologic units with dense, non-aqueous-phase liquids. Given the level of detail and the correlation of these data with results from other methods, this data set should be appropriate for the evaluation of multiphase fluid transport models.

Two Million Atlas Data Enhanced

One to two-million-scale (2M) digital cartographic data, first published in 1970 as sectional maps in "The National Atlas of the United States of America" and updated in 1972 and 1973 for distribution as separate sheets, have been improved and enhanced. A project to digitize and update these sectional maps was completed in 1981, providing the first consistent nationwide data set. These digital line graphs (DLGs) were widely used by those needing national digital cartographic coverage and later became available on CD-ROM.

In 1993, largely as a result of the increasing demand for small-scale Federal land information, the USGS undertook an extensive project to update the 2M digital cartographic data. Not only were the cartographic features updated but the data also were expanded to include additional Federal land information and the Public Land Survey System (PLSS). In addition, conformance of the data format with current standards was achieved.

The number of attribute codes for Federal land categories was expanded from 10 to 65. Each parcel is now tagged with the agency responsible for its administration. This Federal land information is used by resource planners in the Federal and State governments and in private organizations.

Because many customers depend on the PLSS system for referencing their projects in the 30 public land States, PLSS data, which were not included in the National Atlas, were added in the new 2M DLGs. Each township (a 6-mile square) is identified by its township and range designation. Land grants are included with the PLSS data.

Another new feature is text files containing information such as place names and population, airport names, land grant names, and State and county Federal Information Processing Standards codes. The records in these text files can be related to corresponding features in the DLGs. Although such information is not included in the 1995 CD-ROM, work is underway to add the proper name to each Federal land parcel and to name all hydrographic features.

The data are organized by State or Territory rather than by large regions, as they were in the previous version. For each State, six or seven categories of DLG data are available. For example, the boundaries category contains States, counties, and Federal lands; the hydrography category shows streams and waterbodies; the roads category includes Interstate, U.S., and primary State highways; the railroads category contains main and branch lines; the miscellaneous transportation category shows airports; the manmade features category contains built-up areas, capitals, county seats, populated places, and population range; and the PLSS category in public land States includes land grants and PLSS townships.

These data are available on CD-ROM in Optional DLG format or in the Spatial Data Transfer Standard (SDTS) format. Each CD-ROM also contains descriptive text files to acquaint users with the data formats and software needed to display and query the data.

To promote the use of the SDTS, the USGS is providing the 2M data in SDTS format to the public at no cost via the Internet. World Wide Web users can retrieve these data at the following Universal Resource Locator (URL): http://sun1.cr.usgs.gov/glis/hyper/guide/2mil/. SDTS transfers can also be retrieved from the Internet by direct file transfer protocol (anonymous FTP) at the following address:

edcftp.cr.usgs.gov
username: anonymous
password: enter your e-mail address

For World Wide Web users the URL is:
ftp://edcftp.cr.usgs.gov/pub/data/DLG/2M/

These files contain data for 49 States and the District of Columbia. Data for the U.S. Virgin Islands, Puerto Rico, and Alaska will be included in the next release, planned for late 1996. The USGS will be a primary user of the 2M data, which are already being used as the geographic reference base in the development of an electronic version of "The National Atlas of the United States of America."

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National Spatial Data Infrastructure: National Geospatial Data Clearinghouse

"Information technologies are changing the way that government and other organizations conduct business. A growing reliance on the use of computers for processing information is dramatically increasing demands for electronic data."

—The U.S. National Spatial Data Infrastructure: Building the Foundation of an Information Based Society

Federal Geographic Data Committee
November 1993

The USGS has established a World Wide Web node of the National Spatial Data Infrastructure (NSDI) Clearinghouse to feature the bureau's full line of earth science data products for users of the Internet.

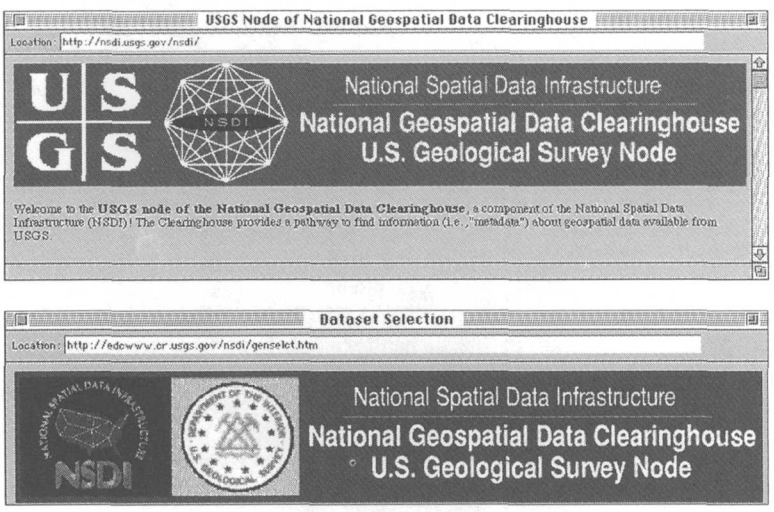
Information about USGS product lines are documented on the USGS NSDI node. Sample products, references to other USGS online documentation and data standards, and links to the online products themselves are also featured.

The USGS's EROS Data Center (EDC) has established an NSDI server on the Internet to provide full interactive product-level query capability using the international ANSI Z39.50 standard to query. Users of this node have been able to search for geospatial data products including Digital Line Graph (DLG) and Digital Elevation Model (DEM) data, satellite images, and photographs of the Earth's surface since May 1995.

As stewards of the Nation's digital cartographic and image data, the USGS must not only conserve and protect those data but must also provide easy, efficient, and low-cost access to information about them. The USGS has interpreted this mandate to include, where possible, online access to the data products themselves. Those geospatial data products/files that are available in the FGDC Spatial Data Transfer Standard (SDTS) are accessible online from the USGS NSDI node at no cost to customers. This approach to Clearinghouse implementation has had little or no impact on USGS resources or staff. Distribution of USGS digital products has increased, and staffing and operational costs have been reduced through automation and self-service access to USGS information and products.

As the USGS completes conversion of its geospatial data from the traditional distribution formats to the FGDC SDTS format, it will be placing its data products on the Internet for direct access from the USGS Clearinghouse node. Currently, data products accessible from USGS servers include 1:24,000-, 1:100,000-, and 1:2,000,000-scale DLG's, 1:250,000-scale DEM's, and 1:100,000- and 1:250,000-scale Land Use and Land Cover. In FY 96, 7.5-minute DEMs will be available on the Internet.

Hedy J. Rossmeissl *is the Senior Program Advisor for Data and Information Delivery and has oversight for USGS maps, digital cartographic and elevation data, and both aerial and satellite imagery.*



Vist the National Spatial Data Infrastructure Clearinghouse on the World Wide Web at: http://nsdi.er.usgs.gov/nsdi/

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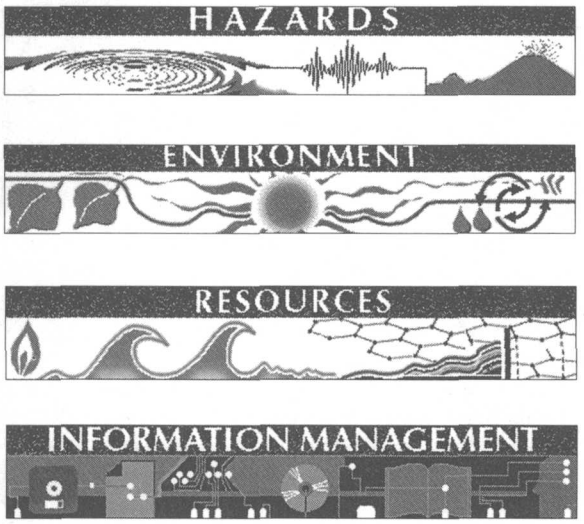
World Wide Web Takes Off

USGS Home Page:
http://www.usgs.gov

USGS By Theme:
http://www.usgs.gov/themes/



USGS information served over the World Wide Web (WWW) increased eightfold over the past year. More than 90,000 people visit USGS WWW sites each month and find a wealth of fact sheets, online reports, and historical and real-time data.

Almost all new USGS fact sheets are available both in print and on the Web. Users can select from a list of fact sheets organized by topic or State. In addition to being in color (most fact sheets are printed in black and white), the WWW versions offer "hyperlinks" to additional online information available from the USGS and other sources. Electronic fact sheets are never out of stock and are available at literally millions of locations worldwide. This service is distributing more than 22,000 fact sheets per month.

The USGS has also placed the complete text of some of its more popular reports on the WWW. For example, U.S. Geological Survey Circular 1123, "Stream-Gaging Program of the U.S. Geological Survey," can be read in its entirety online. The immediate availability of this reference is useful to those viewing online streamflow data and helps to educate the public user about this scientific program. The National Water Quality Assessment (NAWQA) Program also has placed many of its publications online.

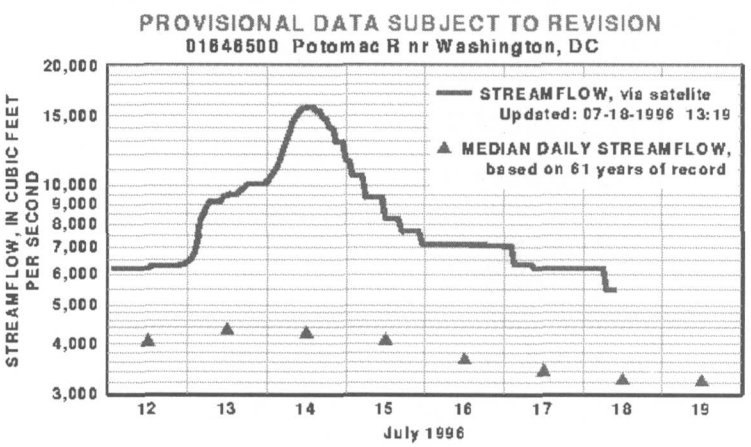
The public has shown considerable interest in online data collected in "real time." Current streamflow at about 1800 stations now can be viewed on the Web. Although originally intended for an audience of scientists and engineers, this service has proved popular with whitewater boaters and fishermen, whose feedback via electronic mail has been enthusiastic.

Real-time streamflow information also becomes critical during times of flooding, when a local office may find hundreds of electronic visitors per week viewing current streamflow data on its WWW site.

The WWW is also one of the most popular ways for the public to see the USGS's vast holding of digital spatial data, including digital line graphs (DLGs), digital elevation models (DEMs), and satellite images. More than 30,000 users visit the National Mapping Information site each month.

The WWW is an excellent way to learn about earth science. The Learning Web offers K-12 students an opportunity to investigate topics about the Earth that affect people every day and everywhere. Visitors can learn about radon gas, where their water comes from, and how to prepare for volcanic eruptions. The Learning Web also provides online materials for teaching about global environmental change and working with maps.

Current Streamflow:
http://h2o.usgs.gov/public/realtime.html



Clearly, the WWW is a valuable tool for bringing earth science information to the public. This information is now served from a network of 112 WWW sites. Responsibility for and control of the information are placed at the lowest possible organizational levels, so that each site can adapt to the local needs of its customers and still retain its USGS identity.

Amost every agency of the Federal Government has its own WWW site. USGS sites are now connected with those of many other scientific agencies to form a vast "virtual library." The USGS plays a major role in Department of the Interior WWW activities. The WWW is only just getting off the ground, and the USGS is gearing up to handle continued growth in WWW traffic. The next stage will involve working toward fully integrating the Web into the publication process. New reports will take advantage of WWW's emerging technology to show three-dimensional views and movies, include full links to their supporting databases, and allow interactive demonstrations.

***Kenneth J. Lanfear** is responsible for ensuring that "cybersurfers" on the Internet can find and retrieve the water-resources information that they need.*

Ordering USGS Products:
http://www-nmd.usgs.gov/esic/to_order.html

USGS Fact Sheets:
http://h2o.usgs.gov/public/wid/indexlist.html

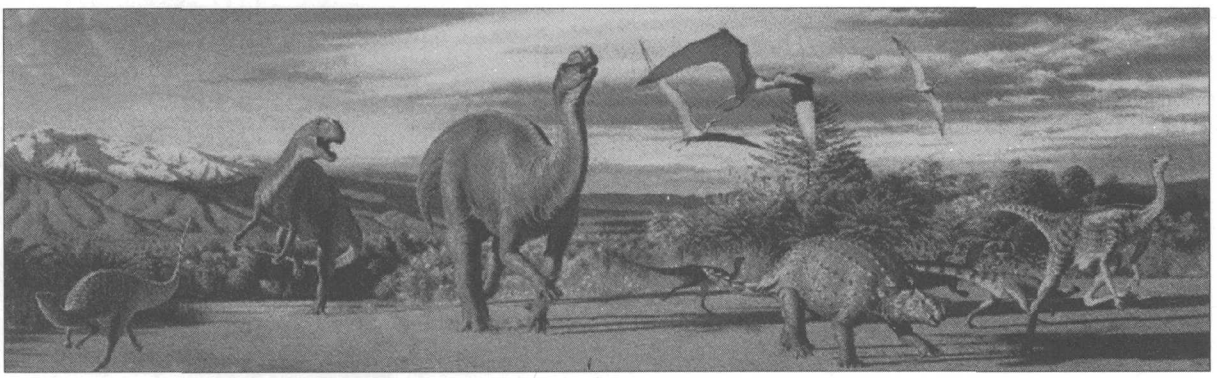
Geologic Information:
http://geology.usgs.gov

Hydrologic Information:
http://h2o.usgs.gov

Minerals Information:
http://minerals.er.usgs.gov/minerals/

National Mapping Information:
http://www-nmd.usgs.gov/

NAWQA Program:
http://wwwrvares.er.usgs.gov/nawqa/nawqa.home.html



This Dynamic Earth: The Story of Plate Tectonics
http://pubs.usgs.gov/publications/text/dynamic.html

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Feedback http://www.usgs.gov/index.html

Learning Web

The Learning Web is the USGS's World Wide Web site dedicated to K-12 education, exploration, and life-long learning.

Teaching in the Learning Web—This collection of K-12 educational activities on Global Change, Working With Maps, and Earth Science includes exciting exercises such as Mud Fossils, Earth as Home, and Exploring Maps. Visit http://www.usgs.gov/education/learnweb/.

Exploring Maps—Interact with activities focusing on Location, Navigation, Information, and Exploration that explore the "tools of the ancients" and how maps can document the changing characteristics of a place. Transform a globe to a flat sheet of paper and follow the paths of great explorers. Discover how plotting data can create a trail of knowledge and how designing a thematic map can convey a message. Enjoy the "landscape of a novel" and map the third dimension. Visit http://www.usgs.gov/education/learnweb/Maps.html.

Ask-A-Geologist—Have you ever had a question about volcanoes, earthquakes, glaciers, or rivers? Why not ask a geologist for an answer? General questions on earth sciences may be sent by electronic mail to the Internet address: Ask-A-Geologist@usgs.gov or visit http://walrus.wr.usgs.gov/docs/ask-a-ge.html.

What's the Red in the Water?—What's the black on the rocks? What's the oil on the surface? This how-to Web site describes collecting and viewing the microbial community that fixes iron and manganese in the natural environment. Follow one group on their fieldtrip adventure at http://pubs.usgs.gov/publications/text/Norriemicrobes.html

Water Education Posters—Water-resources topics of all completed posters are drawn in a cartoon format. Posters are available in color or black and white. The reverse sides of the color posters contain educational activities: one version for children in grades 3-5 and the other with activities for children in grades 6-8. The black-and-white posters are intended for coloring by children in grades K-5. Visit http://h2o.usgs.gov/public/outreach/OutReach.html.

