

National Streamflow Information Program Implementation Plan and Progress Report

by Robert M. Hirsch and J. Michael Norris

River Information – A Vital National Asset

Information on the flow of rivers is a vital national asset that safeguards lives and property and ensures adequate water resources for a healthy economy. The U.S. Geological Survey (USGS) operates about 7,000 streamflow-gaging stations that keep watch on the Nation's rivers. The vast majority of these stations are jointly funded in partnerships with more than 800 State, local, tribal, or other Federal agencies. The USGS network provides real-time and long-term historical streamflow information that is accurate and unbiased, and that meets the needs of many users. For example, streamflow information is needed for:

- Flood forecasting and flood-prone area mapping;
- Planning and managing water supplies and upholding interstate compacts;
- Developing water-quality standards and monitoring changes in flow;
- Designing structures such as dams, levees, bridges, and highways.

In 1998, Congress expressed concern about the health of the USGS streamgaging program with the following observation: "The [Appropriations] Committee has noted the steady decline in the number of streamgaging stations in the past decade, while the need for streamflow data for flood forecasting and long-term water management uses continues to grow. The Committee requests that the Survey provide a report describing the goals and current status of the streamgaging network and an evaluation of the ability of the network to meet its goals."

"Streamflow data ... form the corner-stone for national, regional, and local efforts ... by providing continued, up-to-date information about water conditions and understanding of hydrologic phenomena."-- National Research Council Report

The USGS report to Congress prepared in November 1998 to respond to this request stated:

- The network's ability to meet longstanding Federal goals has declined because of:
 - (1) a decrease in the number of streamgages;
 - (2) a disproportionate loss of streamgages with a long period of record; and
 - (3) the declining ability of the USGS to continue operating high priority streamgages when partners discontinue funding.
- New resource-management issues and new data-delivery capabilities have increased the demand for streamflow information.
- New technologies need to be implemented to improve the reliability and application of streamflow information and to decrease the cost and uncertainty of this information.

Figure 1 shows the mixture of funding sources that support the current network, and illustrates the very large dependence on partners. The USGS had direct control of only 7 percent of the funding for the streamgaging network in FY 2000.

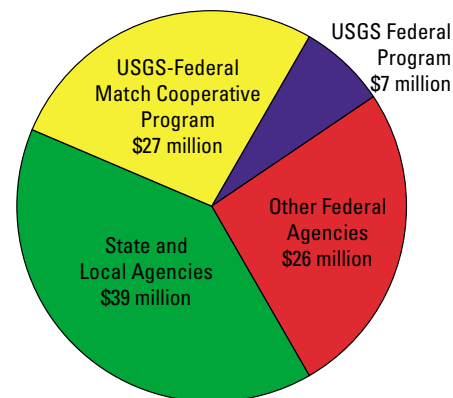


Figure 1. Fiscal Year 2000 Funding Sources for USGS Streamgaging Program (\$99 million)

A New Approach

To respond to these major issues, the USGS developed a conceptual plan for a new approach to the acquisition and delivery of streamflow information. An initial report on that plan, "Streamflow Information for the Next Century" (USGS Open-File Report 99-456), serves as a



USGS Streamgaging at Snake River, WY.

