Fact Sheet

United States Geological Survey
An Overview of the Stream-Gaging Program

The USGS provides maps, reports, and information to help others meet their needs to manage, develop, and protect America's water, energy, mineral, and land resources. We help find natural resources needed to build tomorrow, and supply scientific understanding needed to help minimize or mitigate the effects of natural hazards and environmental damage caused by human activities. The results of our efforts touch the daily lives of almost every American.

Introduction

The growth and development of the United States has been dependent on the availability of water resources. As the population grew during the late 1800's, people moved west into more arid regions of the country where the flow of rivers and streams was much less dependable than in the humid East. The necessity of reliable water supplies led to the need for streamflow data with which to design storage and distribution facilities. In 1889, the first stream-gaging station operated in the United States by the U.S. Geological Survey (USGS) was established on the Rio Grande near Embudo, New Mexico. The establishment of this early station was an outgrowth of efforts to train individuals to measure the flow of rivers and streams and to define standard stream-gaging procedures. As the need for streamflow data increased, the stream-gaging program operated by the USGS has grown to include, in 1994, 7,292 continuous-record stream-gaging stations (herein referred to as "stations") in the United States, Puerto Rico, and the Trust Territory of the Pacific Islands (fig. 1). More than 90 percent of these stations are operated with at least partial support from other Federal, State, and local agencies.

The stream-gaging program of the USGS does not represent a single "network" of stations, but is an aggregation of networks and individual streamflow stations that had been established for various purposes. Data from the 7,292 active stations, as well as from discontinued stations, are available through the USGS's National Water Data Storage and Retrieval System (WATSTORE) that holds mean daily-discharge data for about 18,500 locations and more than 400,000 station-years of record, or more than 146 million individual mean daily-discharge values. Additional data are added to the data base each year. The stream-discharge data base is an ever-growing resource for water-resources planning and design, hydrologic research, and operation of water-resources projects.

Funding the Program

Just as the network of stations represents an aggregation, so does the program funding. Operating funds for individual stations in the program may come from a blend of Federal funds appropriated to the USGS, funds from State and local agencies, and funds appropriated to other Federal agencies. More than 50 percent of the 7,292 stations operated in 1994 by the USGS are funded through the USGS Federal–State Cooperative Program (fig. 2). Under that program, the USGS provides up to 50 percent of the funds, and the State or local agency provides the remainder. Presently, more than 600 State and local agencies provide funds for the stream-gaging program. Other stations in the program are operated by the USGS and funded by other Federal agencies, such as the U.S. Army Corps of Engineers (COE) and the Bureau of Reclamation (BOR), to provide those agencies with the hydrologic data needed for planning and operating water-resources projects. Additionally, some of the stations are funded by the USGS to support national programs of water-resources investigations; to collect data required by court decree, treaty, or compact; and to conduct hydrologic research. The USGS provides full support for fewer than 10 percent of the stations that it operates. Many of the stations supported primarily by State, local, or other Federal agency funds are critically important to USGS-funded programs such as the National Water Quality Assessment Program.

Uses of Streamflow Data

The USGS stream-gaging program provides hydrologic information needed to help define, use, and manage the Nation's water

