BENEFITS OF USGS STREAMGAGING PROGRAM

USERS AND USES OF USGS STREAMFLOW DATA

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National Oceanic and Atmospheric Administration

Cover - Grand Coulee Dam - *United States Bureau of Reclamation*

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Executive Summary

Purpose

The United States Geological Survey (USGS) developed the National Streamflow Information Program (NSIP) to plan for future streamgaging activities. However, the NSIP documentation does not present tangible and intangible benefits of the network to the nation. If well-informed decisions are to be made about the USGS streamgaging network, an evaluation of the benefits of the network is required.

That evaluation must:

- Identify and describe the range of tangible and intangible benefits of the USGS streamgaging network.
- Estimate the probable tangible benefits of the network, thus permitting a comparison of economic benefit to cost.

In this report the range of benefits is identified and described through presentation of information about users and uses. A companion report presents the probable economic benefit of USGS streamgage data use.

Results in brief

- Data from the network are used by public and private users in various applications, such as the following:

1. Planning, designing, operating, and maintaining the nation's multipurpose water management systems.
2. Issuing flood warnings to protect lives and reduce property damage.
3. Designing highways and bridges.
4. Mapping floodplains.
5. Monitoring environmental conditions and protecting aquatic habitats.
6. Protecting water quality and regulating pollutant discharges.
7. Managing water rights and transboundary water issues.
8. Education and research.
9. Recreational uses.

Each of the 9 categories of uses listed above has a range of data users, data uses, and beneficiaries of the data. Each category provides benefits – either direct or indirect, tangible or intangible.

- The value of streamflow records increase over time. Streamgages with a long period of record are particularly valuable as they form a baseline for information about future changes.
- Online access to USGS streamgage records dramatically streamlines the process for obtaining historical streamflow data. In the future, both the number of users and the ways in which the data is being used will increase, and the information's value will increase accordingly.
- Streamgages serve multiple uses. The same gage may provide useful information for water diversions, water quality monitoring, or floodplain mapping. Often, users have a one-time need for data. These ad hoc uses are difficult to properly value, but produce additional benefits that can be quite large over the period of record.

Background

The USGS operates and maintains a nationwide streamgaging network of about 7,000 gages. The network is supported by funding through the USGS's Cooperative Water Program, the USGS National Streamflow Information Program, other federal water and environmental agencies, and approximately 800 state and local funding partners.

Data from this network are used by a large number of public and private users, including government agencies responsible for water management and emergency response, utilities, environmental agencies, universities, colleges, consulting firms, and recreational interests. Likewise, these users access the data for a wide variety of uses, including decision making related to water supply, hydropower, flood control, forecasting floods and droughts, water quality, environmental and watershed management, research, navigation, fishing, and water-based recreation.

The USGS streamgaging network provides continuous recordings of water stage levels. These data, along with discharge calculations from precise physical measurements of stream velocity at multiple locations and depths across the stream channel, are converted into streamflow information by developing stage-discharge curves that relate water surface elevation to flow. While some users need water stage data, the vast majority of users require the computed discharge values that are the end result of this labor-intensive process.

In response to a request from Congress, the USGS in 1998 evaluated the capability of the streamgaging network to provide streamflow information to

adequately meet federal needs (USGS 1998). This evaluation led the USGS to recommend a plan for the future of the streamgaging network. This plan will "...produce information for multiple uses, be shared freely, made readily accessible for current use, archived for future use, be quality assured, and be viewed as neutral, objective, and of high quality by all parties" (USGS 1999).

Motivation for this study

NSIP identifies plans for enhancing the network and estimates resources needed. The plan has been reviewed and found technically adequate, but the economic feasibility of the proposals has not been addressed. That is, the NSIP documentation does not present benefits of the network to the nation.

If well-informed decisions are to be made about the NSIP, an evaluation of the benefits is required. That evaluation must:

- Identify and describe the range of benefits of the USGS network.
- Estimate the probable value of these benefits, thus permitting a comparison of economic benefit to cost.