This Dynamic Earth—This book provides a brief introduction to the concept of plate tectonics and complements the visual and written information presented in *This Dynamic Planet*, a map published in 1994 by the USGS and the Smithsonian Institution. The book highlights some of the people and discoveries that advanced the development of the theory and traces its progress since its proposal. Although the notion of plate tectonics is now widely accepted, many aspects still continue to confound and challenge scientists.

http://www.usgs.gov/education/

The *Global Information Locator* initiative is intended to make it easier for people to find information. Consistent with national and international systems, policies, and standards, consensus has been achieved on a Global Information Locator Service definition using international open standards. This service facilitates access to libraries, museums, data centers, and archives worldwide. It can also be extended to the many ways in which people need to abstract information.

This initiative is part of the G7 Global Information Society Environment and Natural Resources Management project to improve the exchange and integration of data and information. The project is demonstrating the breadth of data and information already existing internationally and shows the mutual public benefits of improved accessibility for policymakers, researchers, nongovernmental organizations, and the general public. The result will be public access to virtual libraries of environmental data and information held in globally distributed electronic sites.

http://www.usgs.gov/gils/

OUTREACH AND CUSTOMER SERVICE

Communicating with customers about the daily impacts of science as well as its wonders took on new meaning for the USGS in FY 95. Successful bureau outreach efforts included an Earth Science Day Open House at the Reston, Va., headquarters that attracted some 20,000 people who came to look, learn, and participate in hundreds of earth science activities. The mysteries of volcanoes unfold for visitors to the Cascade Volcano Observatory every day through the staff's constant search for the most effective ways of explaining the incredible power held within the volcanoes of the Cascade range. The State of Kansas and the USGS celebrated 100 years of working cooperatively, a venture that paved the way for States and Federal agencies like the USGS to work together for the betterment of science. And the delicate nature of the south Florida ecosystem was exposed, to the delight of many visitors, through the combined efforts and scientific investigations of several State and Federal agencies. Through these efforts and many others like them, opening new channels of communications with the public and with its professional customers has become a top priority for the USGS.

For more information on USGS outreach activities, visit www.usgs.gov/themes/themes.html on the World Wide Web.

Determining the Needs of USGS Customers

To help guide product modernization decisions, the USGS surveyed its professional data users to evaluate customer satisfaction with the accuracy, content, and utility of USGS maps and digital data.

The survey encompassed major USGS cartographic product lines, including 1:24,000- and 1:100,000-scale digital line graphs (DLGs) and printed quadrangle maps, digital elevation models (DEMs), and digital orthophoto quadrangles (DOQs). A questionnaire was developed after soliciting the concerns and needs of spatial data users during 11 focus group meetings held across the United States.

In the spring of 1994, the questionnaire was sent to more than 18,000 individuals in the spatial data community. The sample group covered a broad mix of data producers and users in the public and private sector. A total of 2,245 usable responses were received. Of these, 20 percent were from Federal Government, 16 percent from State government, 18 percent from local government, 29 percent from private industry, 9 percent from academic institutions, 5 percent from utilities, and 3 percent from other types of organizations.

More than 95 percent of all respondents reported that they use printed quadrangle maps; 65 percent use DLGs; 61 percent use DEMs; and 53 percent use DOQs. The users generally are satisfied with vertical and horizontal product accuracy and feature content but need more current data. Larger scale products are used more frequently than smaller scales. Federal and State government respondents were the most frequent users of USGS products.

The Federal Government uses USGS products mostly in rural areas, whereas local governments use them mostly in urban and suburban areas. Local government users reported a need for more current data than other government users.

Ninety-five percent of DLG users said that edge matching is very important. Forty percent of users said that the USGS should modify its data to reflect the North American Vertical Datum of 1988; of that 40 percent, more than two-thirds would be satisfied if the USGS merely provided the shift algorithms. By an overwhelming majority, 1:24,000-scale map users prefer the traditional flat sheet to a redesigned folded sheet.

Users of USGS digital data strongly prefer to receive it on CD-ROM and desire expanded Internet access. In response, the USGS now offers all digital cartographic data on CD-ROM or Compact Disc-Recordable (CD-R) media. Orders can be shipped on CD-R discs within 48 hours of receipt.

On the basis of the knowledge gained in the survey, the USGS will conduct additional information-gathering activities, including focus groups and quantitative survey research. This research will be used to fill information gaps related to customer needs, to test new products and product ideas, and to understand industry trends and the impacts of technology on customer needs.

Five professional associations (the American Congress on Surveying and Mapping, the American Society for Photogrammetry and Remote Sensing, the Association of American Geographers, AM/FM International, and the Urban and Regional Information Systems Association) and two private sector firms (Intergraph Corporation and Environmental Systems Research Institute, Inc.) assisted in the development of the survey sampling frame. *GIS World* magazine distributed the questionnaire shrink wrapped in its May 1994 issue.

***Stephen Gillespie** is an economist in the Strategic Planning and Program Development Group of the National Mapping Division.*

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"What to Do With a Volcano in Your Backyard": Volcano Hazards Outreach at Mount Rainier

Mount Rainier is widely regarded as one of the most hazardous volcanoes in the Pacific Northwest's Cascade Mountain Range because of its history of frequent debris flows. More than 55 debris flows in recent geologic time have swept down river valleys leading from the volcano. Some reached the Puget Sound Lowland, an area that is experiencing rapid population growth. The debris flows were triggered by eruptions, massive landslides, and glacial-outburst floods. The USGS recently expanded its public education effort to communicate hazard information to residents of western Washington State, especially in communities identified by K.M. Scott and J.W. Vallance in 1995 as being in particularly hazardous areas.

The goals of this outreach effort—called "What to do with a volcano in your backyard"—are to create forums for communicating the results of USGS hazard assessments, provide new and current information about the natural history of Mount Rainier, and seek partners for pursuing collaborative public outreach activities. The effort was launched with the creation of a new outreach position at the USGS Cascades Volcano Observatory (CVO) in Vancouver, Wash., and the production of a series of information products (such as brochures and fact sheets) focusing on Mount Rainier.

Debris flows are an especially hazardous phenomenon; more than 23,000 people were killed by debris flows from Nevada del Ruiz volcano in Colombia in 1985. Mount Rainier presents the most severe debris flow risk of any volcano in the United States and has produced numerous debris flows that have traveled more than 100 kilometers to the Puget Sound Lowland. About 100,000 people now live on debris flow deposits from Mount Rainier. The mountain's hydrothermally weakened structure and its long history of eruptions and collapses suggest that risks from Mount Rainier remain.

Potential hazards posed by Mount Rainier led to its designation as a "Decade Volcano" as part of the United Nations-sponsored "Decade for Natural Hazards Reduction." As such, it is one of 16 volcanoes worldwide judged by scientists as being particularly hazardous to large populations. The goal of the Decade Volcano Project is to demonstrate ways in which future volcano hazards can be mitigated through scientific study and by collaboration between scientists, civil authorities, and the public.

The success of this effort stems from collaboration with Mount Rainier National Park, educators, county planners, emergency response personnel, community libraries, and citizen groups.

An educational video now in production about volcano hazards at Mount Rainier, "Perilous Beauty—the Hidden Hazards at Mount Rainier Volcano", describes the effects of previous activity, shows what is likely to occur in the future, and explains the role of the USGS in monitoring the mountain. It contains spectacular footage of debris flows and hot ash flows at volcanoes similar to Mount Rainier. This 28-minute video, intended for distribution through the USGS and Mount Rainier National Park, will be available to the public in late 1996.

Visitors to the CVO Home Page on the World Wide Web will find photographs, maps, fact sheets, and scientific articles about Mount Rainier's hazards and eruptive history. Use of the CVO server has grown steadily since it went online in August 1994, currently about 10,000 "hits" per month. People in approximately 75 countries have accessed the CVO server, which has direct links to the National Park Service,

CVO Home Page: http://vulcan.wr.usgs.gov

Publications

Two articles written for Mount Rainier and Mount St. Helens visitor publications describe eruptive hazards at the two volcanoes and compare their eruptive processes. The articles were distributed to several hundred thousand visitors during 1995.

Updated hazard assessments for all five volcanoes in Washington State were completed by USGS staff during 1995. Each publication includes descriptions of potential hazards and maps showing areas most likely to be affected by future eruptions or landslides. Six open-file reports have been published about volcano hazards in general and the Cascade volcanoes in particular. They are distributed at workshops and presentations and are available on request to the general public.

earth science educational groups, and a variety of universities and scientific organizations.

About 40 teachers have taken part in three pilot workshops for educators. More workshops will follow in the coming year. Each workshop includes lectures on volcano processes; specially designed science experiments illustrating volcano hazards specific to Mount Rainier; map-reading exercises to help teachers and students read volcano hazard maps correctly; and talks by local emergency management teams about how to prepare for future natural events.

At the invitation of local community groups, USGS scientists have made presentations to about 300 people in communities in the vicinity of Mount Rainier. These presentations have focused on the previous behavior of Mount Rainier and hazards presented by future eruptions and landslides. Attendees are shown maps of volcano hazard zones, given handouts about volcano hazards, and encouraged to ask questions.

In celebration of the fifteenth anniversary of the eruption of Mount St. Helens, 29 walks, talks, and demonstrations were given at Mount St. Helens National Volcanic Monument between May and August 1995. USGS employees demonstrated volcano-monitoring equipment and explained volcano processes and hazards. About 20 large posters were produced for these talks, which were attended by approximately 2,000 to 3,000 visitors.

Approximately 50 local emergency management officials from western Washington State attended a workshop about Mount Rainier's volcano hazards sponsored by the National Park Service, the Pierce County Department of Emergency Management, and the USGS. The workshop provided an opportunity to describe current efforts to learn more about the volcano's past activity, discuss future plans for reducing risk from debris flows, and establish contacts.

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EXHIBITS

•Since 1993, the USGS has sponsored temporary exhibits at the National Park Service's Paradise Visitor Center focusing on many aspects of the volcano's geologic history, including eruptions, landslides, mudflows, glacial outburst floods, glaciers, and monitoring. The exhibits emphasize new results from ongoing studies.

•The USGS is working with Mount Rainier National Park to develop a permanent exhibit for the Sunrise Visitor Center about volcanic processes and hazards at Mount Rainier. It is expected to be on display by fall 1996.

•At the request of a number of community groups, a portable tabletop exhibit about volcano hazards at Mount Rainier has been assembled. Since April 1996, the exhibit has been displayed at libraries and public gatherings in the vicinity of Mount Rainier. Publications about volcanic hazards are available for distribution during each showing.

•A large exhibit was displayed at the fall 1995 Western Washington State Fair in Puyallup, Wash., entitled "What to Do With a Volcano in Your Backyard—Volcano Hazards at Mount Rainier." Photographs, text, and maps addressed questions about volcano hazards at Mount Rainier for the approximately 1.3 million visitors who attended the three-week-long event. An estimated 40,000 people watched a video entitled "Understanding Volcanic Hazards" or perused the exhibit.

Scientists, Stakeholders, and the South Florida Ecosystem

Over a century ago, the first European settlers in south Florida found an expanse of wetland—"a River of Grass" in Marjory Stoneman Douglas's words. To those who put down roots, it was a barely habitable place—too much water in the wet season and too many fires during droughts. Thus, most settlement occurred on the Atlantic ridge to the east of the Everglades. The need to control flooding from devastating hurricanes brought increasing pressure for manmade controls until the Everglades was crisscrossed by canals and divided into isolated blocks of land. The land south of Lake Okeechobee and west of the urbanizing Atlantic ridge, formerly part of the "River of Grass," could now be farmed.

Nutrient-laden water flowing out of the agricultural areas helped to change plant communities from native sawgrass to cattails. Loss of wetlands to agriculture and urbanization reduced the area's water storage capacity, needed during hurricanes and tropical storms, and resulted in continued economic losses from flooding and fires.

The extensive system of canals efficiently moved water to the east and the west, but less and less water now reached the south. As a result, an area that had once sustained millions of birds could now support only one-tenth that number. Increased nutrients and salinity in the waters of Florida Bay caused seagrasses and corals to die off. Water that had been a fisherman's paradise was cloudy with sediment, fish populations were greatly reduced, and fisheries were closed because of mercury contamination.

The public gradually began to see the need to revitalize the greater Everglades system, including Florida Bay, and to accept the idea that a different management strategy was required—one that was in the long-term interest of both the people and the ecology of south Florida. At the same time, many agencies, groups, and individuals were starting to work toward the restoration of the greater Everglades. Scientists in academia, State government, and Federal agencies were investigating different pieces of the scientific puzzle. Resource managers in the National Park Service and the U.S. Fish and Wildlife Service were acquiring the scientific information needed to stem the invasion of exotic species and restore decimated fish and wildlife populations. The U.S. Environmental Protection Agency and the State of Florida were gathering data on the extent and causes of mercury contamination in fish. The South Florida Water Management District and the U.S. Army Corps of Engineers were developing plans for restoring the historical annual hydrologic regime in south Florida. The USGS was studying the hydrology and geology, making maps of the area, and conducting interdisciplinary studies. Whole-landscape studies by USGS scientists took an interdisciplinary approach, encompassing ground water, water quality, geology, soils, and vegetation in the urban, agricultural, and environmentally sensitive lands of south Florida.

Over the past 10 years, the national approach to managing ecosystems such as the Everglades has been changing. This approach, which was developed in the Pacific Northwest,

For additional articles pertaining to South Florida, please see "Studies in South Florida" on page 22 and "Florida Cooperative Mapping Project" on page 23.

south Florida, and elsewhere, goes by different names (for example, place-based management, ecological stewardship, and ecosystem management) and involves managing a region in a more holistic manner. Water, birds, and rocks do not stop at the boundary of an agency's land, and neither can the management of those resources. The following definition, taken from a September 1994 National Park Service document entitled, "Ecosystem Management in the National Park Service," sums up the philosophy behind such a management approach:

> Ecosystem management is a collaborative approach to natural and cultural resource management that integrates scientific knowledge of ecological relationships with resource stewardship practices for the goal of sustainable ecological, cultural, and socioeconomic systems.

In practice, ecosystem management brings stakeholders (individuals, groups, and agencies that have an interest in the outcome) and scientific information into the decisionmaking process and allows managers to make informed decisions about the physical, biological, social, and economic responses of ecosystems, resources, and communities to alternative management strategies. The approach is also adaptive in that it calls for improving those strategies as better scientific information becomes available. Economic and social sciences also can make vital contributions because human activity is a dynamic part of the mix that is an ecosystem. Many managers have come to believe that adaptive ecosystem management is necessary to resolve environmental problems before they can polarize stakeholders and undermine the ability of resource managers to craft long-term solutions and strategies.

Within south Florida, the USGS is one of the agencies providing the information needed for successful ecosystem management. As a long-time member of the scientific community in the environmentally complex area of south Florida, the USGS has assembled an interdisciplinary team enabling scientists from appropriate fields to work together. With the recent addition of the National Biological Service (which will become the Biological Resources Division of the USGS on October 1996), the USGS is now conducting integrated biological, chemical, cartographic, geologic, and hydrologic studies where they are most needed to answer scientific questions. For instance, the USGS is integrating information on algae with geochemical information to better understand the cycling of mercury and has produced a satellite image map of south Florida that includes an interpretive key to major vegetation types.

Many agencies that have scientific capabilities also are responsible for managing and in

some cases protecting certain resources, but the USGS is an earth and natural science information agency and has no resource management or regulatory responsibilities. As such, the USGS can provide impartial scientific information and analysis on some of today's most difficult environmental issues. Although the position of the USGS facilitates the provision of such information, it also presents the USGS with major challenges. The USGS is making a greater effort to communicate with resource managers to ensure that it provides science that is understandable, timely, and relevant to the resource and policy decisionmaking needs of resource managers.