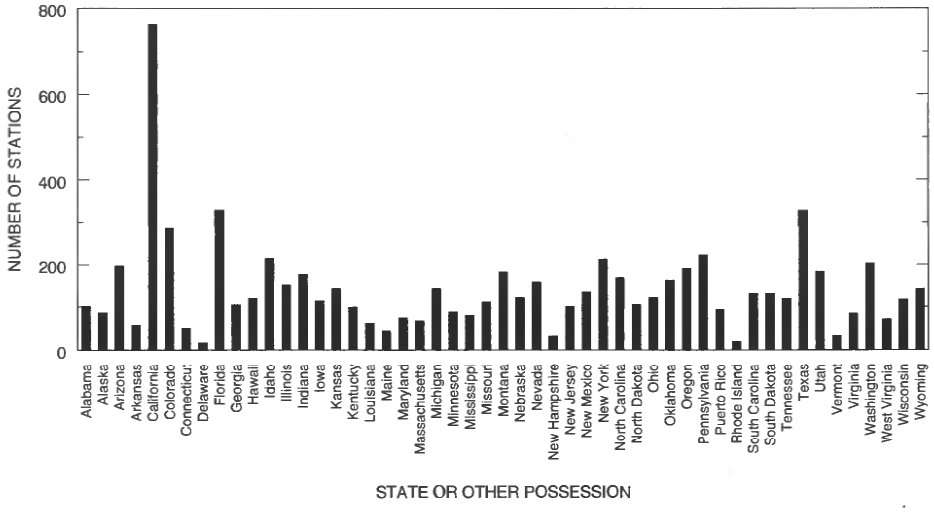
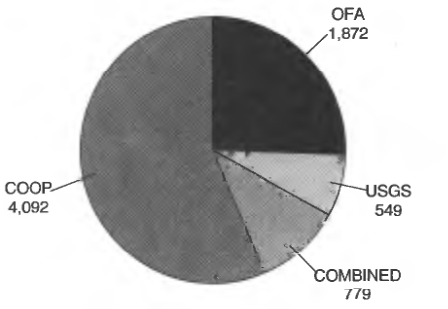


Figure 1. Number of stations operated by the U.S. Geological Survey in 1994, by State or possession.



SOURCES OF FUNDS

COOP	Combination of USGS and non-Federal agency
OFA	Other Federal agencies
USGS	USGS appropriations
COMBINED	A combination of any two or more from OFA, USGS, and COOP

Total stations in 1994 is 7,292

Figure 2. Number of stations and sources of funds, 1994 fiscal year.

resources. The program provides a continuous, well-documented, well-archived, unbiased, and broad-based source of reliable and consistent water data. Because of the nationally consistent, prescribed standards by which the data are collected and processed, the data from individual stations are commonly used for purposes beyond the original purpose for an individual station. Those possible uses include, but are not limited to, the following:

- Providing data for forecasting and managing floods
- Characterizing current water-quality conditions
- Delineating and managing flood plains
- Operating and designing multipurpose reservoirs
- Setting permit requirements for discharge of treated wastewater
- Designing highway bridges and culverts
- Monitoring compliance with minimum flow requirements
- Scheduling power production
- Designing, operating, and maintaining navigation and recreational facilities
- Allocating water for municipal, industrial, and irrigation uses
- Administering compacts or resolving conflicts on interstate rivers
- Defining and apportioning the water resources at our international borders
- Undertaking scientific studies of long-term changes in the hydrologic cycle

Data for one or more of these purposes are needed at some point in time on virtually every stream in the country, and a data-collection system must be in place to provide the required information. The general objective of the stream-gaging program is to provide information on streamflow characteristics at any point on any stream. Streamflow data are needed for immediate decisionmaking and future planning and project design. Data, such as that needed to issue and update flood forecasts, are referred to as "data for current needs." Other data, such as that needed for the design of a future bridge or reservoir, are referred to as "data for future or long-term needs." Some data, of course, fit into both classifications; a station that supplies data for flood forecasting and also provides data to define long-term trends clearly fits both classifications.

Data for Current Needs

Streamflow data are needed at many sites on a daily basis for forecasting flow extremes, water-management decisions, assessing current water availability, managing water quality, and meeting legal requirements. These activities require streamflow information at a given location for a specified time or period. These needs generally are best satisfied by operating a station to produce a continuous (or daily) record of flow.

Data from about 4,200 of the 7,292 stations are telemetered by an earth-satellite-based communications system that enables the data to be available in real-time for the operation of water-resources projects by many agencies and for flood forecasting by the National Weather Service (NWS). The NWS uses data from USGS stations in concert with its own precipitation data to forecast river stages and flow conditions on large rivers and their associated tributaries.