These tasks are the subject of this brief report and a companion report. Here, the range of benefits is identified and described through presentation of information about users and uses. Users and uses of USGS streamflow data and examples contained herein were established by review of available literature and by correspondence from approximately 100 representative users of USGS data from across the United States. In the second report, probable economic benefits incurred as a consequence of selected uses are presented.

Benefit categories

The USGS streamgage network yields what economists would refer to as tangible and intangible benefits. Tangible benefits are those that we can "take to the bank"; benefits to which a monetary value can be assigned. For example, if we use stream data from the network to decide to protect property from rising water, that action yields a direct economic benefit equal to the damage avoided. On the other hand, if we consult the streamflow data this morning to decide whether to go or avoid whitewater rafting this afternoon, the benefit of that use is intangible. Such benefits cannot be measured or expressed conveniently in monetary terms.

Benefits that accrue from using the data provided by the network can also be classified as direct and indirect benefits. Direct benefits are those that can be assigned to the immediate users. For example, if the operator of a hydropower reservoir consults data from the network to schedule generation, the utility that sells the power gains a direct benefit. In this case, that benefit is a tangible benefit. On the other hand, if a bridge designer selects the size of the bridge opening based upon statistical analysis of the historical record of flows in the stream that is crossed, the designer is not really the beneficiary of the availability of data. Instead, those of us who drive our cars over the bridge, safe from the water below, benefit from the data. In this case, the benefit is an indirect benefit. Further, this benefit is an indirect intangible benefit, as we commonly do not assign monetary value to life safety.

Users of USGS streamgaging data

An idea of the range of USGS streamgaging data users is shown in **Table 1**. This list, which was assembled for the Maryland Water Monitoring Council, is typical of users found in all states. It includes local, state, and federal agencies, industry, educational institutions, non-government organizations, and even individual citizens. The benefits that these users derive are both direct and indirect, both tangible and intangible. For example, the Fisheries Service of the Maryland Department of Natural Resources uses the data to make decisions that lead to environmental protection – decisions that have an impact on the economy associated with recreational fisheries. These decisions also have an impact on the future aquatic environment in the state, an impact that is intangible and indirect.

Brett Cannady

Table 1—Users of streamflow data

- Maryland Department of the Environment — Environmental Permits
- National Weather Service
- US Fish and Wildlife Service — Chesapeake Bay Field Office
- National Park Service — Antietam National Battlefield
- Susquehanna River Basin Commission
- US Army Corps of Engineers — Baltimore District
- Maryland Department of Natural Resources — Watershed Modeling and Analysis Section
- Maryland Department of the Environment — Water Rights Division
- Maryland State Highway Administration — Division of Bridge Design
- Baltimore County Department of Environmental Protection and Resource Management
- Frederick County Planning Commission
- Montgomery County Department of Environment Protection
- Allegany Soil Conservation District
- Natural Resources Conservation Service
- St. Mary's County Department of Planning & Zoning
- Washington Suburban Sanitary Commission — Operations
- Baltimore City Department of Public Works — Water Quality Management Section
- Upper Potomac River Commission
- Frostburg State University — Center for Environmental and Estuarine Studies
- Interstate Commission on the Potomac River Basin
- Metropolitan Washington Council of Governments
- Maryland Department of the Environment — Flood Hazard Mitigation Section
- University of Maryland — Wye Research and Education Center
- US Geological Survey Water Resources Division — Maryland-Delaware-District of Columbia District
- Caroline County Department of Public Works
- Maryland Department of the Environment — Water Management Administration, Surface Discharge Permits Division
- Monocacy Canoe Club
- Maryland Department of the Environment — Technical and Regulatory Services
- Federal Emergency Management Agency
- National Park Service — Chesapeake & Ohio Canal National Historical Park
- Maryland Geological Survey
- US Army Corps of Engineers — Pittsburgh District
- Deer Creek Watershed Association
- Maryland Department of Natural Resources — Fisheries Service
- US Geological Survey Water Resources Division — Pennsylvania District
- Maryland State Highway Administration — Division of Highway Hydraulics
- Private Citizens — boating, wading, and fishing in Conococheague Creek, Washington County
- Harford County Department of Public Works
- Prince Georges County Department of Environmental Resources
- Talbot Soil Conservation District
- Seven River Association
- Dewberry and Davis Consulting Engineers
- Washington Suburban Sanitary Commission — Engineering Support Division
- Washington Suburban Sanitary Commission — Water Resources Planning Section
- St. Mary's College — Biology Department
- Maryland National Capital Park and Planning Commission
- Anne Arundel County Department of Public Works
- Brightwater Consulting
- Maryland Department of the Environment — Nontidal Wetlands and Waterways Division
- American Society of Civil Engineers — Design Improvements/Restore Monocacy Aqueduct
- Washington Suburban Sanitary Commission — Systems Control
- Baltimore City Reservoir Natural Resources Office
- Maryland Department of the Environment — Water Management Administration, Compliance Program