How can the USGS best identify the kind of scientific studies that are needed and deliver the required scientific information to resource managers for use in making good management decisions? One approach is through the USGS Ecosystem Program, which benefits from interaction with the South Florida Ecosystem Restoration Task Force and associated Work Groups. These regional groups, made up of stakeholders (for example, resource managers, the U.S. Army Corps of Engineers, the general public, and other scientists), have been actively engaged in helping the USGS by providing information on their priorities for scientific information in support of ecosystem restoration. The USGS works primarily though the Science Subgroup, which coordinates the extensive scientific activities of participating agencies. The USGS reaches another stakeholder group—the general public—through the Outreach and Education Subgroup. Throughout the duration of a project, USGS scientists meet with stakeholders to bring them up to date on their progress and to ensure that the projects coordinate well with agency activities, do not duplicate the activities of other agencies, and will meet specific needs in a timely manner.

The success of the Ecosystem Program also depends on the development of working relationships between USGS scientists and resource managers. The traditional vehicles for scientific results—peer-reviewed publications and scientific meetings—are necessary but are not sufficient alone. The program makes the results of its scientific investigations available in formats that are understandable to both nonscientific and scientific audiences. USGS scientists also take a more personal approach, through small meetings with scientists and managers in client agencies and articles written for specific groups of resource managers. Through the Ecosystem Program, the USGS fulfills its obligation to communicate its science to resource managers involved in the restoration of south Florida so that policymakers can conserve the Nation's resources, protect its environment, and improve the quality of life of its citizens.

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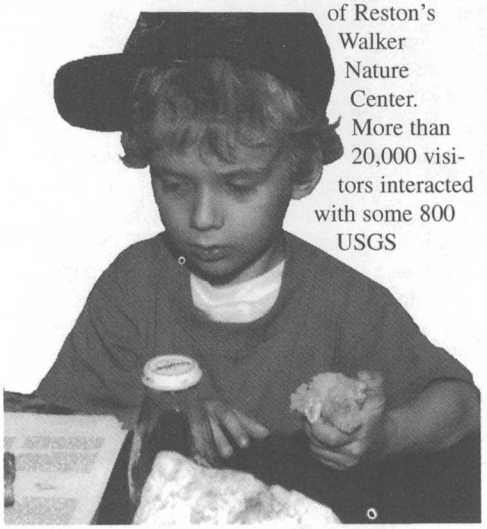
Earth Science Day 1995: Earth Science Outreach at the Community Level

On Earth Science Day (April 29, 1995), the USGS hosted open houses at a dozen locations across the Nation from Alaska to South Carolina and at the National Center in Reston, Va.

At the National Center, the USGS celebrated partnerships with over 75 Federal, State, and local agencies. For the first time, the event was co-hosted with more than 50 local businesses and citizen groups under the banner of Reston's Walker Nature Center. More than 20,000 visitors interacted with some 800 USGS employee volunteers to gain a better understanding of how the USGS provides earth science in the public service.



A young visitor contemplates the complexities of rocks and minerals.

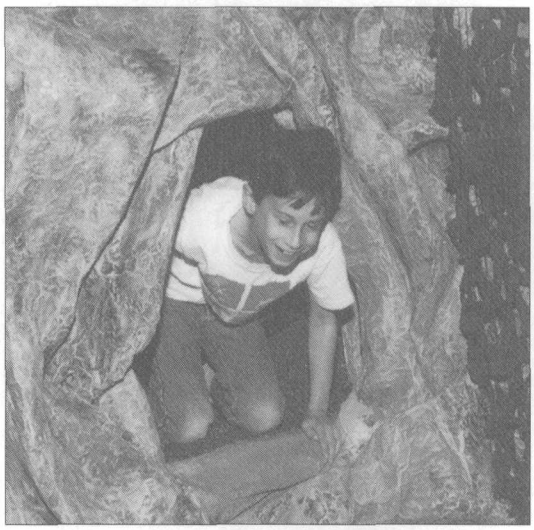
On the first day, April 28, more than 2,000 students panned for gold, learned the importance of water quality, explored the fascinating world of fossils, and visited an historic recreation of John Wesley Powell's 1870's field camp in the Grand Canyon. A resource room for teachers provided numerous packets to assist them in teaching Earth science. The second day, April 29, saw Fairfax County, Va., Supervisor Bob Dix and U.S. Representative Tom Davis sound the air guns to start a 2-kilometer Fun Run and a more serious 5-kilometer race in which a combined total of 742 runners participated. Welcoming remarks were offered by USGS Director Gordon Eaton and Supervisor Dix. An concert by the U.S. Army Blues Band and a color guard ceremony officially opened the 1995 Reston Open House.

In addition to the 150 scientific exhibits, the public was entertained throughout the day by concerts, puppet shows, and good food coordinated by 300 volunteers from local groups. The day was billed as a family event and offered activities for all ages.

One of the highlights of the Open House was "The Cave," a joint creation of the entire bureau. The creation of the hand-made papier mache "cave" started early, with volunteers

A military color guard marches through the crowd to commence Earth Science Day 1995.

The Fun Run drew participants from all age levels.



This visitor's expressions reveals that "The Cave" was a favorite of young and old alike.

donating evenings, weekends, and even their children to help with the construction. More than 8,000 children and adults crawled through, including Secretary of the Interior Bruce Babbitt. The cave is now a permanent exhibit at the "The Museum of Scientific Discovery" in Harrisburg, Pa.

Open houses are an effective means of reaching local communities and increasing public awareness of the role the USGS plays in the lives of citizens everywhere. Another example of such a successfully planned and executed event was the first USGS open house ever held in the State of Alaska. Between 1500 and 2000 people visited 31 exhibits and heard 8 slide-illustrated talks on Alaskan geology. Other activities offered included making globes, volcano models, and casts of dinosaur footprints, panning for gold, and visiting an old-time field camp. Hundreds of resource packets were also distributed for educational and private use. Response to the event, which was planned and carried out by 45 USGS employees and 25 volunteers, including partners from the U.S. Bureau of Mines (now the USGS Minerals Information Office) and the Bureau of Land Management, was so positive that plans are already underway for a second open house in 1997.

Peter Lyttle *is a geologist who has mapped in the Appalachians for 20 years and is now serving as the Geologic Division liaison to the Office of Outreach.*

Elizabeth A. Stettner *is a technical information specialist who has spent the last 4 of her 18 years with the USGS in the Earth Science Information Center. She currently serves as outreach coordinator for the Mapping Applications Center.*

Bruce Gamble *is an economic geologist who has worked 13 years in Alaska on igneous rocks and gold deposits and is now the Scientist-in-Charge of the Alaska Minerals field office.*

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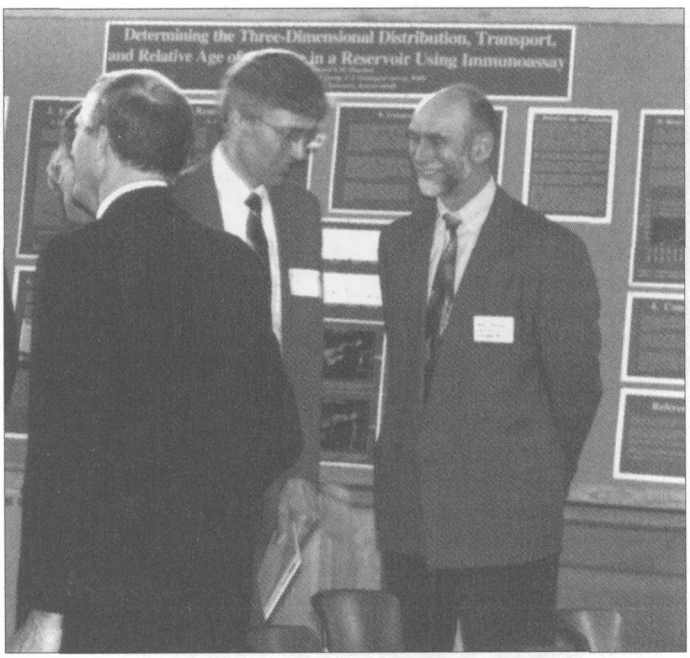
Local Girl Scouts started their day with the Fun Run and ended it with a visit to John Wesley Powell's 1870's field camp.

Nation's Largest Cooperative Water Information Program Celebrates 100 Years of Federal-State Partnership

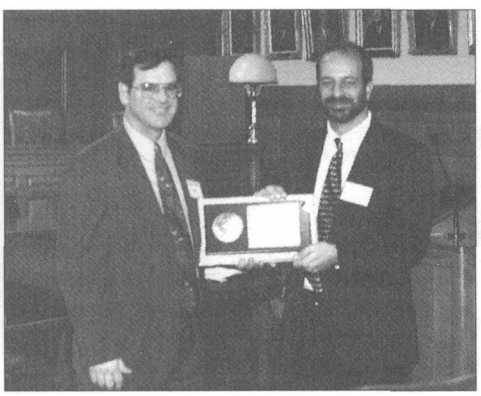
In 1895, the first USGS Federal-State Cooperative Water Resources Program in the Nation began in Kansas through an agreement with the newly established Kansas Board of Irrigation Survey and Experiment (now known as the Division of Water Resources of the Kansas Department of Agriculture). The agreement provided for measurement of streamflow at seven sites to ascertain water-supply potential. Streamflow gages are currently operating near two of the original sites—Republican River below Milford Dam and Smoky Hill River at Ellsworth. In fact, less than half of the streamflow-gaging sites ever operated in Kansas are now in service— a testimony to the flexible nature of the cooperative program; stations are retained only as long as they are needed by both cooperating parties.

During the 100-year history of the cooperative program, the USGS has performed many data-collection and investigation activities in cooperation with a variety of State and local agencies to help meet agency goals and to further the understanding of water resources throughout the Nation. The thousands of reports and information products that have been produced during this time as a part of the cooperative program have become a vital component in addressing water issues of local, State, and national interest. Water-resources knowledge from the partnership enables water managers and others to improve the operation of reservoir systems for water supply and flood control, to improve the design of bridges, to develop new water supplies, and to manage agricultural and municipal water quality.

On May 4, 1995, a recognition ceremony was held in the Old Supreme Court Meeting Room of the Capitol Building in Topeka, Kans., to commemorate the one hundredth anniversary of the program. USGS Chief Hydrologist Robert Hirsch, Kansas State Engineer David Pope, and Director of the Kansas Water Office Stephen Hurst were present and spoke about the value of this cost-sharing partnership in meeting the needs of Federal, State, and local interests. They also addressed the benefits of having a single nonregulatory agency contribute to water-resources data collection and analysis in a consistent, objective manner. "Every State in the country owes a debt of gratitude to the foresight of a few Kansas officials who in 1895 recog-



Officials browse through a poster session on the water resources of Kansas.



Kansas State Engineer David Pope (left) and USGS Chief Hydrologist Robert Hirsch display a plaque commemorating the 100-year partnership between Kansas and the USGS.

nized the benefit of pooling State and local resources with the Federal government to collect mutually important water resources information," Hirsch said. "From the single Kansas agency working with the USGS to measure the flow in seven State rivers, the USGS Federal-State Cooperative Program now involves more than 1,100 agencies in all 50 States, cooperatively monitoring surface-water and ground-water quantity and quality at more than 40,000 sites."

Approximately 25 cooperators and other interested parties from across the State also attended the celebration. In addition to the ceremony, posters were displayed describing some of the ongoing and recently completed water-resources information studies initiated as a part of the cooperative program in Kansas. A demonstration of the USGS real-time surface-water data telemetry system was also conducted. At the conclusion of the ceremony, Hirsch presented Pope with a plaque commemorating 100 years of cooperation between the State of Kansas and the USGS.

Walter Aucott *is chief of the Kansas Water Resources District Office and is responsible for USGS water-resources programs in the State.*

An early USGS field scientist prepares to collect data.

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NEW PRODUCTS AND SERVICES

Ask-A-Geologist: Innovative Use of the Internet for Outreach

Since October 1994, earth science questions sent to "Ask-A-Geologist@usgs.gov" have been routed to a rotating list of USGS scientists for answers. In the first year, Ask-A-Geologist received over 2,000 inquiries from all over the United States and the world. Most inquiries were answered in two or three working days. Questioners have ranged from elementary school students with simple questions to professional geologists searching for specific information. In October 1995, the Ask-A-Geologist program was awarded the Department of Interior Innovation Award.

Visit
Ask-A-Geologist on
the World Wide Web at
http://walrus.wr.usgs.gov/docs/ask-a-ge.html

EarthFax: Any-Day Any-Time Access to USGS News and Information

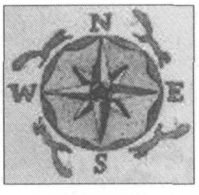
1995 was the inaugural year for EarthFax, the USGS's fax-broadcast system. EarthFax provides rapid access to press releases, fact sheets, and product information for customers with access to fax machines or personal computers with fax reception software. This service is available 24 hours a day.

EarthFax (703) 648-4888

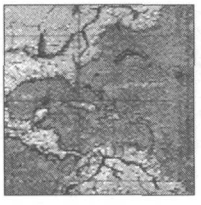
Documents can be retrieved simply by calling the system and following the easy instructions provided by an interactive series of voice prompts. To access the system, dial (703) 648-4888 from a fax machine's handset or from a touch-tone phone and follow the step-by-step instructions.

Instructions for using EarthFax can be found on the World Wide Web at http://h2o.usgs.gov/public/wid/earthfax_instr.html

New Teacher's Packets



Map Adventures, a new packet of teaching information for children in grades K through 3, contains a large poster of an imaginary amusement park, 7 lesson plans, 2 activity sheets, 16 black-and-white illustrations, and a teacher's information sheet. The packet teaches children how to understand and use maps. *Map Adventures* is available to educators upon request.



The *Exploring Maps* teacher's packet includes two annotated posters, a teaching guide, and four activity sheets appropriate for grades 7-12. The materials can be used to assist students in learning basic mapmaking and map-reading skills. The images and activities in the packet can be used in geography, history, math, art, and English, as well as the sciences. *Exploring Maps* is available to educators upon request as well as online in The Learning Web at http://www.usgs.gov/education/learnweb/Maps.html.

Internet: Earth Science Link to the Information Superhighway

The USGS' EROS Data Center (EDC) in Sioux Falls, S. Dak., opened its World Wide Web (WWW) server to provide public access to the online National Digital Cartographic Data Base (NDCDB) documentation and digital data files in September 1993.

In May 1994, when the NDCDB Sales Data Base (SDB) became operational, its digital map files also were placed on the WWW server to provide no-cost public access to these USGS products. The SDB holds the distribution copy of the NDCDB master products archives housed at the USGS cartographic production centers located in Reston, Va., Rolla, Mo., Denver, Colo., and Menlo Park, Calif. Public response to these online digital products has been very positive.

To ensure efficient and timely delivery of products from the SDB, the EDC has placed these digital data files on an optical disc mass-storage file server accessible from the Internet. The availability of these digital products online provides USGS customers with Internet self-service access to the NDCDB data as part of the USGS contribution to the National Spatial Data Infrastructure (NSDI). This online access also allows the EDC Product Distribution System (PDS) to rapidly select those files necessary to fill offline customer orders and write them on the customer's choice of magnetic tape or optical disc media.

The development of Internet access to the USGS NDCDB data was done as a cooperative effort between the EDC and both Reston headquarters and the four USGS cartographic production centers mentioned above. The design, functional flow, and implementation were done on the basis of input from in-house applications researchers who use the NDCDB and from the USGS customer community.

Digital map products that previously cost far more to produce and distribute by traditional manual methods now cost significantly less than a dollar each to deliver online over the Internet. Both the lower cost to the Government and the wider customer base demonstrate the power and efficiency of using the Internet to distribute Federal earth science information and products to USGS customers.

Owing to the success of the initial NDCDB product distribution over the Internet, the USGS has defined a growth plan for distributing other digital products that will take advantage of the cost savings and efficiencies inherent in online access. During FY 96 and 97, the SDB will be expanded to offer self-service Internet catalog query and ordering for two new USGS product lines: Digital Raster Graphics (DRG) and Digital Orthophoto Quadrangles (DOQ). Plans are also underway to offer similar Internet catalog query and ordering for nondigital USGS products, including topographic and thematic maps, books, and publications.