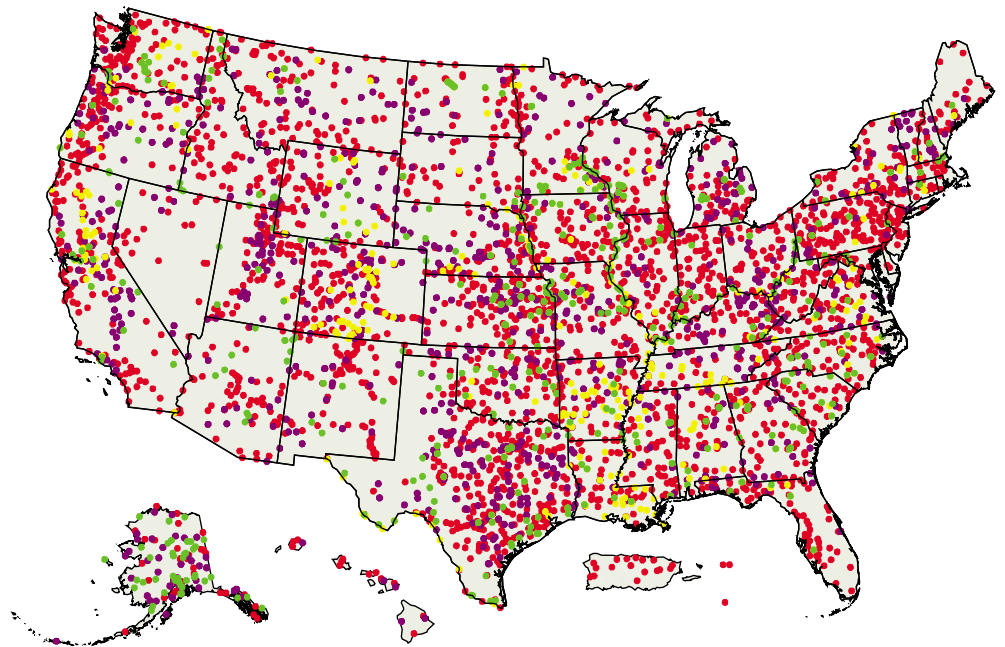
basis for discussion with experts and stakeholders on developing a comprehensive National Streamflow Information Program (NSIP).

This fact sheet briefly describes NSIP concepts and recent progress in planning the program. It also describes enhancements to the existing streamgaging network in FY 2000 and FY 2001 as a result of recent increases in funding: \$2 million in FY 2000, \$3.1 million in the base Federal funding for streamgaging in FY 2001, and a special appropriation of \$5 million in FY 2001 for streamgage capital improvements. Stakeholders and users of USGS streamgaging information are encouraged to provide feedback for improving the plan. For additional background information on the USGS streamgaging program, the uses of the data, detailed plans, and progress reports see: <http://water.usgs.gov/nsip>.

Streamflow Information for Tomorrow – Issues, Plans, and Actions

The NSIP plan provides for a stable, modernized streamgaging network that addresses core Federal and cooperator needs. It also provides for:

- Collecting critical information during floods and droughts;
- Periodic assessments and evaluation of streamflow characteristics to assess the impacts of climate and land-use change;
- Developing a highly reliable system for delivering data to users; and
- Implementing a program of research and development to build better data-collection, delivery, and interpretation capabilities for the future.



● Active USGS Site ● Inactive USGS Site ● Other Agency Site ● New/Proposed Site
Proposed network of USGS-funded stations in the National Streamflow Information Program.

"...the network of USGS gaging stations is truly a national treasure..."
--Bernard W. Sweeney, Director
Stroud Water Resources Center

At the core of NSIP will be a set of USGS-funded streamgages strategically positioned across the country that are continuously operated to fulfill the five Federal goals described in box 1. These will be a permanent set of core streamgages from which streamflow information would be delivered in real time,

uncompromised by changing support from funding partners. These streamgages are shown in the map above.

In designing this proposed network, USGS personnel selected active USGS streamgages whenever possible. If none existed, they turned to either inactive USGS streamgages or streamgages operated by other agencies. If none of these possibilities were available, they proposed initiating a new streamgage for NSIP. In those instances where another agency's streamgages are part of the design, the USGS would provide funding to that agency to assure that their streamgages follow NSIP requirements for data collection and data delivery. During calendar year 2001, the USGS is working with State and regional interests to assure that the proposed network meets the National goals in the most effective manner.

In addition to operating these USGS-funded streamgages, the USGS would continue to work with many partners to operate additional streamgages that would provide the breadth and depth of coverage needed by the ever-growing community of data users. The full network would be cooperatively designed to meet Federal, State, tribal, and local needs.

Cooperators in other agencies have more than carried their share of the current network (see figure 1). Their active participation would continue to be crucial in the future but would build on a more robust and stable USGS-funded base than currently exists.