(Modified from Cleaves and Doheny 2000)

Overview of uses of USGS streamgaging data

Uses of USGS streamgaging data fall broadly into the following 9 categories:

1. Planning, designing, operating, and maintaining the nation's multipurpose water management systems.

2. Issuing flood warnings to protect lives and reduce property damage.

3. Designing highways and bridges.

4. Mapping floodplains.

5. Monitoring environmental conditions and protecting aquatic habitats.

6. Protecting water quality and regulating pollutant discharges.

7. Managing water rights and transboundary water issues.

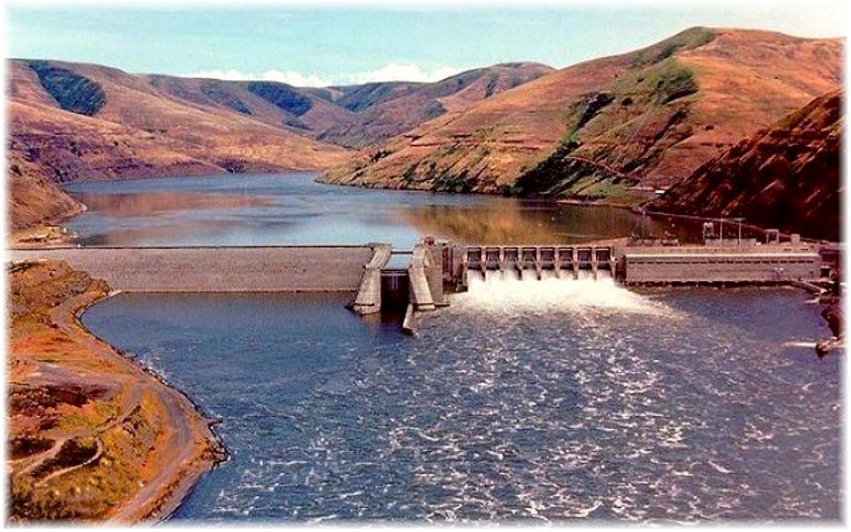
8. Education and research.

9. Recreational uses.

These are described in the following sections.

City of Overland Park — Public Works Department

1 Planning, designing, operating, and maintaining the nation's multipurpose water management systems



United States Army Corps of Engineers

Data from a large percentage of active USGS streamgages are used for managing multipurpose reservoir systems for water supply, hydropower, flood protection, instream flow requirements, recreation, and navigation. Water management facilities, including reservoirs, hydropower plants, canals, and so on reduce impacts of flooding and drought; provide irrigation water supply, public water supply, and industrial water supply; generate electricity; provide flows for fisheries; and in some cases, provide recreational opportunities.

How data are used

Historical streamflow data is an essential design requirement for properly sizing reservoir storage capacities, spillways, flood reservation space, hydropower plants, diversion structures, pumping plants, canals, and navigation facilities. Historical peak flows are needed as well as long-term continuous records that represent both extreme wet and dry periods.

Real-time streamflow data downstream of a reservoir are needed to schedule releases for water diversions, to achieve minimum flow requirements, or to stay within non-damaging levels during periods of high water. Reservoir operations for most systems require continuous monitoring of water levels at key locations downstream, often to meet Federal Energy Regulatory Commission (FERC) license requirements. Operations schedules typically have environmental, water quality, or temperature requirements that require continuous monitoring of streamflows.

While most reservoir operations rely on computed inflows based on changes in the reservoir water surface elevation, it is common to monitor streamgages upstream of the reservoir to gain additional lead-time for anticipating future inflows.