> The U.S. Geological Survey stream gaging network is vital to the National Weather Service's river forecast and warning program and the goal to reduce flood damages and loss of life. Without data from this network, this nation would experience increased losses from floods of both life and property [Elbert W. Friday, Jr., Assistant Administrator for Weather Services, National Weather Service, written commun., January 19, 1995].

During the 1993 Mississippi River flood, USGS field personnel made more than 2,000 visits to stations in the flood-affected areas to verify that the instruments were working properly, to make repairs as needed, and to make direct measurements of the streamflow. Data from these stations were provided continuously to the NWS, the COE, and local agencies and formed the basis for flood forecasts that allowed people to be evacuated from areas about to be inundated. The COE and local agencies used the streamflow information to protect lives and property and to focus flood-fighting activities where they were most needed.

Data for Future or Long-Term Needs

The collection of data to meet future needs often represents a larger challenge than does collection of data for current needs because the future needs are seldom known precisely and, in fact, may be impossible to anticipate. Because operating stations at all points on all streams is physically and economically impossible, mechanisms must be available to transfer streamflow information from stations to points where there are no streamflow data (ungaged sites).

Transfer of streamflow information for unregulated streams may be accomplished in many ways, ranging from the simple to the complex. Simple methods are interpolation between or extrapolation from stations on the same stream on the basis of drainage-area size. More complex methods may involve transferring information from basins with similar hydrologic characteristics, mapping station data to define approximate lines of equal runoff values, or correlating short records with long records. A statistical technique known as multiple-regression analysis has proven to be effective for defining equations that relate streamflow characteristics to the basin and climatic characteristics that affect streamflow. The resulting equations usually are referred to as "regional relations" because they can be applied to ungaged streams within a defined hydrologic area or region (Jennings and others, 1994).

Trend analysis is another application that requires long records. Concern is widespread that increased greenhouse-gas concentrations in the atmosphere are affecting the climate and the hydrology of the Earth. Analysts have used actual streamflow records to determine whether streamflows are beginning to change as a result of human activities or global warming. Natural climatic episodes of wetter or dryer than normal and lasting longer than a decade have been observed. Given the occurrence of such episodes and the inherent variability of streamflow, record lengths of more than 50 years are essential if real trends are to be detected. Slack and Landwehr (1992) reviewed the USGS data base to identify streamflow records that reflected natural conditions and could be useful in trend analysis. They identified 1,659 stations in the United States and its possessions. Over 500 of these stations have record lengths in excess of 50 years.

Specific Categories of Use

The USGS has a long history of analyzing and evaluating its stream-gaging program. As part of the most recent nationwide evaluation from 1983 to 1988, uses of the data for individual stations were defined for 6,238 of the approxi-

mately 7,000 stations then operated by USGS (Thomas and Wahl, 1993). Individual stations were identified as belonging to one or more of nine categories, which are based on the principal uses made of the data.

Hydrologic systems.—One of the more common uses of streamflow data is to account for and monitor the flow through a river basin or to define the general hydrologic conditions in the basin. Data from about 4,200 active stations are used to understand and evaluate the interactions of ground- and surface-water resources and to monitor diversions and return flows. At the State and interstate level, many of the stations serve a key role in the process of allocating and regulating water rights.

> I am writing you on behalf of the Missouri River Basin Association, a coalition of eight states and twenty-eight Indian Tribes in the Missouri basin. For years, we have been working closely with the federal agencies that have jurisdiction in the basin to improve management of the basin's water resources. As you know from your years with the USGS, good water management depends upon good data. An important source of good data has been USGS's Coop Program [Excerpt of letter from J. Edward Brown, President, Missouri River Basin Association to Gordon P. Eaton, Director, U.S. Geological Survey, February 14, 1994].