__Donna Scholz__ is responsible for development and management of Internet-based customer query and order systems and for the managament and distribution of USGS digital cartographic and elevation data products and satellite and aircraft images.

Visit the Eros Data Center on the World Wide Web at
http://edcwww.cr.usgs.gov/eros-home.html

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EROS Data Center
Sioux Falls, SD 57198

Customer Services
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Sioux Falls, SD 57198
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Telephone: (605) 594-6151
TDD: (605) 594-6933
Fax: (605) 594-6589

GNIS Online

GNIS was developed by the USGS in close cooperation with the BGN. Established by public law in 1947, the BGN is comprised of representatives from Federal agencies concerned with the publication and printing of geographic names. Its mandate is to standardize geographic name usage throughout the Federal Government. Members include representatives of the Departments of Agriculture, Commerce, Defense, Interior, and State; the Central Intelligence Agency; the Government Printing Office; the Library of Congress; and the U.S. Postal Service. The GNIS WWW site provides a link to the Defense Mapping Agency's Geographic Names Processing System (GNPS), which contains information about foreign geographic feature names.

The USGS's Geographic Names Information System (GNIS) database is now available on the World Wide Web (WWW). Online users can query the database by feature name, feature type, State, or county and receive information instantaneously. A file transfer option allows users to quickly and easily obtain standardized digital files by State from the database.

GNIS, developed by the USGS in cooperation with the U.S. Board on Geographic Names (BGN), is the Nation's official repository of domestic geographic names information and lists the federally recognized names for almost 2 million features located throughout the United States.

GNIS is the vehicle by which the BGN implements its domestic geographic names standardization program. Only those feature names identified as official in the GNIS database can be used on federally published maps and charts. The newly developed WWW site enables anyone with access to the Internet to obtain up-to-date information from the GNIS database. All publishers of maps, charts, and other documents now have instant access to federally approved feature names.

The system's utility extends beyond standardizing geographic name usage. The database also identifies the location of features by geographic coordinates—information that can be useful in a wide array of applications. GNIS has helped solve problems in emergency preparedness, delivery and transportation routing, and site selection and analysis. Because historical documents as well as current ones are researched in compiling the database, genealogists and other researchers of history also find the system invaluable.

The GNIS database is growing. Names appearing on Federal documents have already been entered into the database, and other sources of information are being researched in an ongoing effort to collect data.

The USGS, through development of this WWW site, is making publicly held data more easily and readily accessible by their owners. As steward of the GNIS database, the USGS is promoting the standardization of domestic geographic nomenclature and providing a ready and reliable source of feature location information that can used in many applications.

Goals of the project include:

- Extending the GNIS WWW site to include a map-based graphical query capability, enabling users to point to specific areas of interest to receive desired information.

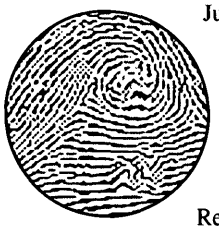
- Providing links to companion product databases such as listings of topographic maps showing features of interest.

- Integrating an online product ordering and payment system.

Judy Nowakowski is a computer specialist with the Geographic Names Office.

Acknowledgments:
Rebecca Bish (U.S. Geological Survey)
David Govoni (U.S.Geological Survey)
Roger Payne (U.S. Geological Survey)

For more information, contact:



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12201 Sunrise Valley Drive
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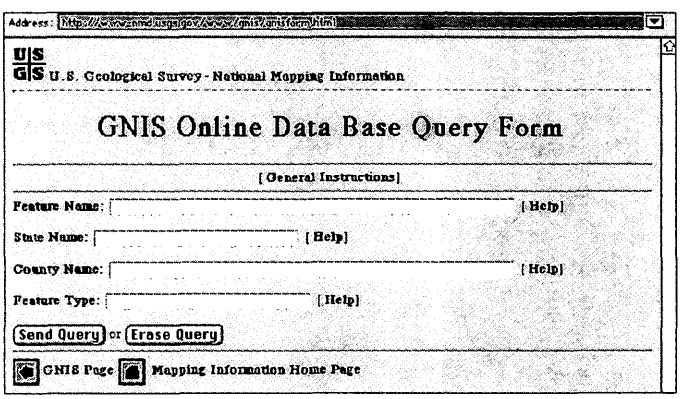


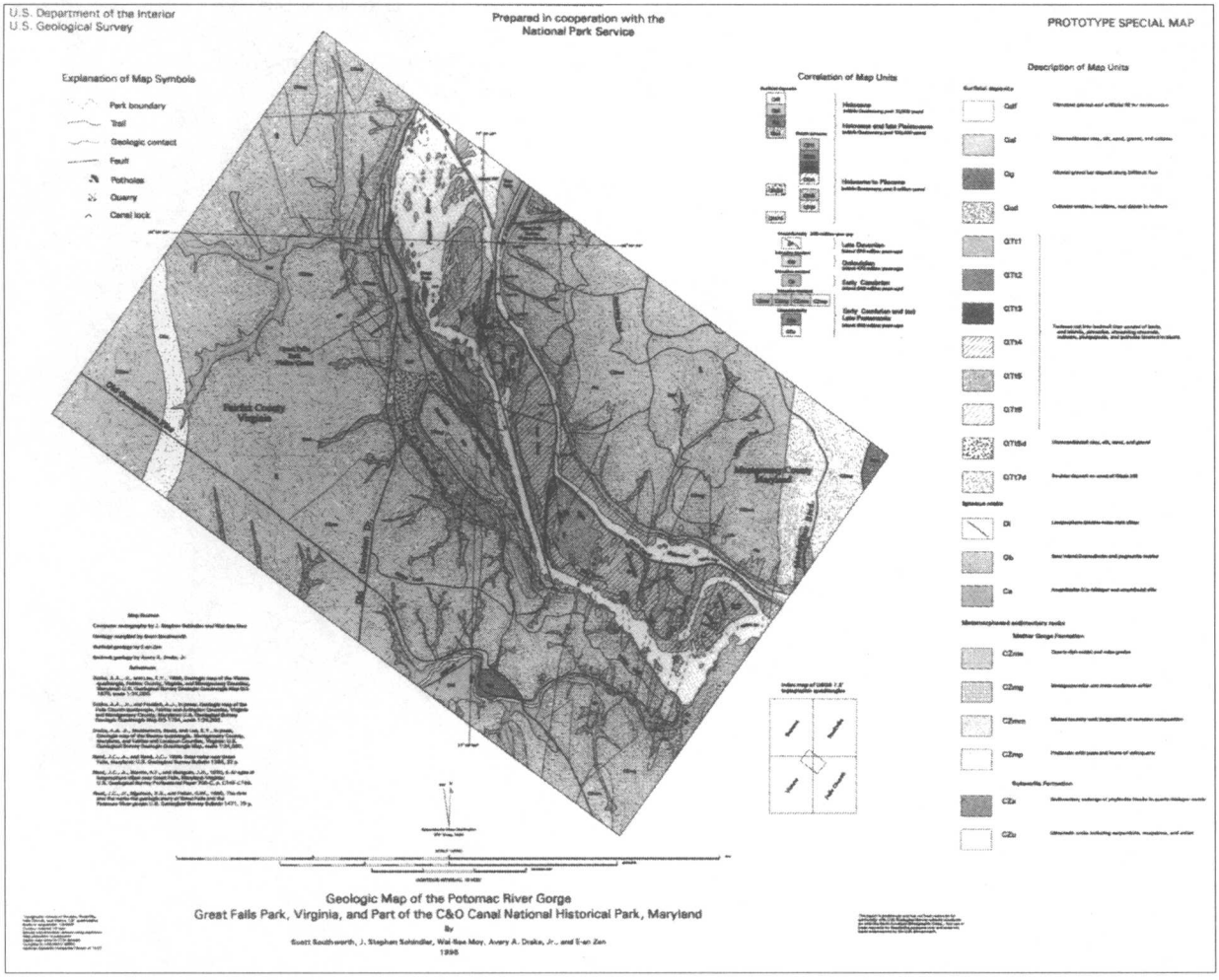
Visit the GNIS database on the World Wide Web at http://www-nmd.usgs.gov/www/gnis/

Products for the Parks: National Park Service/USGS Cooperative Project on the Geology of National Park Lands

Geologic Map and Exhibit for Great Falls Park, Virginia and Great Falls Visitor Center of the Chesapeake and Ohio Canal National Historical Park — A geologic map based on the ARC-INFO geographic information system and showing bedrock and surficial deposits at 1:6000 scale was produced for sale and exhibit at Great Falls Park Visitor Center in Great Falls, Va. The exhibit uses aerial photographs and rock specimens to assist visitors in completing the park's popular "geology walk ." A similar exhibit emphasizing the effects of floods is on display at the C&O Canal's Great Falls Tavern Visitor Center in Maryland.

Geologic Map and Exhibits of the C&O Canal National Historical Park — A series of 17 1:24,000-scale geologic maps of the 184.5-mile-long C&O Canal and Potomac River corridor (a 2-mile-wide swath centered on the river) are being produced cooperatively by the National Park Service (NPS) and the USGS. The Maryland Geological Survey and the West Virginia Geological and Economic Survey are also involved. The maps will be used by the NPS to manage and interpret the resources in this unique park, which transects five geologic provinces in the Potomac River basin. Exhibits planned for each visitor center will emphasize the local and regional geology and the engineering aspects of and construction materials used for the canal as well as historical and recent flood events that have damaged it. The maps will be of general interest to hikers, bikers, and boaters along the "Nation's river."

Geology of the Harpers Ferry Quadrangle — As part of a cooperative investigation between the Loudoun County, Va., Department of Environmental Resources, the Maryland Geological Survey, the NPS, and the Harpers Ferry Historical Association (HFHA),



Geologic map of the Potomac River Gorge, Great Falls Park, Va., and part of the C&O Canal National Historical Park, Md.

the USGS is producing a general interest publication on the Harpers Ferry quadrangle. The book will be accompanied by a 1:24,000-scale geologic map and will be sold in the Harpers Ferry National Historical Park bookstore. It will be the only source of information on the geology of this popular region and will be written for a nontechnical audience. Both the Maryland Geological Survey and the HFHA have agreed to help defray the cost of printing in exchange for distribution copies. The HFHA can transfer 25 percent of the profits from its sale of the book to the Interpretive Program of the National Historical Park, thereby providing the USGS with a unique way to fund outreach programs for the Department of the Interior.

***Scott Southworth** is a research geologist specializing in the geomorphic and tectonic histories of the Central Appalachians and the Potomac River Valley.*

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Budget Information

The USGS receives funding through direct appropriations and reimbursable work. The following table reflects a FY 95 budget authority of $570.507 million to program element level.

Activity/subactivity/program element	FY 95 Enacted
National Mapping, Geography, and Surveys	**$123,966**
National Map and Digital Data Production	56,035
Cartographic Data and Map Revision	49,059
Thematic and Special Data	4,829
Data Cooperatives/Partnerships	2,147
Information and Data Systems	21,638
National Data Base Management	10,946
Information Dissemination Services	3,325
Global Change Data Systems	7,367
Research and Technology	21,950
Cartographic and Geographic Research	9,334
National Cartographic Requirements, Coordination, and Standards	8,463
Geographic and Spatial Information Analysis	4,153
Advanced Cartographic Systems	24,343
Geologic and Mineral Resource Surveys and Mapping	**213,486**
Geologic Hazards Surveys	71,139
Earthquake Hazards Reduction	48,838
Volcano and Geothermal Investigations	19,999
Landslide Hazards	2,302
Geologic Framework and Processes	26,530
National Cooperative Geologic Mapping	21,847
Continental Surveys	2,904
Magnetic Field Monitoring and Charting	1,779
Global Change and Climate History	9,674
Global Change and Climate History	9,674
Marine and Coastal Geologic Surveys	36,365
Marine and Coastal Geologic Surveys	36,365
Mineral Resource Surveys	44,566
Mineral Resource Surveys	44,566
Energy Resource Surveys	25,212
Energy Resource Surveys	25,212

Activity/subactivity/program element	FY 95 Enacted
Water Resources Investigations	**$185,916**
National Water Resources Research and Information System—Federal Program	119,233
Data Collection and Analysis	20,347
Hydrogeology of Critical Aquifers	3,095
Core Program Hydrologic Research	10,399
Water Resources Assessment	1,425
Toxic Substances Hydrology	14,028
Acid Rain	1,720
Scientific and Technical Publications	2,161
National Water-Quality Assessment Program	58,071
Global Change Hydrology	5,770
Truckee-Carson Program	1,219
Watershed Modeling System	998
National Water Resources Research and Information System—Federal-State Cooperative Program	62,130
Data Collection and Analysis, Areal Appraisals, and Special Studies	58,106
Water Use	4,024
National Water Resources Research and Information System—State Research Institutes and Research Grants Program	4,553
State Water Resources Research Institutes	4,320
Program Administration	233
General Administration	**24,320**
Executive Direction and Program Support	14,027
Reimbursements to the Department of Labor	2,768
Payments to Other for Services	989
Washington Administrative Service Center	6,536
Facilities	**22,819**
National Center—Rental Payments to GSA	19,393
National Center—Facilities Management	3,073
Day Care Centers—Rental Payments to GSA	353
Total, SIR	**$570,507**

The following table reflects actual obligations from all sources of funds. In FY 95, the USGS had actual obligations of $919.4 million, distributed as follows: $581.4 million from direct appropriations, $6.6 million from estimated receipts from map sales, and $331.4 million from reimbursements. Percentage of total funds by activity: National Mapping, Geography, and Surveys, 18; Geologic and Mineral Resources Surveys and Mapping, 28; Water Resources Investigations, 44; General Administration, 3; Facilities, 3, Computer Services, 1. The Working Capital Fund is 3 percent.
[Dollars in thousands]

Funding of the U.S. Geological Survey	1992	1993	1994	1995
Total	**$851,979**	**$862,335**	**$886,093**	**$919,426**
Direct program	586,699	582,891	586,505	581,424
Reimbursable program	265,280	279,444	299,588	338,002
States, counties, municipalities	89,950	91,299	93,270	95,287
Miscellaneous non-Federal sources	14,609	14,842	13,572	14,665
Other Federal agencies	160,721	173,303	206,526	228,050
National Mapping, Geography, and Surveys	**164,981**	**156,898**	**165,507**	**169,181**
Direct program	132,612	126,092	129,406	131,189
Reimbursable program	32,369	30,806	36,101	37,992
States, counties, municipalities	3,028	3,219	2,771	3,069
Miscellaneous non-Federal sources	10,633	10,562	9,174	10,675
Other Federal agencies	18,708	17,025	24,156	24,248
Geologic and Mineral Resources Surveys and Mapping	**267,457**	**261,079**	**259,366**	**254,052**
Direct program	225,198	222,555	219,101	217,697
Reimbursable program	42,259	38,524	40,265	36,355
States, counties, municipalities	3,077	1,609	1,607	1,869
Miscellaneous non-Federal sources	536	834	687	868
Other Federal agencies	38,646	36,081	37,971	33,619
Water Resources Investigations	**363,287**	**384,467**	**400,122**	**404,025**
Direct program	184,489	186,933	188,631	185,364
Reimbursable program	178,798	197,534	211,491	218,661
States, counties, municipalities	83,845	86,471	88,892	90,349
Miscellaneous non-Federal sources	3,424	3,440	3,706	3,118
Other Federal agencies	91,529	107,623	118,893	125,194
General Administration	**25,028**	**25,886**	**28,765**	**25,471**
Direct program	23,883	24,506	25,951	24,203
Reimbursable program	1,145	1,380	2,814	1,268
States, counties, municipalities				0
Miscellaneous non-Federal sources	1	1	2	2
Other Federal agencies	1,144	1,379	2,812	1,266
Facilities	**20,304**	**23,111**	**23,368**	**29,482**
Direct program	20,304	22,750	23,282	22,773
Reimbursable program	0	361	86	6,709
Computer and Administrative Services	**10,709**	**10,839**	**8,831**	**8,381**
Reimbursable program	10,709	10,839	8,831	8,381
Miscellaneous non-Federal sources	15	5	3	2
Other Federal agencies	10,694	10,834	8,828	8,379
Operation and Maintenance of Quarters	**28**	**45**	**15**	**31**
Direct program	28	45	15	31
Contributed Funds	**185**	**10**	**119**	**168**
Direct program	185	10	119	168
Working Capital Fund			**13,780**	**28,363**
Reimbursable program			13,780	28,363

Direct program includes actual obligations of $569,408 for current year and $11,817 for no-year. Reimbursable program includes $6,693 for General Service Administration. Allocation accounts are not included.