Who uses data

The users of the streamflow data include operating agencies such as water districts and municipal utilities, the US Army Corps of Engineers, US Bureau of Reclamation, and other public and private entities that operate reservoirs.

Who benefits from uses of data

Beneficiaries of the water management category of streamflow data use include residential, agricultural, and industrial water users, electric utility customers, communities and businesses that receive flood protection, and recreational users.

Consequences of absence of data

If streamgaging data at key downstream locations are not available, reservoir operations will be less efficient. For example, if a tributary below the reservoir contributes a portion of the flow required to meet a downstream objective, but the operator does not have the data, they will tend to play it safe and release slightly more than is required to make sure the objective is met. If this overcompensation occurs regularly, the overall operation will be inefficient and adversely impact water supply, hydropower, recreation, or other project benefits. Similarly, in the absence of downstream flow data, a reservoir operator with flood control as a project purpose may delay flood releases to avoid exceeding a safe level downstream until they are certain that the tributary flows are receding. If this delay in evacuating reservoir flood space were to cause subsequent releases to exceed the safe downstream channel capacity, as is possible in a longer duration flood event, avoidable flood damages may occur.

Categories of benefits

The benefits of uses for planning are largely tangible benefits. For example, better reservoir operations yield monetary benefits through flood damage reduction, increased hydropower production, and improved water supply.

2 Issuing flood warnings to protect lives and reduce property damage

United States Geological Survey

The use of USGS streamgaging data in the National Weather Service's (NWS) flood warning program is well documented in the National Research Council's *Assessing the National Streamflow Information Program* (2004). Real-time river stage and discharge are essential to warn the public when flooding is imminent. The NWS flood warning program provides valuable lead-time for emergency response agencies to take effective action in advance of rising waters. Current data from both stream and precipitation gages are basic requirements to model watershed response, project future streamflows, and issue appropriate warnings.

How data are used

Historical streamflow data are essential for the NWS River Forecast Centers (RFCs) to calibrate the rainfall-runoff models in the National Weather Service River Forecast System (NWSRFS) that are the basis for flood warnings. A long-term historical record that includes extreme wet and dry periods allows forecasters to define rate dependent watershed parameters that govern the watershed response to the full range of possible hydrologic conditions.

For operational forecasting, real-time streamflow data allows river forecasters to adjust model states or the projected hydrographs to match observed flows. Projected hydrographs at headwater points are routed downstream along with reservoir releases and intervening local flows. The routed flows must be converted to a stage at each forecast point. Stage-discharge relationships developed and maintained by the USGS that are based on periodic streamflow measurements are very important in this process. Physical changes in the channel due to scour or deposition will alter the stage-discharge relationship, which river forecasters must take into account.

In summary, the NWS flood warning program relies on long-term historical streamflow data, real-time stage and flow observations, and up-to-date stage-discharge relationships. The USGS, through the National Streamflow Information Program, provides a large percentage of the streamflow data used for flood warnings.

State and local government agencies also use real-time USGS streamflow data for site-specific flood warning and flood forecasting, and real-time inundation mapping.

Who uses data

Data are used by NWS, state and local government agencies, private entities, and some members of the general public.

Who benefits from uses of data

The beneficiaries of flood warnings are residents, communities, and businesses that, given sufficient lead-time, take action to reduce flood damages. Flood warnings allow emergency response agencies to inspect vulnerable portions of flood control systems, conduct flood fights, notify residents at risk, recommend evacuations, close roads, remove equipment from low lying areas, establish temporary shelters and mass care facilities, and provide assistance to those with special needs.

Consequences of absence of data

If streamflow data were not available, flood warnings would have much lower accuracy. The uncertainty in watershed response and stage-discharge relationships would make the forecasting process more difficult and likely lead to delays in issuing flood warnings. Much of the benefits associated with the NWS investment in NWSRFS would be foregone and forecasters would be forced to employ simplified techniques for projecting stages based on a few observations, such as historical crest stage relationships between upstream and downstream locations.

While the focus of this section is flood warning, the RFCs provide significant support to water system management with day-to-day river forecast products. The streamflow data needs described above for flood warning are also applicable to the more general mission of river forecasting.