Regional hydrology.—Stations supplying data that are largely unaffected by manmade storage or diversion furnish much of the data needed for future or long-term needs. Data from about 3,800 active stations can be used to develop regional relations for estimating streamflow characteristics at ungaged sites or sites where only small amounts of streamflow data are available.

Project operation.—Data from stations in this classification are used by water managers in making daily operational decisions. For example, data from about 2,900 active stations are used by the COE, the BOR, and others to operate more than 2,000 flood control, navigation, and water-supply reservoirs.

Hydrologic forecasting.—Data from stations so classified provide information for flood and water-supply forecasting. These stations play a key role in efforts by Federal, State, and local agencies to protect the lives and welfare of the public. More than 3,000 of the stations operated by the USGS are used in the NWS's flood-forecasting system.

Water-quality monitoring.—The evaluation of water quality in rivers, lakes, reservoirs, and estuaries depends on having data on the chemistry of the water and the streamflow. Other program components provide data on the chemical quality of surface- and ground-water resources, sediment in streams and lakes, and water use (fig. 3). To compare the relative amounts of contaminants coming from different sources (various tributaries or wastewater treatment plants), one must know the flux of the contaminants computed as the concentration times the rate of streamflow. Data from about 2,700 active stations in this category provide the streamflow data needed to evaluate the quality of the Nation's surface-water resources.

Planning and design.—Data from about 1,100 active stations in this category are used to plan and design a specific project, such as a reservoir, levee, water-treatment facility, or hydroelectric powerplant.

> The U.S.G.S. basic water data collection program is of vital importance to water resource planning, design, and operation in the United States. Reductions in surface water data collection will have long-term adverse effects on the efficiency and certainty of planning, design, construction, and operation of projects. Civil engineers rely on surface water data for numerous projects, including flood control, pollution control, transportation, and navigation [Excerpt from American Society of Civil Engineers Policy Statement on Surface-Water Data Collection, October 24, 1993].

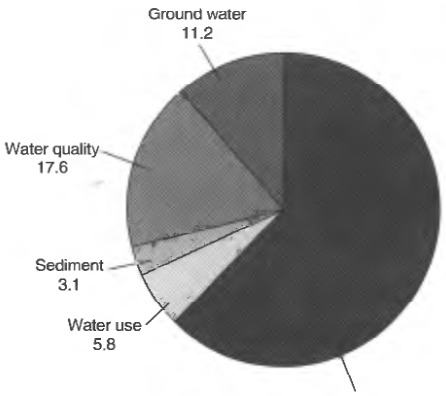


Figure 3. Percentage distribution of funds for U.S. Geological Survey hydrologic data collection, 1994 fiscal year.

Legal obligations.—Data from these stations satisfy a legal responsibility of the USGS or of signatories of treaties, compacts, and decrees. The USGS operates about 250 stations in support of 17 interstate compacts, 2 Supreme Court decrees, and 1 international treaty.

> The U.S. Supreme Court in a 1954 decree required that the USGS monitor flows in the Delaware River at Montague, New Jersey and the diversions out of the Delaware River Basin through the Delaware and Raritan Canal. The decree settled a water-rights suit in which four States were involved. The USGS operates two stations to monitor the flows as identified in the U.S. Supreme Court decree [William J. Carswell, Jr., Delaware River Master, U.S. Geological Survey, oral commun., January 1995].

Research.—Data from about 700 active stations are collected for particular research or water-investigation studies. As such, the data supply a current need. The length of time that the data will be needed is dictated by the particular project. Some research needs, such as detection of hydrologic trends, can be met only by long-term, high-quality streamflow records.

> Detection of hydrologic change requires long-term data sets of greater quality and reliability than are normally needed in the investigations of processes [National Research Council, 1991, p. 223].

Other uses.—These stations supply data for uses that do not fit into any of the other categories. These include, for example, recreational purposes, such as providing data for canoeists, rafters, and fishermen. Data from about 700 active stations supply a current need for recreational-type information.