The USGS was reimbursed for work performed for other Federal, State, and local agencies whose need for earth science expertise complements USGS program objectives. Cooperative agreements with more than 1,000 Federal, State, and local agencies and the academic community support a large share of USGS research and investigations. Work for State, county, and municipal agencies is most often conducted on a cost-sharing basis. The following table provides detailed information on the particular agencies for which the USGS performs work.

[Dollars in thousands]

Source of funds	1992	1993	1994	1995
Department of Agriculture	$3,714	$2,697	$5,620	$6,063
Department of Commerce	9	103	196	27
National Oceanic and Atmospheric Administration	5,146	1,630	1,414	999
Department of Defense	56,461	64,518	71,281	69,652
Department of Energy	30,679	33,651	38,309	40,291
Bonneville Power Administration	217	445	481	322
Department of Interior				
Bureau of Indian Affairs	1,347	881	1,462	1,386
Bureau of Land Management	1,508	1,797	1,535	1,257
Bureau of Reclamation	5,990	6,495	7,133	8,318
Minerals Management Service	207	107	50	1,881
National Park Service	1,107	1,111	2,158	6
Office of the Secretary	1,551	1,298	1,159	1,005
Office of Surface Mining	8	22	0	283
Fish and Wildlife Service	733	379	586	912
Department of State	10,524	13,333	10,030	6,171
Department of Transportation	661	605	770	1,217
Environmental Protection Agency	6,414	7,671	10,422	11,059
Federal Emergency Management Agency			1,927	1,857
National Aeronautics and Space Administration	9,589	10,108	11,068	10,348
National Science Foundation	1,838	2,096	1,252	2,770
Nuclear Regulatory Commission	539	1,087	870	751
Tennessee Valley Authority	275	417	437	234
Miscellaneous Federal agencies	22,204	22,852	38,366	61,241
Total	$160,721	$173,303	$206,526	$228,050

Guide to Information and Publications

In addition to these USGS information outlets, access USGS earth science information on the World Wide Web at

http://www.usgs.gov

Earth Science Information Centers

To obtain information on cartographic data and on earth science programs, publications, and services or to obtain copies of reports and maps, write or visit U.S. Geological Survey Earth Science Information Centers at the following addresses:

Alaska:
Room 101
4230 University Dr., Rm. 101
Anchorage, AK 99508-4664
907-786-7011; Fax 907-786-7050
gfdurocher@usgs.gov

California:
Bldg.3, Room 3128, Mail Stop 532
345 Middlefield Rd.
Menlo Park, CA 94025-3591
415-329-4309; Fax 415-329-5130
TDD 415-329-5092
wesi@ignatx.wr.usgs.gov

Colorado:
Box 25046, Bldg. 810
Denver Federal Center, Mail Stop 504
Denver, CO 80225-0046
303-202-4200; Fax 303-202-4188
esic@rmmc1.cr.usgs.gov

District of Columbia:
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Spokane, WA 99201-1088
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USGS Library System

The USGS Library system is one of the largest earth science collections in the world and contains more than one million monographs, serial publications, maps, and microforms. The collection covers all aspects of the geological sciences and related subjects. An online catalog provides public access. The library honors the standard interlibrary loan request forms as well as requests received online from the Interlibrary Loan System of the On-Line Computer Library Center. Information and reference services are available from the following library locations:

USGS Library
950 National Center
Reston, VA 20192

USGS Library
Mail Stop 955 (Bldg. 5, Room 507)
345 Middlefield Rd.
Menlo Park, CA 94025-3591

USGS Library
2255 N. Gemini Dr.
Flagstaff, AZ 86001-1698

USGS Library
Box 25046, Mail Stop 914
Denver Federal Center
Denver, CO 80225-0046

Water Information

http://h2o.usgs.gov/

Sources of Water Data

To obtain assistance in locating sources of water data, identifying sites at which data have been collected, and obtaining specific information, write or visit:

National Water Data Exchange
U.S. Geological Survey
421 National Center
Reston, VA 20192

http://h2o.usgs.gov/public/nawdex/nawdex.html

Water-Data Acquisition Activities

To obtain information on ongoing and planned water-data acquisition activities of all Federal agencies and many non-Federal organizations, write or visit:

Office of Water Data Coordination
U.S. Geological Survey
417 National Center
Reston, VA 20192

http://h2o.usgs.gov/public/wicp/

To obtain information on water resources in general and about the water resources of specific areas in the United States, write:

National Water Information Clearinghouse
U.S. Geological Survey
417 National Center
Reston, VA 20192

Geologic Information

http://geology.usgs.gov/

General Geology

To obtain information on geologic topics such as earthquakes and volcanoes, energy and mineral resources, the geology of specific areas, and geologic maps and mapping, write, call, or visit:

Geologic Inquiries Group
U.S. Geological Survey
907 National Center
Reston, VA 20192
(703) 648-4383

http://geology.er.usgs.gov/eastern/inquiries.html

Mineral Resources

To obtain information on mineral resources, write, call, or visit:

Mineral Resource Surveys Program
U.S. Geological Survey
913 National Center
Reston, VA 20192
(703) 648-6100

http://minerals.er.usgs.gov/

Maps and Books

To buy topographic and thematic maps of all areas of the United States, to request USGS catalogs, pamphlets, leaflets, and circulars (limited quantities free), and to buy USGS book publications, write or visit:

USGS Information Services
Box 25286, Bldg. 810
Denver Federal Center
Denver, CO 80225

Open-File Reports

To buy USGS open-file reports or to obtain information on the availability of microfiche or paper-duplicate copies of open-file reports, write:

USGS Open-File Reports
Box 25286, Bldg. 810
Denver Federal Center
Denver, CO 80225

Periodicals

New Publications

To be added to the mailing list for the monthly list of *New Publications of the U.S. Geological Survey* (free), write or visit:

USGS New Publications
569 National Center
Reston, VA 20192

http://pubs.usgs.gov/publications/

For More Information

Access EarthFax, the fax-on-demand system for sending documents directly to your facsimile machine. EarthFax is available 24 hours a day at (703) 648-4888.

Access The Learning Web, the USGS World Wide Web site for K-12 educational information, at **http://www.usgs.gov/education/**

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Memoranda of Understanding for Fiscal Year 1995

Domestic Agreements
U.S. Geological Survey

Counterpart organization(s)	Description
•Bureau of Reclamation	Development, testing, and implementation of water-resources models and fully integrated data management systems as part of the Watershed Modeling Systems Initiatives.
•Cedar Lane Center Fairfax County Public Schools Vienna, Va.	Establish partnership in education to provide the Center with available and feasible USGS scientific and technical resources, to enrich the school curriculum with USGS missions and initiatives, and to share educational, cultural, and other activities.
•Bureau of Land Management Bureau of Mines	Provide a cooperative mechanism for proper implementation of the BLM Surface Management Program.
•Environmental Protection Agency National Biological Service National Oceanic and Atmospheric Administration	Establish the basis for a multi-agency partnership entitled Multi-Resolution Land Characteristics Consortium with the goal of joint acquisition of Landsat Thematic Mapper imagery for the conterminous United States.
•Environmental Protection Agency Food and Drug Administration Department of Energy National Oceanic and Atmospheric Administration: National Marine Fisheries Service National Ocean Survey National Aeronautics and Space Administration Deptartment of Transportation: U.S. Coast Guard Department of the Interior: Fish and Wildlife Service National Park Service National Biolgical Service Minerals Management Service U.S. Geological Survey Department of Agriculture: Natural Resources Conservation Service Cooperative State Research, Education, and Extension Service U.S. Forest Service U.S. Army U.S. Navy U.S. Air Force States of Texas, Louisiana, Mississippi, Alabama, and Florida	Support to the Gulf of Mexico Program. Develop and implement a strategy for protecting, restoring, and maintaining the health and productivity of the Gulf of Mexico.
•Federal Children's Center Herndon, Va.	Partnership in Education Program. Provide school with USGS resources, enrich the school curriculum via USGS information, and provide an early opportunity to learn about the wonders of earth science.
•Truckee-Carson Irrigation District Newlands Project Fallon, Nev.	Provide access to a USGS minicomputer for retrieval of National Water Information System data according to the policy and guidelines set forth by the Water Resources Division of the USGS.

Cooperators and Other Financial Contributors

Cooperators listed are those with whom the USGS had a written agreement cosigned by USGS officials and officials of the cooperating agency for financial cooperation in fiscal year 1994. Parent agencies are listed separately from their subdivisions whenever there are separate cooperative agreements for different projects with a parent agency and with a subdivision of it. Agencies are listed in alphabetical order under the State or territory where they have cooperative agreements with the USGS. Agencies with whom the USGS has research contracts and to whom it supplied research funds are not listed.

Cooperating office of the U.S. Geological Survey
g—Geologic Division
n—National Mapping Division
w—Water Resources Division

ALABAMA

Alabama Department of—
- •Economic and Community Affairs (w)
- •Emergency Management (w)
- •Environmental Management (w)
- •Transportation - Highway Department Bridge Sites (w)

Anniston, City of (w)
Auburn University (w)
Baldwin County Commission (w)
Birmingham, City of (w)
Blountsville, Town of (w)
Century, City of, Florida (w)
Coffee County Commission (w)
Courtland, Town of (w)
Dallas County Commission (w)
Florida Department of Environmental Protection, Office of Water Policy (w)
Geological Survey of Alabama (w)
Greenville, City of (w)
Huntsville, City of (w)
Jasper Water Works & Sewer Board (w)
Jefferson County Commission (w)
Mobile, City of (w)
Montgomery, City of (w)
Parrish, Town of (w)
Prattville, City of (w)
Sumter County Commission (w)
Thomasville, City of (w)
Tuscaloosa, City of (w)

ALASKA

Alaska Department of—
- •Community and Regional Affairs, Division of Energy (w)
- •Environmental Conservation (w)
- •Fish and Game (g, w)
- •Military and Veterans Affairs (g)
- •Natural Resources (g, w)
  - Division of Water (w)
  - Division of Mining and Water Management (w)
  - Division of Oil and Gas (g)
  - Division of Geological and Geophysical Survey (g)
- •Transportation and Public Facilities (n, w)

Alaska Energy Authority (w)
AK Industrial Development and Export Authority (w)
Anchorage, Municipality of (w)
DCRA, Division of Energy (w)
Juneau, City and Borough of (w)
Kenai Peninsula Borough (w)
Sitka, City and Borough of (w)
University of Alaska, Fairbanks (g, w)

AMERICAN SAMOA

Environmental Protection Agency of American Samoa (w)
Power Authority (w)

ARIZONA

Arizona Department of—
- •Environmental Quality (w)
- •Game and Fish (w)
- •Transportation (g)
- •Water Resources (w)

Arizona State University (g)
Central Arizona Water Conservation District (w)
Cochise County Flood Control District (w)
Flagstaff, City of (w)
Gila Valley Irrigation District (w)
Gila Water Commission (w)
Havasupai Tribe (w)
Hualapai Indian Tribe (w)
Hopi Tribe (w)
Maricopa County Flood Control District (w)
Metropolitan Domestic Water Improvement District (w)
Metropolitan Water District of Southern California (w)
Navajo Nation (w)
Payson, Town of (w)
Petrified Forest Museum Association (g)
Pima County Board of Supervisors (w)
Safford, City of, Water, Gas, and Sewer Department (w)
Salt River Valley Water Users Association (w)
Show Low Irrigation Company (w)
Tohono O'Dham Nation (w)
Tucson, City of (g, w)
University of Arizona (g)
- •Research Lab for Riparian Studies (w)

Yavapi Tribe (w)

ARKANSAS

Arkansas Department of—
- •Parks and Tourism (w)
- •Pollution Control (w)

Arkansas Game and Fish Commission (w)

Arkansas Geological Commission (n,w)
Arkansas Soil and Water Conservation Commission (w)
Arkansas State Highway Commission (w)
Arkansas-Oklahoma: Arkansas River Compact Commission (w)
Fort Smith, City of (w)
Little Rock—
•Municipal Water Works (w)
University of Arkansas—
•at Fayetteville (w)
•at Little Rock (w)

CALIFORNIA

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•Flood Control and Water Conservation District (Hayward) (w)
•Water District (w)
Antelope Valley-East Kern Water Agency (w)
Atherton, City of (w)
Borrego Water District (w)
Calaveras County Water District (w)
California Department of—
•Fish and Game (w)
•Parks and Recreation (w)
•Transportation (w)
•Water Resources (w)
California Water Resources Control Board (w)
Callequas Municipal Water District (w)
Carpinteria County Water District (w)
Casitas Municipal Water District (w)
Coachella Valley Water District (w)
Contra Costa County Flood Control and Water Conservation District (w)
Contra Costa Water District (w)
CRWQCB - San Francisco Bay Region (w)
Desert Water Agency (w)
East Bay Municipal Utility District (w)
Eastern Municipal Water District (w)
Georgetown Divide Public Utility District (w)
Goleta County Water District (w)
Hetch Hetchy Water and Power (w)
Hoopa Valley Tribe (w)
Hopland Band of Pomo Indians (w)
Humboldt Bay Municipal Water District (w)
Imperial County Department of Public Works (w)
Imperial Irrigation District (w)
Irvine Ranch Water District (w)
Lompoc, City of (w)
Los Angeles, County of (w)
Madera Irrigation District (w)
Marin Municipal Water District (w)
Mendocino County Water Agency (w)
Menlo Park, City of (w)
Merced Irrigation District (w)
Metropolitan Water District of Southern California (g)
Mission Springs Water District (w)
Mojave Water Agency (g, w)
Mono, County of (w)
Montecito Water District (w)
Monterey County Water Resources Agency (w)
Monterey Peninsula Water Management District (w)
Morongo Band of Mission Indians (w)
Napa County Flood Control & Water Control District (w)
Orange County Water District (w)
Padre Dam Municipal Water District (w)
Pechanga Indian Reservation (w)
Riverside County Flood Control and Water Conservation District (w)
Sacramento Regional County Sanitation District (w)
San Benito County Water Control and Flood Control District (w)
San Bernardino Environmental Public Works Flood Control District (w)
San Bernardino Valley Municipal Water District (w)
San Diego County Department of Public Works(w)
San Francisco Water Department (w)
San Gorgonio Pass Water Agency (w)
San Juan Basin Authority (w)
San Luis Obispo County Engineering Department (w)
Santa Barbara, City of, Department of Public Works (w)
Santa Barbara County—
•Water Agency (w)
Santa Clara Valley Water District (w)
Santa Cruz, City of (w)
Santa Cruz County Flood Control and Water Conservation District (w)
Santa Maria Valley Water Conservation District (w)
Santa Ynez River Water Conservation District (w)
Scotts Valley Water District (w)
Sonoma County—
•Planning Department (w)
•Water Agency (w)
Soquel Creek County Water District (w)
Stockton, City of (w)
Sweetwater Authority (w)
Tia Juana Valley County Water District (w)
Tulare County Flood Control District (w)
Turlock Irrigation District (w)
United Water Conservation District (w)
University of California—
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•Irvine (w)
•Lawrence Livermore National Laboratory (g)
•Los Alamos National Laboratory (g)
•Los Angeles (g)
•Sanata Cruz (g)
•Stanford University (g)
Ventura County Public Works Agency (w)
Water Master—Santa Margarita River Watershed (w)
Water Replenishment District of Southern California (w)
Woodbridge Irrigation District (w)
Yolo County Flood Control and Water Conservation District (w)
Yuba County Water Agency (w)