Categories of benefits

Benefits of timely flood warnings are direct and tangible when actions are taken to reduce property damage. For example, occupants of floodplains can make arrangements to move belongings and valuables to a higher floor in their home or out of the floodplain. Occupants can also implement temporary flood-proofing activities to reduce flood damages if warnings are issued with enough lead-time. This inundation-reduction is quantifiable.

Benefits such as protection of human health and safety are direct and intangible. Flood warning can result in the timely and orderly evacuation of a floodplain, which reduces risks to evacuees.

3 Designing highways and bridges

National Park Service

How data are used

Federal, state, and local consulting design engineers use historical peak streamflow data to develop generalized flow frequency curves for the design of bridges and culverts, bridge scour analysis, and stream stability measures. A discharge for the required design frequency is developed to use in hydraulic studies to ensure that a structure will safely pass the design flow. The design frequency depends on the importance of the structure and public safety considerations. Flood frequency analyses are sensitive to both record length and the consistency of station records over the period of record. Long records and consistent measurement techniques provide a high degree of confidence in design flood estimates. The resulting benefits are cost containment in highway structures.

Since highway designers must evaluate flood frequencies at many locations that have never been gaged, other methods frequently are used to estimate the discharge for the design frequency. The USGS develops regional regression equations using streamgage data at nearby sites. These equations compute the estimated discharge for a given frequency based on the channel slope and area of the ungaged basin. Separate regression equations may be developed for rural and urban areas to differentiate between basins in which development has altered the basin's natural response to rainfall (Missouri DOT 2004). If the regional regression equations have not been updated to include recent peak flows, they are less likely to yield acceptable estimates for design flows.

Who uses data

Data are used by federal, state, and local consulting design engineers.

Who benefits from uses of data

Beneficiaries of this data use include federal, state, and local governments, the transportation industry, and the general public.

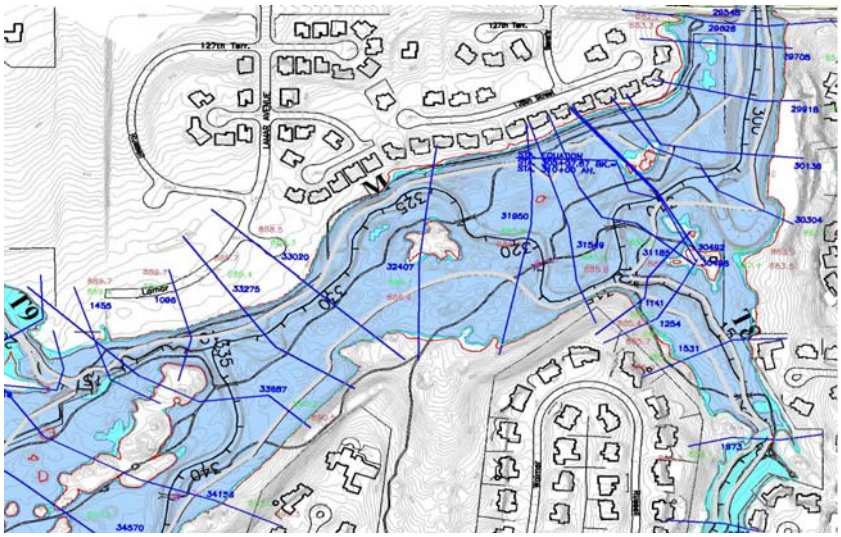
Consequences of absence of data

In addition to regional regression equations, rainfall-runoff modeling is an alternative approach for estimating design flow at an ungaged location. A watershed model is developed to compute runoff based on storm precipitation representing the design frequency. A design engineer will build in additional factors of safety if limited data exist, which could result in overdesign and additional expense.

Categories of benefits

The benefits of adequate streamgage data for highway and bridge design are both direct tangible and indirect intangible. The costs of underdesigning a project can be estimated if, for example, a bridge is constructed at too low an elevation and causes water to back up and inundate the road. The direct tangible benefits would be the damages avoided over the life of the project. A bridge built too high would have additional construction costs. A bridge built to adequate height provides life safety benefits to those who drive over it; these benefits are indirect intangible.