"A critical national network of stream gages must be specified and federally funded through the U.S. Geological Survey's budget."--Association of State Floodplain Managers

Box 1.--Federal Goals for the Public Good

Five Federal goals have been identified as those that should be met by the core set of USGS-funded streamgages in NSIP. Many other goals exist; these would be the highest priority.

Interstate and International Waters - Interstate compacts, court decrees, and international treaties mandate long-term, accurate, and unbiased streamgaging by the USGS at State-line crossings, compact points, and international boundaries.

Flood Forecasts - Real-time stage and streamflow data are required to support flood forecasting by the National Weather Service across the country.

River Basin Outflows - Resource managers need to account for the contribution of water from each of the Nation's 350 major river basins to the next downstream basin, estuary, ocean, or the Great Lakes.

Sentinel Watersheds - Long-term streamflow information, unaffected by regulation or diversion, from each of the 800 unique ecological/hydrological areas of the Nation, are needed to describe the ever-changing status of regional streamflow as it varies in response to changes in climate and land use.

Water Quality - Streamflow information is needed to support the three national USGS water-quality networks that cover the Nation's largest rivers, intermediate-sized rivers, and small, pristine watersheds.

Blueprint for the Network

A recent comprehensive evaluation of the current USGS streamgaging network, coupled with external reviews of the value and utility of the network, served as the blueprint for the proposed network of USGS-funded streamgages. The evaluation was based on a Geographic Information System (GIS) analysis that enables USGS hydrologists to assess the current network and to explore options for improvements in meeting the five Federal goals. This approach is crucial to minimizing network costs and maximizing the value of the information collected. Maps and lists of the proposed streamgages in the Federal network are available online at: (<http://water.usgs.gov/nsip>).

Under full NSIP implementation, streamgages in the network will have the following characteristics.

Real-Time Data Delivery. The delivery of streamflow data in real time is important for three reasons: (1) Users need accurate information delivered quickly and easily; (2) USGS needs remote access to information on flow conditions for deploying field crews to measure extreme low or high flows more effectively; and (3) USGS needs to know about equipment malfunctions quickly to minimize loss of data. The NSIP goal is to have real-time capability for all streamgaging stations. Currently, 1,717 of 7,096 gages in the USGS streamgaging network need to be upgraded to real-time capability.

Flood Hardened. Streamgages must be able to withstand the impact of a 200-year flood and still keep operating. Disaster preparedness agencies and the public rely on USGS streamgages for emergency information, and any interruption in service during large floods is

Table 1. Total number of USGS-funded streamgaging stations required to meet each core Federal goal. "Total Needed" is significantly less than the "sum" because many stations can be used to satisfy multiple goals.

Federal goals to be met by NSIP core streamgages	Total number of streamgages required	New streamgages needed	Reactivated streamgages needed	Other agency streamgages requiring upgrades
Interstate and International Waters	506	17	61	15
Flood Forecasts	3,245	338	610	235
River Basin Outflows	445	13	66	24
Sentinel Watersheds	874	123	206	16
Water Quality	210	0	0	1
Sum	5,250	491	943	291
Total Needed	4,421	485	867	278

*"The federal government should fund the entire cost of a baseline national network of stream gages that measure the 'pulse' of the Nation's surface water resources. Through the USGS Water Cooperative program, regional, state, and local governments and appropriate private entities should financially support additional gaging stations that they need for specific issues."--
Association of American State Geologists*

unacceptable. Estimates are that about 3,000 streamgages at critical flood-forecast locations need to be hardened (moved or upgraded) to ensure reliable service during floods.

Accurate data for the full range of anticipated flows. Rating curves—the relation between stage (water level) and discharge (streamflow) unique to each streamgage location—need to be extended to include very low and very high stages so they are useful for estimating flow during extreme events. During large floods and severe droughts, in particular, disaster response agencies need accurate flow information. Rating curves for about 3,000 streamgages at critical flood-forecast locations need to be extended.