COLORADO

Arapahoe County Water and Wastewater Authority (w)
Arkansas River Compact Administration (w)
Aurora, City of (w)
Black Hawk, City of (w)
Boulder, City of (w)
Boulder, County of, Department of Public Works (w)
Breckenridge, Town of (w)
Breckenridge Sanitation District (w)
Centennial Water and Sanitation District (w)
Center Soil Conservation District (w)
Cherokee Metropolitan District (w)
Clear Creek Board of County Commissioners (w)
Colorado Department of—
- •Agriculture (w)
- •Health (w)
- •Transportation (w)

Colorado Division of Parks and Outdoor Recreation (w)
Colorado Division of Wildlife (n, w)
Colorado Office of the State Engineer (w)
Colorado Oil and Gas Conservation Commission (g)
Colorado River Water Conservation District (w)
Colorado School of Mines (g)
Colorado Springs, City of—
- •City Manager (w)
- •Department of Public Utilities (w)

Crested Butte, Town of (w)
Crested Butte South Metro District (w)
Delta County Board of Commissioners (w)
Denver Board of Water Commissioners (n, w)
Denver, City and County (w)
Desert Research Institute (w)
Eagle County Board of Commissioners (w)
East Grand, County of, Water Quality Board (w)
Englewood, City of (w)
Evergreen Metropolitan District (w)
Fort Collins, City of (w)
Fountain Valley Authority (w)
Fremont Sanitation District (w)
Garfield, County of (w)
Glendale, City of (w)
Glenwood Springs, City of (w)
Greenwood Village, City of (w)
Gunnison, City of (w)
Gunnison, County of (w)
Lakewood, City of (w)
Lamar, City of (w)
Las Animas, City of (w)
La Plata County (w)
Longmont, City of (w)
Loveland, City of (w)
Lower Fountain Water-Quality Management Association (w)
Meeker Sanitation District (w)
Meeker, Town of (w)
Mesa, County of (n)
Metropolitan Wastewater Reclamation District (w)
Moffat, County of, Commissioners (w)
Mt. Crested Butte Water/Sanitation District (w)
Northern Colorado Water Conservation District (w)
Pueblo Board of Water Works (w)
Pueblo, City of, Department of Utilities (w)
Pueblo, County of (w)
Pueblo West Metropolitan District (w)
Purgatoire River Water Conservancy District (w)
Rio Blanco, County of (w)
Rio Blanco Water Conservancy District (w)
Rio Grande Water Conservation District (w)
Rocky Ford, City of (w)
Routt, County of (w)
St. Charles Mesa Water District (w)
Southeastern Colorado Water Conservancy District (w)
Southern Ute Indian Tribe (g, w)
Southwestern Colorado Water Conservation District (w)
Steamboat Springs, City of (w)
Teller-Park Soil Conservation District (w)
Trinchera Water Conservation District (w)
Uncompahgre Valley Water Users Association (w)
University of Colorado (g)
Upper Arkansas Council of Governments (w)
Upper Arkansas River Water Conservation District (w)
Upper Eagle Regional Water Authority (w)
Upper Gunnison River (w)
Upper Yampa Water Conservancy District (w)
Urban Drainage and Flood Control District (w)
Vail Valley Consolidated Water Authority (w)
Westminster, City of (w)
Yellow Jacket Water Conservancy District (w)

COMMONWEALTH OF NORTHERN MARIANA ISLANDS

Commonwealth Utilities Corp., Saipan (w)
Northern Mariana Islands, Commonwealth of (w) —
- •Division of Environmental Quality (w)
- •Municipality of Tinian and Aguigar(w)

CONNECTICUT

Connecticut Department of—
- •Environmental Protection (g,n,w)
- •Transportation, Bureau of Hydraulics and Drainage (w)

Fairfield, Town of, Conservation Department (w)
New Britain, City of, Board of Water Commissioners (w)
South Central Connecticut Regional Water Authority (w)
Torrington, City of (w)
Woodbury, Town of (w)

DELAWARE

Geological Survey (n,w)
University of Delaware (w)

DISTRICT OF COLUMBIA

Department of—
- •Consumer and Regulatory Affairs (w)
- •Public Works (w)

FLORIDA

Boca Raton, City of, Public Utilities (w)
Bradenton, City of, Public Works (w)
Broward, County of (w)
Cape Coral, City of, Department of Public Service (w)
Century, City of (w)
Clearwater, City of (w)
Cocoa, City of, Utilities and Public Works (w)
Daytona Beach, City of (w)
Deerfield Beach, City of (w)
Dunedin, City of, Public Works and Utilities (w)
Florida Department of—
•Environmental Protection (w)
•Environmental Regulation, Bureau of Drinking Water/Ground Water Resources (n,w)
•Natural Resources, Division of Survey and Mapping (n)
•Transportation (n,w)
Florida Keys Aqueduct Authority (w)
Fort Lauderdale, City of, Utilities Department (w)
Game and Freshwater Fish Commission (w)
Hallandale, City of, Utilities and Engineering (w)
Hillsborough, County of (w)
Hollywood, City of, Public Utilities (w)
Institute of Phosphate Research (w)
Jacksonville, City of, Department of Public Utilities (w)
Jacksonville Electric Authority (w)
Lake, County of (w)
Lee, County of, Division of Natural Resources Management (w)
Manatee County (w)—
•Public Services Department (w)
•Environmental Action Commission (w)
Metropolitan Dade County (w)
Miami-Dade Water and Sewer Authority (w)
North Port Water Control District (w)
Northwest Florida Water Management District (w)
Orange County of (w)
Orange County Public Works (w)
Orlando, City of (w)
Perry, City of (w)
Pinellas, County of, Department of Public Works and Utilities (w)
Reedy Creek Improvement District (w)
Sarasota, City of (w)
Sarasota, County of (w)
Seminole, County of (w)
South Florida Water Management District (g, w)
South Indian River Water Control (w)
Southwest Florida Water Management District (n, w)
St. Johns River Water Management District (g, w)
St. Petersburg, City of, Public Utilities (w)
Suwannee River Water Management District (w)
Tallahassee, City of—
•Electric Department (w)
•Water Quality Laboratory (w)
Tampa, City of, Water Department (w)
University of Florida (g)
Volusia, County of (w)
Walton, County of (w)
West Coast Regional Water Supply Authority (w)

FREELY ASSOCIATED STATES

Palau, Government of (w)

GEORGIA

Albany Doughtery Planning Commission (w)
Albany Water, Gas, and Light Commission (w)
Athens-Clarke County, Department of Public Utilities (w)
Atlanta, City of, Office of Public Works (w)
Attapulgus, City of (w)
Bibb, County of (w)
Blairsville, Town of (w)
Brunswick, City of (w)
Chatham, County of (w)
Cherokee County Water and Sewage Authority (w)
Clayton County Water Authority (w)
Covington, City of (w)
De Kalb County Public Works Department (w)
Douglas, County of, Department of Planning and Zoning (w)
Florida Department of Environmental Protection - Office of Water Policy (w)
Georgia Department of—
•Community Affairs (n)
•Natural Resources—
Environmental Protection Division (w)
Geologic Survey (w)
Water Resources Management Program (w)
•Transportation (w)—
at Atlanta (n, w)
at Forest Park (n, w)
Georgia Forestry Commission (w)
Gwinnett, County of, Department of Transportation (w)
Helena, City of (w)
Henry, County of, Board of Commissioners (w)
Lawrenceville, City of (w)
Macon Water Authority (w)
Monroe Water, Light, and Gas Commission (w)
Springfield, City of (w)
St. Johns River Water Municipal Department (w)
Thomaston, City of (w)
Thomasville, City of (w)
Tift County Commission (w)
Tifton, City of (w)
Valdosta, City of (w)

GUAM

Guam, Government of, Environmental Protection Agency (w)

HAWAII

Hawaii, County of, Department of Water Supply (w)
Hawaii Department of—

•Agriculture, Agricultural Resource Management Division (w)
•Land and Natural Resources (g)—
Commission on Water Resources Management (w)
Division of Forestry and Wildlife (n)
•Transportation (w)
Honolulu, City and County of—
•Board of Water Supply (w)
•Department of Public Works (w)
Kauai, County of, Department of Water Supply (w)
Maui, County of, Department of Water Supply (w)
National Tropical Botanical Gardens (w)
Office of State Planning (n)
Hawaiian Homes Commission (w)
University of Hawaii (g)
Office of Hawaiian Affairs (w)

IDAHO

Boise, City of, Public Works Department (w)
Boise State University (g)
Clearwater Soil and Water Conservation District (w)
County of Shoshone (w)
Fremont-Madison Irrigation District (w)
Idaho Department of—
•Health and Welfare, Division of Environmental Quality (w)
•Transportation (n)
•Water Resources (w)
Nez Perce Indian Tribe (w)
Salmon River Canal Co., Ltd. (w)
Southwest Irrigation District (w)
Water District No. 01 (Idaho Falls) (w)
Water District No. 31 (Dubois) (w)
Water District No. 32D (Dubois) (w)

ILLINOIS

Bloomington and Normal Sanitary District (w)
Campton Township, Board of Trustees (w)
Champaign, City of (w)
Cook County Forest Preserve District (w)
Danville Sanitary District (w)
Decatur, City of (w)
DeKalb, City of, Public Works Department (w)
DuPage County Forest Preserve, Planning and
Development Section (w)
DuPage County Department of Environmental
Conservation (w)
Illinois Department of—
•Conservation (w)
•Natural Resources (n)
Geological Survey Division (n)
State Water Survey (w)
•Transportation—
Division of Highways (n, w)
Division of Water Resources (n,w)
Illinois Environmental Protection Agency (w)
Illinois State Geological Survey (n)
Kane, County of (w)
Kankakee Soil and Water Conservation District (w)
Lake County Department of Planning, Zoning and
Environmental Quality (w)
McHenry County Conservation District (w)
Monticello, City of (w)
Oak Brook, Village of (w)
Otter Creek Lake Utility District (w)
Springfield, City of (w)
University of Illinois (w)
Urbana, City of (w)
Vermilion, County of (w)
Winnebago County Department of Public Works (w)

INDIANA

Carmel, Town of, Utilities (w)
Elkhart, City of, Water Works (w)
Indiana Department of—
•Environmental Management (w)
•Natural Resources (n)—
Division of Water (w)
•Transportation (w)
Indianapolis, City of, Department of Public Works (w)
Purdue University (w)
St. Joseph River Basin Commission (w)

IOWA

Ames, City of (w)
Cedar Rapids, City of, Engineering Department (w)
Clinton, City of (w)
Coralville, City of (w)
Davenport, City of (w)
Des Moines, City of (w)
Fort Dodge, City of (w)
Geological Survey Bureau (n, w)
Institute of Hydraulic Research (w)
Iowa City, City of (w)
Iowa Department of Transportation, Highway Division (w)
Iowa State University (w)
Muscatane Water and Light Board (w)
Sioux City, City of (w)
University of Iowa (w)
•Hygienic Laboratory (w)

KANSAS

Arkansas River Compact Administration (w)
Cameron, City of, Missouri (w)
Equus Beds Groundwater Management District No. 2 (w)
Harvey County Conservation Distict (w)
Hays, City of (w)
Iowa Tribe of Kansas and Nebraska (w)
Johnson, County of, Department of Public Works (w)
Kansas Geological Survey (n, w)
Kansas Highway Commission (w)
Kansas State Board of Agriculture (w)
Kansas State Conservation Commission (w)
Kansas State University Department of Agronomy (w)

Kansas University Center for Research, Inc. (w)
Kansas Water Office (n, w)
Kickapoo Tribe of Kansas (w)
Lake Region Resources Conservation Council, Inc. (w)
Prairie Bend Potawatomie Tribe (w)
Riley, County of (w)
Sac and Fox Tribe of Missouri (w)
Topeka Public Works (w)
Wichita, City of (w)

KENTUCKY

Bullitt, County of (w)
Campbellsville Municipal Water (w)
Carrollton, City of (w)
Elizabethtown, City of (w)
Georgetown, City of (w)
Glasgow Water Company (w)
Kentucky Department of—
•Health Services (w)
•Natural Resources and Environmental Protection Cabinet (w)
Kentucky River Authority (w)
Kentucky Water Office (n)
Louisville, City of (w)
•Office of Health and Environment (w)
Madison County Conservation District (w)
Metropolitan Sewer District (w)
Owensboro, City of (w)
University of Kentucky, Kentucky Geological Survey (n)
University of Louisville (w)

LOUISIANA

Amite River Basin River Commission (w)
Calcasieu Parish (w)
Capital-Area Groundwater Commission (w)
East Baton Rouge Parish (w)
Lake Pontchartrain Foundation (w)
Louisiana, Department of—
•Environmental Quality (w)
•Natural Resources (n, w)
•Transportation and Development—
Bridge Hydraulics (w)
Office of Public Works (n, w)
•Wildlife and Fisheries (w)
Louisiana Geological Survey (n)
Louisiana Office of Emergency Preparedness (w)
LSU - Coastal Ecology Instutite (w)
Sabine River Compact Administration (w)
St. John the Baptist Parish (w)
St. Tammany Parish (w)
West Monroe, City of (w)

MAINE

Greater Portland Council of Governments (w)
Jay, Town of (w)
Maine Department of—
•Environmental Protection (w)
•Human Services (w)
•Transportation (w)
Maine Geological Survey (w)
Northern Maine Regional Planning Commission (w)
Portland Water District (w)
University of Maine at Orono (w)
Windham, Town of (w)

MARYLAND

Baltimore, City of, Water Quality Management (w)
Calvert County Soil Conservation (w)
Interstate Commission on the Potomac River Basin (w)
Maryland Department of the Environment, Water Management Administration (w)
Maryland Geological Survey (n,w)
Maryland State Highway Administration, Office of Bridge Development (w)
University of Maryland (g)

MASSACHUSETTS

Cape Cod Commission (w)
Dartmouth, Town of (w)
Executive Office of Environmental Affairs (n)
Massachusetts Department of—
•Office of Watershed Management (w)
•Environmental Management—
Bureau of Resource Protection (w)
Division of Resource Conservation (w)
Division of Water Supply (w)
•Environmental Protection—
Office of Watershed Managements (w)
Bureau of Wastesite Cleanup (w)
Massachusetts Highway Department (w)
Massachusetts Water Resources Authority (w)
Metropolitan District Commission—
•Parks, Engineering and Construction Division (w)
•Watershed Management Division (w)
Rehoboth, Town of (w)
Woods Hole Oceanographic Institution (g)
Westborough, Town of (w)

MICHIGAN

Antrim County Drain Commission (w)
Battle Creek, City of—
•Board of Public Utilities (w)
Bay Mills Indian Community (w)
Big Rapids, City of (w)
Cadillac, City of (w)
Charter Township of Ypsilanti (w)
Clare, City of (w)
Coldwater, City of (w)
Delta Charter Township (w)
Elsie, Village of, Department of Public Works (w)
Gerrish Township (w)
Huron-Clinton Metropolitan Authority (w)
Huron County Board of Commissioners (w)

Imlay, City of (w)
Kalamazoo, City of, Department of Public Works (w)
Lac Vieux Desert Indian Tribe (w)
Lansing Board of Water and Light (w):
Michigan Department of—
•Agriculture, Pesticide and Plant Management (w)
•Transportation (w)
Portage, City of (w)
Portland, City of (w)
Sault Ste, Marie IndianTribe (w)
Southeast Michigan Council of Governments (w)
Tri-County Regional Planning Commission (w)
Wayne, County of
•Department of Environment (n)
•Department of Public Works (w)
•Division of Environmental Health (w)
Ypsilanti Community Utilities Authority (w)