4 Mapping floodplains



City of Overland Park — Public Works Department

Flood mapping studies are extremely important since the Federal Emergency Management Agency (FEMA) uses floodplain maps to establish flood risk zones and require flood insurance, through the National Flood Insurance Program (NFIP), for properties within the 100-year floodplain. Many areas subject to development in the near future are unmapped or have outdated maps. Preventing new development in floodplains, which reduces future flood damage, is the cornerstone of floodplain management.

How data are used

The need for historical flood peak data to map floodplains is very similar to the previous discussion for highway design. Long records with consistent measurement techniques have high value in developing flood frequency curves to determine the 100-year flood flow. The 100-year flow is used to develop water surface profiles, which are then used to map areas subject to inundation.

Who uses data

FEMA, state, and local governments, and consultants are the primary users of peak streamflow information for floodplain mapping.

Who benefits from uses of data

Beneficiaries from this category of data use include state and local communities as well as homeowners/renters who participate in NFIP (and thus receive insurance reimbursement in the event their home is flooded). Floodplain mapping is a cost-effective tool for reducing future flood damages. The primary benefit is preventing future damage claims from high-risk flood zones.

Consequences of absence of data

If historical peak flows are not available, regional regression estimates and rainfall-runoff modeling are alternative methods for estimating the 100-year discharge. The uncertainties introduced by these alternate methods have a direct impact on the final map boundaries and subsequent land use decisions.

Categories of benefits

The benefits of adequate streamgaging data for floodplain mapping are direct and tangible. The benefits can be determined by reduction in flood loss. For example, a flood damages a home developed in a high-risk flood zone that is not mapped as a flood zone. The damages could have been reduced (or avoided) if the area was mapped correctly. The damages reduced or avoided are quantifiable.

NASA — Earth Observatory

5 Monitoring environmental conditions and protecting aquatic habitats

National Oceanic and Atmospheric Administration

How data are used

This category describes a wide variety of uses and users. Resource agencies use streamflow data to assess the impacts of water projects, hydropower operations, and transportation projects on aquatic systems and to develop recommendations for in-stream flow guidelines. Adaptive management of water projects often relies on real-time streamflow data to monitor flows, temperature, or water quality parameters that affect the survival of aquatic species. Resource agencies are working closely with project operators to better understand the relationships between timing and magnitude of flows and fish migration and spawning. The availability of streamgage data enables environmental scientists to test hypotheses about favorable flow conditions for threatened and endangered species.

Who uses data

The users of this information are federal and state natural resource agencies and many non-governmental organizations with interests in ecosystem restoration and aquatic habitats.

Who benefits from uses of data

Protecting environmental resources has become a major objective for the nation's water resource management programs. Water project operations are required to meet flow thresholds for protecting fisheries and other aquatic species. The nation as a whole benefits from sound environmental policies that are informed by unbiased water resources data.

Consequences of absence of data

Without USGS streamflow data, new methods would need to be developed to monitor impacts of water projects and monitor conditions critical to the health of aquatic species. The progress made in recent years in adapting water project operations to meet constantly changing environmental conditions would not be sustainable.

Categories of benefits

The benefits of streamgaging data for environmental monitoring are largely indirect and intangible. Much is yet to be learned about the timing and flow thresholds that are optimal for aquatic species, so the benefits cannot be measured directly.

United States Army Corps of Engineers

6 Protecting water quality and regulating pollutant discharges

United States Geological Survey

Streamflow data are essential for making water quality assessments of chemical and biological constituents. Causes of impaired water quality can be categorized as: sediment and siltation, pathogens, metals, nutrients, and organic enrichment. Many inorganic and organic species such as pesticides and heavy metals are attached to suspended clays and organic matter in the rivers.

How data are used

Streamflow data are needed to monitor water quality constituents and compute contaminant and sediment loads. Stream discharge and velocity, as well as discharge estimates, are essential for monitoring water quality. Pollutant discharge permits require that there is sufficient flow to provide adequate dilution. Critical low flow values are important in total maximum daily load computations (TMDL) to determine point source wasteload allocations. Accurate measurements of streamflow are essential to monitor how flows and concentrations of pollutants vary over time. Historical streamflow data are required to determine TMDL levels for different flow regimes.