Closing the gaps

Table 1 shows the total number of USGS streamgaging stations required to meet each Federal goal, how many new streamgages are needed, how many former streamgages *not currently in service* would need to be reactivated, and how many upgrades are needed to streamgages operated by other agencies. The NSIP design takes advantage of the fact that many streamgages can fulfill more than one of the five Federal goals. In fact, of the 4,421 streamgages shown in Table 1, 759 satisfy 2 or more goals, and 11 satisfy 4 goals, which means more information will be provided at less cost.

Investments for Tomorrow

The costs of the USGS-funded streamgages should be viewed in three parts. The first is the cost of the network infrastructure, which makes it possible for the USGS to operate the entire network. This infrastructure cost is mostly independent of network size. Costs include maintaining data systems, the computer hardware needed for computations and data dissemination, network support managers at USGS headquarters and in field offices across the Nation, and testing of equipment used to operate the system. The total infrastructure costs, which would support all streamgages—those funded entirely by the USGS as well as partnership-funded streamgages—are about \$37 million per year (in FY 2000 dollars). Under the



Flooded Tar River streamgage at Rocky Mount, North Carolina on September 17, 1999.

NSIP plan, these costs would be funded through direct appropriations to the USGS. These (FY 2000) infrastructure costs are not new. Currently, they are covered largely through overhead charges against all streamgages in the USGS network. Funding the infrastructure through direct appropriations would reduce the annual operating cost of all streamgages (those supported by USGS funds and those by cooperative reimbursements) by about 40 percent from their current levels.

The second part is the cost of annual operation and maintenance of the USGS-funded streamgages. Under full implementation, the annual cost of operating these streamgages would be about \$28 million (in FY 2000 dollars). This estimate factors in reduced annual operating costs that would result from supporting the network infrastructure exclusively with Federal funds, as mentioned previously.

The third part is the cost to modernize USGS-funded streamgages, build required new streamgages, and reactivate discontinued streamgages identified as essential to the Federal goals. This one-time cost would be about \$56 million (in FY 2000 dollars). This process has already begun with the two increases in Federal funding received in FY 2000 and FY 2001. The cost for enhancing non-USGS streamgages for the Federal network has not been determined.

With a set of USGS-funded streamgages at its core, NSIP would provide a full suite of products that would satisfy the many needs of a diversity of customers. NSIP is built on a solid commitment that information will be shared freely, be readily accessible for current use, be archived for future use, be quality-assured, and be viewed by all parties as neutral, objective, and of high quality. Key components planned for NSIP beyond the USGS-funded streamgages include: intensive data collection in response to major floods and droughts; periodic assessments and interpretation of streamflow data to better define statistical characteristics and trends; a highly reliable system for real-time delivery of streamflow information to customers; and a program of research and development that takes advantage of new technology.

*"The federal cost of basic water data collection and analysis pales when compared to the cost of facilities which will be based on inadequate data, as well as to the potential loss of life and property that can occur if errors in design result from use of a faulty data base."--
American Society of Civil Engineers*



Getting a Handle on Floods and Droughts

The NSIP plan calls for intensive data collection during major floods and droughts. This additional information is needed to provide improved estimates of risk and impacts for better hazard response and mitigation. Information collected would include systematic field surveys of precipitation, river stage, river discharge, and water quality. In addition, temporary streamgages would be deployed during floods to ensure adequate data are available for forecasting and response activities in critical locations where there are no permanent streamgages.

Prior to FY 2000, there was no reliable source of funds to cover these intensive data-collection activities during catastrophic events, such as Hurricane Floyd in 1999, the 1997 Red River flood, or the 1993 Mississippi River flood. Supplemental appropriations, if they came at all, were received long after the event and were usually insufficient to cover the costs incurred by the USGS in providing the level of service expected by disaster-preparedness agencies and the public. Increased funding in FY 2000 enabled the USGS to begin the process of building a modest "flood and drought reserve" of \$250,000. This amount has been increased to \$400,000 in FY 2001. The NSIP plan provides a level of reserve funding sufficient to ensure an appropriate scientific response to major floods and droughts—an annual deposit of \$4 million (in FY 2000 dollars) with a mechanism to carry over funds from years in which large events do not occur.