MINNESOTA

Beltrami County SWCD (w)
Boris Forte Lake Superior Band of Chippewa Indians (w)
East Otter Tail Soil and Water Conservation District (w)
Elm Creek Conservation Management and Planning Commission (w)
Grand Portage Reservation Tribal Council (w)
Land Management Information Center (n)
Lower Sioux Indian Community (w)
Minnesota Department of—
•Natural Resources (g,w)
•Transportation (w)
Minnesota Pollution Control Agency (w)
Pennington Soil and Water Conservation District (w)
Pine County Soil and Water District (w)
Prairie Island Indian Community (w)
Red River Watershed Management Board (w)
Rochester, City of (w)
Shakopee Mdewakanton Sioux Community (w)
Upper Sioux Indian Community (w)

MISSISSIPPI

Harrison, County of (w)
Jackson, City of (w)
Jackson County—
•Board of Supervisors (w)
Mississippi Department of—
•Agriculture and Commerce (w)
•Highways (w)
Mississippi Institute of Higher Learning (n)
Mississippi State University (g)
Office of Land and Water Resources (w)
Office of Pollution Control (w)
Pat Harrison Waterway District (w)
Pearl River Basin Development District (w)
Pearl River Valley Water Supply District (w)

MISSOURI

Cameron, City of (w)
Cass County Soil and Water Conservation District (w)
Columbia, City of, Department of Public Works (w)
Illinois Environmental Protection Agency (w)
Independence, City of, Water Department (w)
Jefferson City Division of Health (w)
Mid-America Regional Council (w)
Missouri Department of—
•Conservation (n,w)
•Natural Resources, Division of Geology and Land Survey (n,w)
Division of Environmental Qaulity (w)
Division of Parks, Recreation, and History (w)
Missouri Highway and Transportation Commission (w)
Springfield, City of, Engineering Department (w)
St. Francois County Environmental Corporation (w)

MONTANA

Blackfeet Nation (w)
Chippewa Creek Tribe of Rocky Boys Reservation (g)
Fort Peck Indian Reservation (w)
Judith Basin Conservation District (w)
Lewis and Clark City-County Health Department (w)
Lower Yellowstone Irrigation Project (w)
Montana Bureau of Mines and Geology (w)
Montana Department of—
•Fish, Wildlife and Parks (w)
•Health and Environmental Sciences (w)
•Justice (w)
•Natural Resources and Conservation (w)
•State Lands (w)
•Transportation (w)
North Powell Conservation District (w)
Northern Cheyenne Tribe (w)
Ravalli County Commissioners (w)
Salish and Kootenai Tribes (w)
Two Leggings Water Users Association (w)
Wyoming State Engineer (w)

NEBRASKA

Blue River Compact Administration (w)
Central Platte Natural Resources District (w)
Lancaster County Board of Commissioners (w)
Lincoln, City of (w)
Loup River Public Power District (w)
Lower Elkhorn Natural Resources District (w)
Lower Platte North Natural Resources District (w)
Lower Platte South Natural Resources District (w)
Lower Republican Natural Resources District (w)
Middle Republican Natural Resources District (w)
Nebraska Department of—
•Roads (w)
•Environmental Quality (w)
•Health (w)
•Water Resources (w)

Nebraska Game and Parks Commission (w)
Nebraska Natural Resources Commission (w)
Nemaha Natural Resources District (w)
North Platte Natural Resources District (w)
Papio-Missouri River Natural Resources District (w)
South Platte Natural Resources District (w)
Tecumseh, City of (w)
Twin Platte Natural Resources District (w)
University of Nebraska, Conservation and Survey Division (w)
Upper Big Blue Natural Resources District (w)
Upper Loup Natural Resources District (w)
Upper Niobrara-White Natural Resources District (w)
Upper Republican National Resources District (w)

NEVADA

Carson City Utilities Department (w)
Carson Water Subconservancy District (w)
Churchill, County of (w)
Clark County Regional Flood Control District (w)
Clark County Sanitation District (w)
Douglas, County of (w)
Duck Valley Reservation (w)
Henderson, City of (w)
Las Vegas Valley Water District (g,w)
Nevada Bureau of Mines and Geology (g,n,w)
Nevada Department of—
- •Conservation and Natural Resources—
  - Division of Environmental Protection (w)
  - Division of Water Resources (w)
- •Transportation (w)
- •Wildlife (w)

Pyramid Lake Paiute Tribal Council (w)
Sparks, City of (w)
State of Nevada (g)
Summit Lake Paiute Indian Tribe (w)
Tahoe Regional Planning Agency (w)
Truckee Meadows Fire Protection District (n)
Walker River Pauite Tribe (w)
Washoe, County of, Department of Public Works (w)
Washoe County Planning Department (n)

NEW HAMPSHIRE

Keene, City of (w)
New Hampshire Department of—
- •Environmental Services (w)
- •Transportation (n)

Rochester, City of (w)

NEW JERSEY

Atlantic Highlands, Borough of (w)
Bergen, County of (w)
Brick Township Municipal Utility Authority (w)
Byram Township Environmental Commission (w)
Delaware River Basin (w)
Gloucester County Planning Deparmtnet (w)
Medford, Township of (w)
Mercer County Park Commission (w)
Morris County Municipal Utility Authority (w)
New Brunswick, City of (w)
New Jersey Department of—
- •Environmental Protection (n,w)
- •Transportation (w)

New Jersey Water Supply Authority (w)
North Jersey District Water Supply Commission (w)
Passaic Valley Water Commission (w)
Pennsylvania Department of Environmental Protection (w)
Pinelands Commission (w)
Rutgers State University, Department of Radiation and Environment (w)
Somerset County Board of Chosen Freeholders (w)
Washington Township Municipal Utility Authority (w)
West Windsor, Township of (w)

NEW MEXICO

Albuquerque, City of—
- •Public Works Department—
  - Hydrology Division (w)
  - Water Utility Planning Division (w)
  - Waste Water Division (w)

Albuquerque Metropolitan Arroyo Flood Control Authority (w)
Canadian River Water Authority (w)
Costilla Creek Compact Commission (w)
Elephant Butte Irrigation District (w)
El Paso, City of, Water Utilities (w)
El Paso County Water Improvement (w)
La Cienega Acequia (w)
Las Cruces, City of (w)
New Mexico Department of—
- •Environment (w)
- •Highways and Transportation (w)

New Mexico State University, Water Resources Research Institute (w)
Office of the State Engineer (w)
Pecos River Compact Commission (w)
Pueblo de Cochiti (w)
Pueblo of Zuni (w)
Raton, City of (w)
Rio Grande Compact Commission (w)
Rio San Jose Flood Control District (w)
Ruidoso, Village of (w)
Santa Rosa, City of (w)
Texas Water Development Board (w)
Tribal Council of the Pueblo of Nambe (g)
University of New Mexico (n)

NEW YORK

Amherst, Town of, Engineering Department (w)
Auburn, City of (w)
Camillus, Town of (w)
Chautauqua County Department of Planning and Development (w)
Clifton Park Water Authority (w)

Cornell University (w)
Erie, County of (w)
Hudson-Black River Regulating District (w)
Ithaca, City of, Department of Public Works (w)
Livingston, County of (w)
Monroe County Department of Health (w)
Nassau County Department of Public Works(w)
•Division of Sanitatin and Water Supply (w)
New York City Environmental Protection Administration, Bureau of
Water Supply and Wastewater (w)
New York State Department of—
•Environmental Conservation, Planning, and Restoration, Bureau of Monitoring and Assessment (w)
•Health, Bureau of Public Water Supply Protection (W)
•Transportation (w)
New York State Power Authority (w)
Nyack, Village of, Board of Water Commissioners (w)
Onondaga, County of—
•Department of Drainage and Sanitation (w)
•Water Authority (w)
Saratoga Springs, Office of the Commissioner of Public Works (w)
Seneca Nation of Indians (w)
State University at Syracuse, Department of Environmental Sciences and Forestry (w)
Suny at Buffalo (w)
Suffolk, County of—
•Department of Health Services (w)
•Water Authority (w)
Ulster, County of (w)
•Health Department (w)
Victor, Village of (w)

NORTH CAROLINA

Appalachian State University (g)
Asheville, City of (w)
Bethel, Town of (w)
Brevard, City of (w)
Chapel Hill, Town of (w)
Charlotte, City of (w)
Charlotte - Mechlinberg Utility Department (w)
Danville, Virginia, City of (w)
Durham, City of (w)
Greensboro, City of (w)
Jackson, County Commissioners (w)
Lexington, City of (w)
Lumber River Council of Governments (w)
Mecklenburg, County of (w)
Morganton, City of (w)
North Carolina Cooperative Extension Service, Dallas and Raleigh (w)
North Carolina State Department of—
•Environment, Health, and Natural Resources (n,w)
•Transportation (w)
Orange County (w)
Raleigh, City of (w)
Rocky Mount, City of (w)
Triangle Area Water Supply Monitoring, Project Steering Committee (w)
University of Nebraska, Civil Engineering Department (w)
University of North Carolina, Wilmington, (g)
Western Piedmont Council of Governments (w)

NORTH DAKOTA

Barnes County Soil Conservation District (w)
Cass County Joint Water Resources District (w)
Devils Lake Sioux Tribe (w)
Dickinson, City of (w)
Grand Forks, City of (w)
Lower Heart Water Resources District (w)
Minnesota Pollution Control (w)
Minot, City of (w)
North Dakota Department of Transportation (w)
North Dakota Geological Survey (n)
North Dakota Industrial Commission (n)
Red River Joint Water Management Board (w)
Red River Watershed Management Board (w)
Southeast Cass Water Resources (w)
State Health Department (w)
State Water Commission (w)
Three Affiliated Tribes (w)
Turtle Mountain Tribe (w)

OHIO

Akron, City of (w)
Canton, City of (w)
Columbus, City of, Division of Water (w)
Eastgate Development Transportation Agency (w)
Franklin, County Commissioners (w)
Fremont, City of (w)
Geauga, County of, Planning Commission (w)
Lima, City of (w)
Madison, County Commissioners (w)
Miami Conservancy District (w)
Midwest University, Consortium for International Activities (g)
N.E. Ohio Regional Sewer District (w)
Ohio EPA (w)
Ohio Department of—
•Natural Resources (w)
•Transportation (n,w)
Ohio State University, Department of Agronomy (w)
Ross, County of, Board of Commissioners (w)
Sumit County Engineers (w)
Toledo, City of, and Ohio State University (w)
Washington, County Commissioners (w)

OKLAHOMA

Canadian River Municipal Water Authority (w)
Henryetta, City of (w)
McGee Creek Authority (w)
Oklahoma City, City of (w)—

•Water and Waster Water Utility (w)
•Texas Water Development Board (w)
Office of the Secrtary of the Environment (w)
Oklahoma Conservation Commission (w)
Oklahoma Department of Transportation (n)
Oklahoma Department of Wildlife Conservation (w)
Oklahoma Geological Survey (w)
Oklahoma State University, Division of Agricultural Sciences and Natural Resources (w)
Oklahoma Water Resources Board (w)
Ponca Tribal Business Committee (w)
Sac and Fox Nation (w)
Tulsa, City of (w)

OREGON

Albany, City of (w)
Ashland, City of (w)
Bend, City of (w)
Clackamas County (w)
Coos, County Board of Commissioners (w)
Coos Bay-North Bend Water Board (w)
Douglas, County of, Natural Resources Division (w)
Eugene, City of, Water and Electric Board (w)
Grand Ronde ConFed Tribes (w)
Gresham, City of, Department of Environmental Services (w)
Jackson, County of, Department of Planning and Development (w)
Jefferson County Commission (w)
McMinnville, City of (w)
Oregon Association, Clean Water Agencies (w)
Oregon Department of—
•Energy (w)
•Environmental Quality (w)
•Human Resources, State Health Division (w)
•Transportation, Highway Division (g, w)
•Water Resources (w)
Oregon State University (g)
Portland, City of—
•Bureau of—
Environmental Services (w)
Water Works (w)
Unified Sewerage Agency (w)
Warm Springs Tribal Council (w)
Washington State Department of Ecology (w)
West Linn, City of (w)

PENNSYLVANIA

Allentown, City of, Engineering Department (w)
Bethlehem, City of (w)
Bucks, County of (w)
Chester County Water Resources Authority (w)
Delaware County Solid Waste Authority (w)
Delaware Geological Survey (w)
Delaware River Basin Commission (w)
Delaware DNREC, Division of Soil and Water Conservation (w)
Doylestown Township Municipal Authority (w)
Environmental Conservation Planning and Restoration (w)
Harrisburg, City of, Department of Public Works (w)
Hazelton City Authority Water Department (w)
JPC Lehigh-Northampton Counties (g, w)
JeffersonCounty (w)
Letort Regional Authority (w)
Media Borough Water Department (w)
New Oxford Municipal Authority (w)
North Penn Water Authority (w)
North Wales Water Authority (w)
Philadelphia, City of, Water Department (w)
Pennsylvania Department of—
•Environmental Resources—
Bureau of—
Land and Water Conservation (w)
Mining and Reclamation (w)
Water Supply and Community Health (w)
•Transportation (w)
Pennsylvania State University (w)
Roaring Spring Municipal Authority (w)
Somerset Conservation District (w)
Sunbury, City of, Municipal Authority (w)
Susquehanna River Basin Commission (w)
Union County Emergency Management Services (w)
University Area Joint Authority (w)
Warwick Township (w)
Williamsport, City of (w)

PUERTO RICO

Puerto Rico Aqueduct and Sewer Authority (w)
Puerto Rico Department of—
•Health (w)
•Natural and Environmental Resources (w)
Puerto Rico Civil Devense (w)
Puerto Rico Electric Power Authority (w)
Puerto Rico Environmental Quality Board (w)
Puerto Rico Industrial Development Company (w)
Puerto Rico Mineral Resources Development Corporation (g)
University of Puerto Rico - Department of Environmental Health (w)

RHODE ISLAND

Narragansett Bay Water Quality Commission (w)
North Kingstown, Town of (w)
Providence, City of, Water Supply Board (w)
Rhode Island State Department of Environmental Management—
•Division of —
Freshwater Wetlands (w)
Water Resources (w)
Water Supply (w)
State Water Resources Board (w)

SOUTH CAROLINA

Anderson, City of (w)
Beaufort-Jasper County Water Authority (w)
Camden, City of (w)
Charleston Harbor Project (w)
Charleston Public Works (w)
Clarendon Sumter Soil and Water Conservation District (w)
Clemson University (w)
East Carolina University, Department of Biology (w)
Greer Commission of Public Works (w)
Land Resources Conservation Commission (n)
Laurens County Water and Sewer Commission (w)
Mt. Pleasant Waterworks and Sewer Department (w)
Myrtle Beach, City of (w)
Oconee County Sewer Commission (w)
South Carolina State—
- •Department of—
  - Health and Environmental Control (w)
  - Transportation, Construciton, Engineering and Planning (w)
  - Natural Resources, Water Resources Division (w)
- •Public Service Authority (w)

Spartanburg Sanitary Sewer District (w)
Spartanburg Water System (w)
University of South Carolina
- •Department of Environmental and Health Services (w)
- •Coastal Carolina College (g)

Waccamaw Regional Planning and Development Council (w)
Western Carolina Regional Sewer Authority (w)

SOUTH DAKOTA

Area II Minnesota River Basin (w)
Belle Fourche Irrigation District (w)
Cheyenne River Sioux Tribe (w)
East Dakota Water Development District (w)
Faulk Conservation District (w)
Lake Kampeska Water Project District (w)
Lawrence, County of (n)
Lower Brule Sioux Tribe (w)
Mellette, County of (w)
North Sioux City, City of (w)
Ogallala Sioux Tribe, Department of Natural Resources (w)
Pelican Lake Water Project District (w)
Rapid City, City of Public Works Department (n, w)
Roberts, County of (w)
Rosebud Sioux Tribe, Office of Water Resources (w)
Sioux Falls, City of, Utility Department (w)
Sisseton-Wahpeton Dakota Nation (w)
South Dakota Department of—
- •Agriculture (n)
- •Environmental Natural Resources (n)
  - Environmental Regulation Division (w)
  - Geological Survey Division (w)
  - Water Rights Division (w)
- •Game, Fish and Parks (w)
  - Custer State Park Division (w)
- •Transportation (n, w)