Who uses data

Federal, state, and local governments use these data for monitoring water quality purposes. Section 303 (d) of the Federal Clean Water Act requires states to develop TMDL management plans for water bodies determined to be water quality limited. Public and private agencies, consulting firms, universities and researchers also use these data.

Who benefits from uses of data

Water quality monitoring and pollutant regulation provide benefits to the overall health of the nation's waters.

Consequences of absence of data

TMDLs cannot be determined accurately without streamflow data. To err on the side of caution, TMDL levels set without reliable streamflow information must be set at lower levels than probably necessary. Thus, a basin management plan may have an unnecessarily high cost to achieve a water quality standard. Similarly, if historical streamflow data is unavailable and the critical low flow period is underestimated, costly treatment processes or detention storage could be required to meet proper dilution ratios for treated wastewater discharges.

Categories of benefits

The benefits of streamgaging data for protecting water quality provide direct and tangible benefits since it leads to proper design of facilities with associated costs that can be estimated. There are also indirect tangible benefits in that increased certainty in the information available to establish basin water management plans could avoid costly plan revisions and approvals from regulatory agencies.

United States Geological Survey

7 Managing water rights and transboundary water issues

NASA — Earth Observatory

Ensuring that water is allocated properly among water rights holders is another important use of streamgaging data. Whether users are adjacent landowners in a watershed or states that share a boundary, consistent methods of accounting for available water supply are needed. Many interstate compacts and transboundary agreements also have provisions for managing water quality and flood waters.

How data are used

Streamgages are essential to identify how much water is available for diversion. Often basin watermasters are responsible for distributing a portion of the available streamflow to water users under a defined water right system. Real-time streamgage data are used to determine how much water can be diverted and to restrict diversions when flows fall below instream needs. Long-term records of streamflow are also important to water right proceedings when regulatory agencies consider new applications for diversion. As with other uses of the streamgage data, there is a high value in consistent measurements both within the diversion season and over many years to establish a reliable baseline.

Also in this category, is the need to account for flows between states as required by interstate compacts and flows that cross US borders with Canada and Mexico subject to international agreements.

Who uses data

State water rights boards, other state and federal resource agencies, and interstate and international commissions who have the responsibility for ensuring that water resources are allocated equitably use these data.

Who benefits from uses of data

The beneficiaries include the full range of water and environmental interests: water supply for agriculture, communities, and businesses; instream uses; flood management; water quality; hydropower generation; and recreation.

Consequences of absence of data

As our population increases, water distribution between states, and indeed, water rights in general is becoming significantly important. Without the ability to measure the flow into/out of state would jeopardize legal compacts regarding water distribution. As the National Research Council (2004) notes, the dispute of interstate water control will rest on a foundation of long-term streamflow information. When these disputes arise, it will be too late to begin collecting information.

Categories of benefits

The benefits of streamgaging for managing water rights and transboundary agreements are direct and tangible. For example, the value of water allocated among the entitled users can be estimated and the costs associated with decisions based on lack of information can also be estimated. In addition, the costs associated with legal disputes are also a direct tangible cost. In cases where diversions are made without sufficient streamflow information, there may also be indirect intangible costs to the environment, ecosystems, and protected species.

8 Education and Research

United States Geological Survey

Streamflow data are a primary requirement to further our understanding of hydrologic trends and changes in natural processes. The inherent variability in hydrology is an important factor in many research efforts. Consistently measured, unbiased data allows researchers to model complex interactions between physical and natural systems.

How data are used

Both historical and real-time streamflow data have great value to students, researchers, and scientific organizations. Streamflow data are needed to develop a wide range of models, from watershed models that assess impacts of land use changes to hydrodynamic models for evaluating the effects of varying flow regimes in estuaries. Historical and real-time data are increasingly used in biological models to project how changes in flows will affect habitats and species.

Long-term streamflow data assists in research "river science" as defined and discussed by the National Research Council. Likewise, long-term historical streamgage records at sites relatively undisturbed by development are important indicators of climate trends and ecological patterns, as recognized by the USGS in establishing gages within "sentinel" watersheds as one of NSIP's primary goals. Long-term historical data provide benchmark data required for these studies.