Regional and National Streamflow Assessments

Responsible water-resources planning for supply and quality must be based on knowledge of the frequency with which high and low flows occur in a given river. For example, protection of endangered aquatic species depends on knowing how often low flows that threaten their survivability are expected to occur.

Delineation of flood-hazard zones and design of bridges and other structures requires knowing the water level and discharge of the 100- and 200-year floods. Regional and national assessments are needed to provide this information on the frequency and duration of streamflows. Conducting these assessments requires long-term records of streamflow for a diverse set of locations and geospatial information about the local streams and watersheds. These assessments also require trained hydrologists equipped with appropriate software to conduct statistical studies, interpret the data, and provide the results in reports and interactive data bases.

Regional estimates of flow must be revised regularly because additional data improve the accuracy of the estimates, and because flow characteristics change over time due to changes in climate, land use, water-management practices, and water-use patterns. For example, one of the more controversial questions in the climate change debate is whether changes in climate are causing changes in the magnitude and frequency of floods and droughts. Study of this crucial question has been limited and most analyses have been conducted on a State-by-State basis. Stable Federal funding is needed to continually provide the requisite data and analyses on a broad regional scale to address these regional and national questions. The NSIP plan proposes to restudy conditions on a 10-year cycle for each of the major physiographic regions of the Nation at a cost of about \$4 million per year (in FY 2000 dollars).

*[USGS streamgages] "...have revolutionized the way we can respond to drought conditions in a timely manner as well as forecast water supply shortages far enough in advance to provide time for changes in water use planning."--
Governor's Drought Advisory Committee, Montana*

Getting the Information Out— When and Where it is Needed

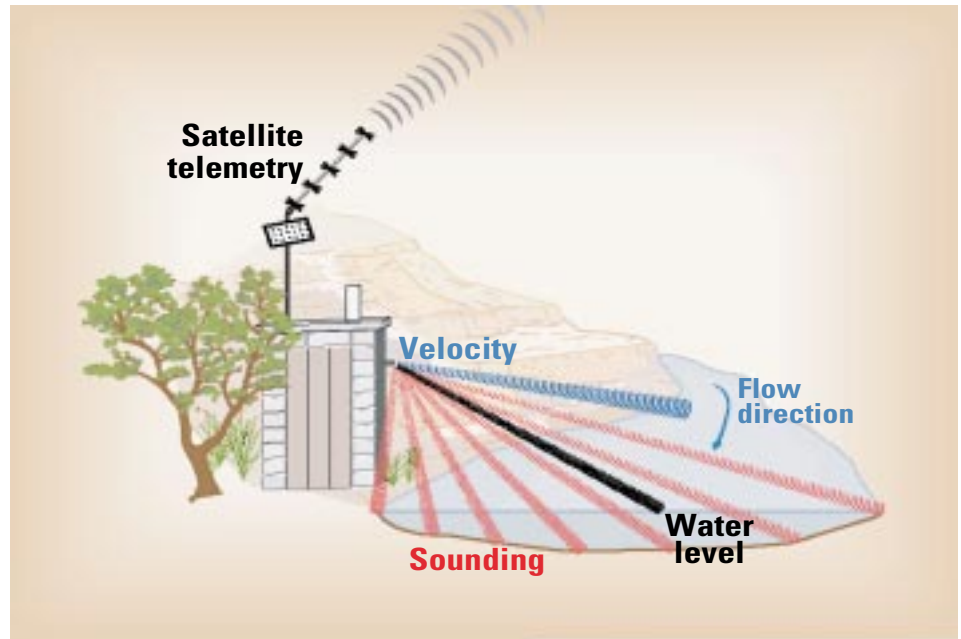
An essential building block of the NSIP plan is to develop new ways to transmit, store, and distribute streamflow information. NSIP will provide convenient and reliable access to all of its information products through the World Wide Web. Access to and delivery of these products must be enhanced to keep pace with rapid technological advancements and customer expectations of having information when and where they need it.