South Dakota School of Mines and Technology (n)
South Dakota State University, Civil Engineering Department (w)
Spearfish, City of (w)
Stanley County Conservation District (w)
Union Cunty Commission (w)
Vermillion Basin Water Development District (w)
Watertown, City of (w)
West Dakota Water Development District (n, w)
West River Water Development District (w)
Wyoming State Engineer (w)

TENNESSEE

Alcoa, City of (w)
Athens Utility Board (w)
Bedford County (w)
Camden, City of (w)
Crossville, City of (w)
Dickson, City of (w)
Dickson City Solid Waste Authority (w)
Duck River Development Agency (w)
Eastside Utility District (w)
Franklin, City of (w)
Germantown, City of (w)
Grundy County Soil Conservation District (w)
Harriman Utility Board (w)
Harpeth Valley Utility District (w)
Hixson Utility District (w)
Johnson City, City of, Public Works Department (w)
Knoxville, City of (w)
Lewisburg, City of (w)
Memphis, City of, Light, Gas, and Water Division (w)
Memphis Department of Public Works (w)
Metropolitan Governments, Nashville, City of, and Davidson, County of (w)
Murfreesboro, City of, Water and Sewer Department (w)
Red Boiling Springs, Town of (w)
Rogersville, Town of (w)
Savannah Valley Utility District (w)
Sevierville, City of (w)
Shelby, County of (w)
Shelby County Soil Conservation District (w)
Springfield, City of (w)
Tennessee Department of—
- •Agriculture (w)
- •Environment and Conservation, Division of Water Managements (w)
- •Transportation (w)

Tennessee Ocoee Development Agency (w)
Tennessee Wildlife Resources Agency (w)
Tullahoma Utilities Board (w)
University of Tennessee Agricultural Extension Service (w)
Wartrace, Town of (w)

TEXAS

Abilene, City of (w)
Arlington, City of (w)
Austin, City of (n, w)
Barton Springs/Edwards Aquifer Conservation District (w)
Bexar-Medina-Atascosa Water District No. 1 (w)
Brazos River Authority (w)
Canadian River Water Authority (w)
Central Texas Council of Governments (w)
Coastal Water Authority (w)
Colorado River Municipal Water District (w)
Corpus Christi Bay National Estuary (w)
Corpus Christi, City of (w)
Dallas, City of (w)
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- •Water Utilities Department (w)

Edwards Underground Water District (w)
El Paso County Water Improvement (w)
Fort Bend Subsidence District (w)
Fort Worth, City of (w)
Gainesville, City of (w)
Galveston, County of (w)
Georgetown, City of (w)
Graham, City of (w)
Greenbelt Municipal and Industrial Water Authority (w)
Guadalupe-Blanco River Authority (w)
Harris, County of, Flood Control District (w)
Harris-Galveston Coastal Subsidence District (w)
Houston, City of (w)
Houston-Galveston Area Council (w)
Lavaca-Navidad River Authority (w)
Lower Colorado River Authority (w)
Lower Neches Valley Authority (w)
Lubbock, City of (w)
Nacogdoches, City of (w)
North Central Texas Council of Governments (w)
North East Texas Municipal Water District (w)
North Texas Municipal Water District (w)
Orange, County of (w)
Pecos River Commission (w)
Sabine River Authority of Texas (w)
Sabine River Compact Administration (w)
San Angelo, City of (w)
San Antonio, City of—
- •Public Service Board (w)
- •Water Systems (w)

San Antonio River Authority (w)
San Jacinto River Authority (w)
Somerville County Water District (w)
Tarrant, County of, Water Control and Improvement District No. 1 (w)
Texas Agricultural Experiment Station (w)
Texas Department of Information Resources (n)
Texas General Land Office (n)
Texas Natural Resource Conservation Committee (w)
Texas Soil and Water Conservation Board (w)
Texas State Department of Transportation (w)
Texas Water Development Board (n,w)
Titus, County of, Fresh Water District (w)
Trinity River Authority (w)
Utah - Department of Geological Science (w)
University of Texas, Austin (g)
Upper Guadalupe River Authority (w)
West Central Texas Municipal Water District (w)
Wichita, County of, Water Improvement District No. 2 (w)
Wichita Falls, City of (w)

U.S. VIRGIN ISLANDS

Virgin Islands Department of Planning and Natural Resources (w)

UTAH

Arizona Department of Water Resources (w)
Automated Geographic Reference Center (n)
Bear River Commission (w)
Central Utah Water Conservation District (w)
Goshute Tribal Government (g)
Grantsville, City of (w)
Kanab, City of, Water Department (w)
Kane County Water Conservancy District (w)
Nephi, City of (w)
Nevada Department of Conservation and Natural Resources (w)
Ogden River Water Users Association (w)
Park City Public Works (w)
Salt Lake, County of, Flood Control (w)
St. George, City of, Water Reclamation Department (w)
Tooele, City of (w)
Tooele, County of (w)
University of Utah (g)
Utah Department of—
- •Environmental Health, Division of Water Quality (w)
- •Natural Resources (g)—
  - Division of Environmental Response and Remediation (w)
  - Division of State Lands and Forestry (w)
  - Geological and Mineral Survey (n)
  - Oil, Gas, and Mining Division (w)
  - State of Utah (g)
  - Water Resources Division (w)
  - Water Rights Division (w)

Utah State University (w)
Utah Division of Wildlife Resources (w)
Washington County Water Conservation District (w)
Weber Basin Water Conservancy District (w)
Weber River Water Users Association (w)

VERMONT

Agency of—
- •Administration (n)
- •Natural Resources (g,n)
- •Transportation (w)
  - Engineering Services Division (w)

Department of Environmental Conservation (w)

VIRGINIA

Alexandria, City of (w)
Danville, City of (w)
Hampton Roads Planning Commission (w)
James City, County of (w)
Newport News, City of (w)
Norfolk, City of (w)
Northern Virginia Planning District Commission (w)
Prince William Public Works (w)
Roanoke, City of (w)
Southeastern Public Service Authority of Virginia (w)
University of Virginia, Department of Environmental Sciences (w)
Virginia Department of—
- •Conservation and Reclamation (w)
- •Environmental Quality (w)
- •Highways and Transportation (w)
- •Mines, Minerals, and Energy, Division of Mineral Resources (n)

Virginia Polytechnic Instutite and State University (w)
Washington County Service Authority (w)
West Piedmont Planning District Commission (w)

WASHINGTON

Aberdeen, City of (w)
Bellevue, City of (w)
Chelan, County of, Public Utility District No. 1 (w)
Clallam County Department of Community Development (w)
Douglas, County of, Public Utility District No. 1 (w)
Fish and Wildlife (w)
Hoh Indian Tribe (w)
Kent, City of (w)
King County Department of Public Works (w)
Lewis County Board of Commissioners (w)
Lower Elwha Tribal Community Council (w)
Makah Indian Tribe (w)
Muckleshoot Indian Tribe (w)
Nisqually Indian Tribe (w)
Oregon Department of Fish and Wildlife (w)
Pierce, County of, Public Works Department (w)
Port Townsend, City of (w)
Quileute Tribal Council (w)
Quinault Indian Business Committee (w)
Seattle, City of, Light Department (w)
Skagit County Department of Public Works (w)
Skokomish Indian Tribe (w)
Snohomish, County of—
- •Board of Commissioners (w)
- •Public Utilities (w)

Spokane County Conservation (w)
Spokane County Commissioners (n)
Tacoma, City of, Department of—
- •Public Utilities (w)
- •Public Works (w)

Tacoma-Pierce County Health (w)
Thurston County Department of Public Works (w)
Umatilla Tribal Council (w)
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- •Fisheries and Wildlife (w)
- •General Administration (w)
- •Health (w)
- •Highways (w)
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- •Natural Resources (n, w)

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Whatcom County Planning Department (w)
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New Martinsville, City of (w)
West Virginia Division of—
- •Environmental Protection (w)
- •Abandoned Mines and Reclamation (w)
- •Highways (w)

West Virginia Geological and Economic Survey (g, w)
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Auburn, Town of (w)
Barron, City of (w)
Beaver Dam, City of (w)
Big Muskego Lake District (w)
Brookfield, City of (w)
Dane, County of—
- •Department of Public Works (w)
- •Regional Planning Commission (w)

Darboy Sanitary District (w)
Delavan, Town of (w)
Desert Research Institute (w)
Dodge, County of (n)
Douglas, County of (n)
Druid Lake Inland Protection and Rehabilitation District (w)
Eagle Spring Lake Management (w)
Fond Du Lac, City of (w)
Fontana Walworth Water Pollution Control Commission (w)
Fowler Lake Management District (w)
Geological Survey (w)
Green Bay Metropolitan Sewerage District (w)
Green Lake Sanitary District (w)
Hillsboro, City of (w)
Kansasville, Town of (w)
Kaukauna Electric and Water Utilities (w)
Kimberly Water Works Department (w)
Lac Du Flambeau Indians (w)
Lake Keesus Management District (w)
Lake Nebagamon, Village of (w)
Lauderdale Lakes Lake Management District (w)
Little Arbor Vitae Protection and Rehabilitation District (w)
Little Chute, Village of (w)

Little Green Lake Protection and Rehabilitation District (w)
Little Muskego Lake District (w)
Madison Engineering Department (w)
Madison Metropolitan Sewerage District (w)
Mead, Township of (w)
Menasha, Town of, Sanitary District No. 4 (w)
Menominee Indian Tribe of Wisconsin (w)
Minnesota Pollution Control Agency, Water Quality Division (w)
Muskego, City of (w)
Montello Lake Inland Protection.and Rehabilitation District (w)
Norway, Town of (w)
Oconomowoc Lake, Village of (w)
Okauchee Lake Management District (w)
Oneida Indian Tribe of Wisconsin (w)
Park Lake Management District (w)
Peshtigo, City of (w)
Potters Lake Rehabilitation and Protection District (w)
Powers Lake Management District (w)
Pretty Lake Management District (w)
Rock, County of, Public Works Department (w)
St. Germain, Town of (w)
Southeastern Wisconsin Regional Planning Commission (w)
Sparta, City of (w)
Stockbridge-Munsee Indians (w)
Summit, Town of (w)
Thorp, City of (w)
Twin Lakes Protection and Rehabilitation District (w)
University of Wisconsin Extension, Geological and Natural History Survey (n)
Upper Nemahbin Lake Management District (w)
Waterford, Town of (w)
Waupun, City of (w)
Whitewater-Rice Lake Management District (w)
Wind Lake Management District (w)
Wisconsin Department of—
- •Justice (w)
- •Natural Resources (n, w)
- •Transportation (w)

Wittenberg, Village of (w)
Wolf Lake Management District (w)

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Arapahoe/Shoshone Joint Business Council (w)
Cheyenne Board of Public Utilities (w)
Cheyenne, City of (w)
Colorado State University (w)
Evanston, City of (w)
Freemont County Weed and Pest District (w)
Game and Fish Commission (w)
Lingle - Ft. Laramie Conservation District (w)
Midvale Irrigation District (w)
Sandia National Laboratories (w)
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Shoshone and Heart Mountain Irrigation District (w)
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South Goshen Conservation District (w)
Teton, County of (w)
Teton County Natural Resources District (w)
Water Development Commission (w)
Wyoming Department of—
- •Agriculture (w)
- •Health and Environment (w)
- •Environmental Quality (w)
- •Transporation (w)

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- Air Force Academy (w)
- Air Mobility Command (w)
- Brooks Air Force Base (w)
- Cannon Air Force Base (w)
- Dover Air Force Base (w)
- Edwards Air Force Base (g)
- Fort Campbell DAO. Inc. (w)
- Hanscom Air Force Base (w)
- Headquarters, AFTAC/AC (g)
- Hill Air Force Base (w)
- Holloman Air Force Base (w)
- Langley Air Force Base (w)
- MacDill Air Force Base (w)
- McGuire Air Force Base (w)
- Newark Air Force Base (w)
- Patrick Air Force Base (g)
- Peterson Air Force Base (g)
- Tyndall Air Force Base (w)
- Wright-Patterson Air Force Base (w)

Department of the Army (w, n)
- Aberdeen Proving Ground (w, g)
- Army Belvoir RDE Center (g)
- Army Engineering District (w)
- Army Environmental Center (w)
- Army Signal Center (w)
- Corps of Engineers (g, n, w)
- Directorate of Public Works (w)
- Fort Bragg (w)
- Fort Bliss Army Base (w)
- Fort Carson (w)

Fort Chaffee (w)
Fort Hyachuca (w)
Fort Irwin (w)
Fort Polk (w)
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Rocky Mountain Arsenal (w)
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Tooele Army Depot (w)
Topographic Engineering Center (w, g)
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90th U.S. Army Reserve Command (w)

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National Oceanic and Atmospheric Administration (g, n, w)
National Oceanic and Atmospheric Administration Damage Assessment Center (w)
National Oceanic and Atmospheric Administration Environmental Research Lab (w)
National Weather Service (w)

Department of Defense Agencies
Defense Advanced Research Projects Agency (g, n)
Defense Intelligence Agency (g)
Defense Mapping Agency (n)
Defense Nuclear Agency (g)
National Guard Bureau (w)

Department of Energy (g, n, w)
Bonneville Power Administration (w)
Hanford Project (w)
Idaho Falls Operations Office (w)
Morgantown Energy Technology Center (g)
National Geothermal Program (g)
Nevada Operations Office (w)
Nuclear Regulatory Commission (w)
Oak Ridge Operations Office (g, w)
Oakland Operations Office (g)
Pittsburgh Energy Technology Center (g)
Sandia National Laboratories (g, w)
Savannah River Operations Office (g, w)
Schenectady Naval Reactors Office (w)
Yucca Mountain Project (g, w)

Department of Health and Human Services
Center for Disease Control (w)
Department of Housing and Urban Development (g)

Department of the Interior
Bureau of Indian Affairs (g, n, w)
Bureau of Land Management (g, n, w)
Bureau of Mines (n, w)
Bureau of Reclamation (g ,n, w)
Minerals Management Service (n)
National Biological Service (w)
National Park Service (g, n, w)
Office of International Affairs (w)
Office of the Secretary (w)
U.S. Fish and Wildlife Service (n, w)

Department of Justice (w)

Department of the Navy
Naval Facilities Engineering Command
Southern Division (g, w)
Southwestern Division (g, w)
Northern Division (g, w)
Pacific Division (g, w)
Chesapeake Division (g, w)
Naval Air Warfare Center - West (g, w)
Naval Research Laboratory (g)
Naval Surface Warfare Center (w)
Naval Weapons Center, China Lake (g)
Naval Weapons Station (w)
Office of Naval Research (g, w)
Special Programs (w)
U.S. Marine Corps (w)

Department of State (g)
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Government of Saudi Arabia (g)
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Federal Highway Administration (g, w)
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Environment Research Laboratory (g)
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Region IX, San Francisco (g)
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Western Area Power Administration (n)

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United Arab Emirates (w)

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- Inter-America Development Bank (g)
- United Nations Development Program (n)
- UNESCO (w)

World Bank (w)

METRIC CONVERSION FACTORS

Multiply	By	To obtain
	Length	
millimeter (mm)	0.0394	inch
centimeter (cm)	0.3937	inch
meter (m)	3.281	foot
kilometer (km)	0.6214	mile
	Area	
square centimeter (cm2)	0.1550	square inch
square meter (m2)	1.196	square yard
hectare (ha)	2.471	acre
	Volume	
cubic centimeter (cm3)	0.06102	cubic inch
liter (L)	1.057	quart
	Mass	
kilogram (kg)	2.205	pound avoirdupois

1995 Yearbook Staff

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As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interest of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

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