Who uses data

Data users include colleges, universities, public and private scientific and research agencies, and individual researchers.

Who benefits from uses of data

There are significant benefits to the nation in terms of advancing our understanding of physical and natural processes and the impacts of human-induced changes. Decision makers at all levels of government benefit from more facts and greater certainty in projections about the future resulting from this research.

Consequences of absence of data

Loss of historical benchmark streamflow data, would equate to the loss of one of the major ways we currently monitor trends in hydrologic, ecologic, climatic, and water quality over time. Loss of streamflow data in education and research would hamper efforts to develop new methods and tools for meeting the challenges of a changing planet.

Categories of benefits

The benefits of streamgaging data for educational and research uses are largely indirect and intangible. It is difficult to assign a value to advances in science.

United States Geological Survey

9 Recreation

United States Geological Survey

Recreational users of streamflow data are a rapidly growing category of users. The USGS effort to add real-time data transmission capability from their gage sites has made it possible for many recreationists and water recreation businesses to monitor stream conditions and plan recreation outings.

How data are used

USGS streamflow data are certainly used for recreational purposes. The full extent of how these data are used is not known. Data are used for sports fishing, fly fishing, boating, kayaking, canoeing, rafters, tubing, and scenic river tours. Some amateur, college, and Olympic level competitive sports use streamflow data as well, include swimming, rowing, and waterskiing.

Who uses data

Data users include recreational groups such as the Monocacy Canoe Club in Maryland, private business that provide water recreation such as rafting trips, agencies who provide permits for rafting and other water recreation, and the general public.

Who benefits from uses of data

Beneficiaries include the recreating public and those who provide recreation. These data can be used to determine whether or not conditions are safe and/or opportune for recreational activities.

Consequences of absence of data

Without these data, other methods would have to be found to determine streamflow in order to make decisions on the safety and/or opportune time/location of the water activity.

Categories of benefits

Benefits for recreational use of USGS streamgage data are, for the most part, direct intangible. For example, kayakers use data to determine when and where the best kayaking opportunities can be found. Recreational use can also have direct intangible benefits for recreation businesses using data to make decisions about safety. Commercial whitewater businesses receive direct tangible benefits when they use the information to plan their operations and schedule their excursions.

California Department of Water Resources

Unique value of USGS streamgaging data

United States Geological Survey

The USGS is unique among public agencies in that it has provided high quality streamflow records to the nation for over 120 years.

The value of streamflow records increase over time

Streamgages with a long period of record are particularly valuable because they enable users to understand extreme events, hydrologic variability, long-term climate trends, and the effects of both land use changes and project operations on streamflows. These records integrate complex physical processes and form a baseline for projections of about future changes. Consistency in measurement techniques and continuing the specialized training of personnel who collect and interpret these records are key factors in providing a reliable source of data.

Use is increasing with online access

Online access to USGS streamgage records dramatically streamlines the process for obtaining historical streamflow data. Data histories that were previously difficult to assemble are now easily downloaded and can be evaluated much more rapidly than before. The concept of an open system available to all is allowing new users to gain experience with the records and put the data to better use. An open system of unbiased information fosters better public decisions and more timely decision-making. In the future, both the number of users and the ways in which the data is being used will increase, and the information's value will increase accordingly.

Streamgages serve multiple uses

Most streamgages have value for more than one use. The same gage may provide useful information for water diversions, water quality monitoring, floodplain mapping, or as a boundary condition for a new basin model. A streamgage near an area that is undergoing development or other land use changes becomes even more valuable when projections of future conditions are needed.

While this report and other evaluations have focused on primary users of the data, particularly the entities who have an ongoing need for the data and contribute funding to operating and maintaining gages, secondary users receive significant benefits from the data. Often, users have a one-time need for the data to answer a specific question or to design a specific structure. Many users will search for the best available or most representative flow data near their area of interest. Some will seek a gage record that includes a specific period of time or event of interest. These ad hoc uses are difficult to properly value, but produce additional benefits that can be quite large over the period of record.

United States Geological Survey

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