One delivery aspect that has been undertaken with the new funding in FY 2001 is a national system of redundant web servers, called NATWEB, designed to ensure data delivery in times of high customer demand, heavy internet traffic, or local failures in power or communications systems. The increasing number of streamgages delivering information in real time heightens customer expectations for data to be available 7 days a week, 24 hours a day. During a recent hurricane, a USGS computer system failure interrupted the flow of information to users in the region where the hurricane was causing severe flooding, even though the streamgages and their satellite telemetry were still working. NATWEB provides "mirror sites" so that the data from any given streamgage can be served by several computers located in different regions of the Nation. This redundancy will greatly enhance the reliability of data delivery.

"The information your Web page provides was very useful to our Emergency Preparedness team...." --Steve Durst, Sumner County, Emergency Preparedness, Welling, Kansas

A second important enhancement in data delivery taking place in FY 2001 is a web-based system for providing the entire storehouse of USGS hydrologic data to the public. The system, called NWIS-Web (<http://water.usgs.gov/nwis>) was first deployed in the Fall of 2000, and delivers historical and current streamflow data in a variety of formats and graphical presentations. One of the customer benefits is the flexibility to create varied forms of output.

A further enhancement will be the delivery of the vast store of streamflow data that have been collected at frequent (usually 15-minute) intervals. These frequently collected data (called "unit values") are invaluable to many types of hydrologic analysis, including calibration of flood-forecasting models, analysis of flood-mitigation strategies, and water-quality studies for Total Maximum Daily Loads (TMDLs), which are used for compliance with water-



Investing in new technology--potential streamgaging station of the future, which would not require human or sensor contact to obtain streamflow information.

quality standards. Currently, when these unit value data are requested by customers in various agencies, engineering firms, and universities, the task of delivering the data is costly for the USGS, and these costs are passed on to the customers if the data requests are large. The data warehouse, as envisioned, will make it possible for these requests to be filled in minutes by the user, with minimal impact on the USGS. Continuation of the special capital investment funds beyond FY 2001 would make this "unit-values data warehouse" a reality in FY 2002.

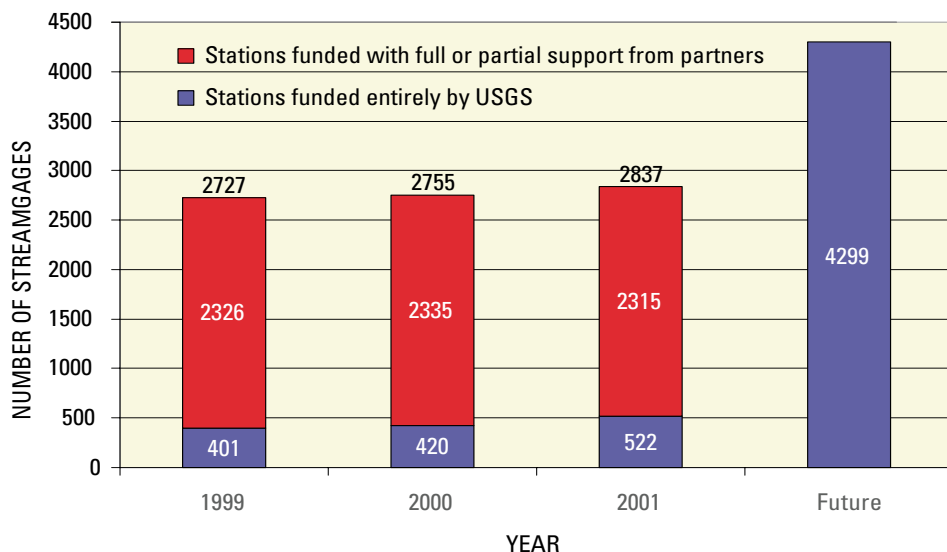
Finally, the NSIP plan calls for new web-based applications that will allow the user to select any location on any stream and use GIS interfaces and existing statistical models to compute streamflow characteristics. The system will *substantially* reduce the time required by engineers and resource management agencies to make determinations of flow statistics required for regulatory activities, such as permit processing, flood-plain delineation, or TMDL applications. The first prototype of such a system has been developed by the USGS for the State of Massachusetts (<http://ma.water.usgs.gov/streamstats>) and serves as an example of the kind of information delivery system that NSIP would provide. Additional capital investments will be needed to apply these technologies nationwide.