The nationwide analysis (Thomas and Wahl, 1993) documented that multiple uses were being made of data collected at stations in the USGS stream-gaging program with about 80 percent of the stations having data uses in two or more of the above categories and about 25 percent having data uses in four or more categories.

Dissemination Of Data

Currently (1995), daily-discharge data are published annually for each State in a USGS report series entitled "Water Resources Data—[State Name]." The data are published on a water-year basis. A

water year is the 12-month period of October 1 through September 30 and is designated by the calendar year in which it ends. Thus, the 1994 water year ends September 30, 1994. Because of the need for review of the completed computations, these reports generally are published from 6 months to 1 year after the end of the water year. Many streamflow data users must make operational decisions daily. For these users, streamflow records are computed and made available on a provisional basis.

Automated telemetry provides the data users with provisional stage and discharge data in a timeframe that meets water-management needs. This technology also permits the USGS field offices to continuously monitor the operation of the hydrologic stations, time visits to stations to coincide with times of maximum need for data (such as during floods) and to service equipment at the stations. Currently, more than half of the 7,292 USGS stations are equipped with automated telemetry.

In addition to the published record, the data collected by the USGS are archived in the nationwide WATSTORE data base. The number of active stations in the WATSTORE data base with associated record lengths is given in figure 4 for each decade from 1900 to 1990. The data in figure 4 also include stations operated by other agencies (primarily State agencies) for which the data are reviewed, archived, and published by USGS. In 1990, data from about 400 stations were provided to the USGS by other agencies.

Beginning with the 1990 water year, Water Data Reports are also available on Compact Disk-Read Only Memory (CD–ROM). The Water Data Reports and the CD–ROM's are distributed to participating agencies and libraries; they also are available for sale by the USGS Earth Science Information Center, Denver, Colorado. Currently (1995), the USGS is

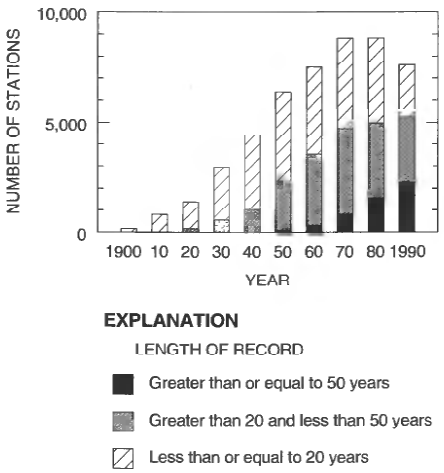


Figure 4. Number of stations in the U.S. Geological Survey data base, 1900–90.

developing procedures to allow access to streamflow data by means of Internet. Historical mean daily-discharge data for about 18,500 stations will soon be available through this source.

Final Comments

The USGS stream-gaging program provides data to many agencies and organizations involved in water-resources projects. USGS goals and objectives for ensuring the continued relevance of this vital program include the following:

- Maintain a long-term and consistent nationwide data base
- Maintain state-of-the-art recorders, sensors, and equipment for data collection
- Provide easy access to archived and realtime data
- Maintain a skilled staff of hydrologists and hydrologic technicians for collecting and computing the streamflow records

The USGS continues to be committed to the collection and dissemination of high-quality streamflow data as a critical part of its overall mission of providing earth science information for the wise management of the Nation's natural resources. The maintenance of a viable stream-gaging program is an integral part of managing these natural resources.

> We believe that the U.S.G.S. basic water quantity data collection activities are: 1) essential, because the value of hydrologic data increases with both the length and continuity of the record; 2) the logical responsibility of the Federal Government because the States cannot possibly assume the support and leadership role of U.S.G.S. for interstate water systems; 3) cost-effective, because coordinated water data collection eliminates overlapping and duplicative efforts [Statements of William J. Carroll, President-elect, American Society of Civil Engineers, before the Subcommittee on Interior and Related Agencies, Committee on Appropriations, U.S. House of Representatives, March 10, 1988].

References

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