Investing in Methods Development and Research

Although there have been great advances in methods for measuring water levels, computing streamflow, and storing and transmitting data, the methods for measuring flow at most

streamgages are almost identical to those of 100 years ago. At a growing number of stations, however, the use of acoustic Doppler technology is dramatically changing the way flow is measured. These acoustic methods enhance the range of conditions for which accurate flow measurements are possible, but they do not provide enhanced efficiency or accuracy at most locations. No new technology has yet been found to provide accurate data over a wide range of hydrologic conditions more cost-effectively than traditional current-meter methods. Prudent management, however, requires that the USGS continue efforts to explore and test new technologies for streamgaging that have the potential to enhance operational safety, reduce cost, improve accuracy, and (or) increase reliability of flow data. In the past 3 years, the USGS has collaborated with university and private-sector partners in a search for new approaches to streamgaging. Early tests of various new radar systems show promise, but much more testing and development are needed before major improvements in technology can be realized. The NSIP plan provides a research investment of \$5 million per year (in FY 2000 dollars) to improve the understanding of streamflow and the way it is measured and analyzed.

"I find it very gratifying in these trying times that you have quietly over the years compiled an invaluable storehouse of data that is so important to our state." --W. Lucius Adkins



Status of streamgages funded by USGS and its partners.

Progress in FY 2000 and FY 2001

The increased funding provided to the USGS for the streamgaging network in FY 2000 and FY 2001 is already at work, moving the Nation toward the kind of system envisioned in the NSIP plan. The new funding for these 2 years will provide for: 37 new and 73 reactivated streamgages (needed for flood forecasting), 127 streamgages with upgraded equipment, 15 flood-hardened streamgages, and 40 streamgages with rating curve extensions. The locations of these streamgages are shown at http://water.usgs.gov/hazards_initiative. In addition, the new funding in FY 2001 will allow the USGS to provide full support for about 100 existing streamgages that are vital to the envisioned NSIP Federal network. These investments are a small first step in providing the stability in Federal funding that is needed to provide the network continuity that so many stakeholders seek. Spending in FY 2001 also includes several enhancements in software and hardware as well as research and development (as described above) to improve system reliability and information delivery.

The Nation and the People Benefit

Better scientific data, tools, and understanding of the Nation's rivers are important to virtually all USGS stakeholders and customers. Whether the customer is a water-management or water-quality agency at the State, local, tribal, or Federal level, an emergency manager, a power or navigation official, a farmer, a kayaker, or a fly fisher, all can benefit from the investments in the National Streamflow Information Program of tomorrow. Partners and cooperators play a critical role in the USGS streamgaging network. What the USGS hears from its customers is that they need sound historical and near real-time, water-resources data on which to make their water-management and water-use decisions. The infrastructure of NSIP, the solid foundation of the USGS-funded network, and the enhancements in water research, assessments, and data delivery systems that are the benefits of this plan, will provide the information that customers need. The investments made to date in the USGS streamgaging network represent healthy progress, but there is still a substantial gap to be filled in reaching the goal of full NSIP implementation.

The Nation's rivers are in many ways the lifeblood of our country and represent a resource that meets countless needs of many people each day. Our rivers deserve the best science the USGS can provide. The plan for the USGS National Streamflow Information Program will ensure that the Nation and its citizens have the information needed to protect and manage its rivers for the benefit of present and future generations.

"The role the USGS Streamgaging Network plays in outdoor recreation and recreation safety is also one of the many important reasons to keep the Network healthy."--American Canoe Association

For further information, please contact:

For additional information on USGS water resources programs in each State, please see <http://water.usgs.gov>. For current information on progress towards the plans for the National Streamflow Information Program, please see <http://water.usgs.gov/nsip> or contact:

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