

Qualitative Comparison of Streamflow Information Programs of the U.S. Geological Survey and Three Non-Federal Agencies

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Abstract

A qualitative comparison was made of the streamgaging programs of the U.S. Geological Survey (USGS) and three non-Federal agencies in terms of approximate costs and streamflow-information products produced. The three non-Federal agencies provided the USGS with detailed information on their streamgaging program and related costs, and the USGS explored, through publicly available Web sites and one-on-one discussions, the comparability of the streamflow information produced.

The type and purpose of streamgages operated, the quality of streamflow record produced, and cost-accounting methods have a great effect on streamgaging costs. There are many uses of streamflow information, and the information requirements for streamgaging programs differ greatly across this range of purposes. A premise of the USGS streamgaging program is that the network must produce consistent data of sufficient quality to support the broadest range of possible uses. Other networks may have a narrower range of purposes; as a consequence, the method of operation, data-quality objectives, and information delivery may be different from those for a multipurpose network. As a result, direct comparison of the overall cost (or of the cost per streamgage) among these programs is not possible. The analysis is, nonetheless, very instructive and provides USGS program managers, agency leadership, and other agency streamgaging program managers useful insight to influence future decisions. Even though the comparison of streamgaging costs and streamflow information products was qualitative, this analysis does offer useful insights on longstanding questions of USGS streamgaging costs.

Introduction

The U.S. Geological Survey (USGS) operates and publishes data for nearly 7,400 streamgages nationwide. Streamgaging is the largest single class of activities in the USGS

water program, with an investment of more than \$120 million per year. Recently, the USGS has been asked informally by stakeholder groups to evaluate the cost of its streamgaging program by comparing USGS costs to those of other organizations or agencies with similar streamgaging programs (programs providing continuous streamflow information). Given the magnitude of the funding and the importance of the information produced, it is reasonable that the USGS should expend the effort to make a comparison of its program with other existing programs as a benchmark to identify opportunities for improved efficiencies and (or) changes in the nature of its streamflow-information products. A qualitative comparison was designed to look at the approximate costs of three independent streamgaging programs across the Nation to the approximate costs of three respective local USGS Water Science Center (WSC) streamgaging programs. The streamgaging programs of the Colorado State Engineers Office (CO SEO), the Lower Colorado River Authority (LCRA), and the Washington Department of Ecology (WA DOE) were the non-USGS agencies participating in the analysis. The streamgaging programs of the Colorado, Texas, and Washington USGS WSCs were used for comparison. The comparison not only looked at costs but also objectives of the individual programs and the associated information products—in terms of type, usefulness, and availability—derived from data collected by the respective streamgage programs and networks. This report describes the results of this comparison.

Comparison of USGS Streamgaging Costs to Other Agencies' Streamgaging Costs

Cost information was provided in the following categories: administrative, building and utilities, field equipment, labor for field and office, vehicles, travel, and data management and delivery (table 1). The values used for the cost comparison were supplied by each agency and WSC.

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Table 1. Cost comparison of streamgaging programs.

[Tabulated values are cost per streamgauge per year. These are reported values from each agency only. Differences in streamgaging data quality and the data-collection process are not accounted for; therefore, direct comparisons should not be made. Columns may not add to total annual cost because of independent rounding. Abbreviations: USGS, U.S. Geological Survey; CO, Colorado; TX, Texas; WA, Washington; WSC, Water Science Center]

Category	USGS CO WSC	USGS Texas WSC	Lower Colorado River Authority (TX)	USGS WA WSC	WA Department of Ecology	Average USGS WSC	Average for other agencies	CO State Engineer's Office
Administrative	\$4,200	\$3,200	\$1,700	\$3,200	\$2,700	\$3,500	\$2,200	\$570
Building and utilities	1,100	1,400	810	1,800	620	1,400	700	130
Field equipment	1,500	1,800	2,400	880	1,200	1,400	1,800	1,200
Labor for field and office	5,300	6,500	4,500	5,500	5,400	5,800	5,000	4,600
Vehicles	490	940	980	540	370	660	700	310
Travel	190	590	15	170	470	320	250	54
Data management and delivery	1,200	570	3,200	1,200	490	990	1,900	440
Annual cost per typical continuous streamgauge	\$14,000	\$15,000	\$13,600	\$12,700	\$11,300	\$14,100	\$12,600	\$7,300

Average Costs Per Streamgauge

On average, the overall cost for the three non-Federal streamgaging programs evaluated was less than the USGS program cost (table 1). Reasons behind the cost differences are numerous. One reason is that the cost information was collected by each agency with its own unique accounting practices. There is no question that all costs are well suited to the respective agencies' needs, but these costs are sufficiently different to limit the comparability of program and overhead cost accounting. Another principal difference that prevents direct comparison of program cost is that the purpose and use of data collected by a particular streamgauge network, or even by a subset of streamgages within a single agency's network, can exert a significant influence on the quality assurance/quality control (QA/QC), collection methods, and frequency of measurements. The network of the CO SEO offers a case in point.

According to the CO SEO, data collection, record review, and publishing for 225 of the 400 continuous streamgages in that network are generally comparable to or exceed the corresponding effort for typical USGS streamgages. In fact, of these 225 CO SEO streamgages, approximately 170 receive significantly more site visits and discharge measurements (18–20) than is typical for most USGS streamgages (10). The CO SEO commonly refers to this 225-streamgauge network as the “published-record” network, because the streamflow records from these sites are published in a CO SEO annual data report. The remaining 175 CO SEO streamgages are used for diversion

and administrative purposes; in general, it appears (with some exceptions) that these streamgages are visited 75 to 80 percent less frequently, resulting in fewer discharge measurements per year than the 225 published-record CO SEO streamgages and about 50 to 70 percent fewer site visits and discharge measurements than a typical USGS streamgauge. About 60 percent of the CO SEO diversion- and administrative-record streamgages are on canals or ditches (as opposed to natural channels), and most are equipped with stable artificial flow controls. Because of the hydrologic stability of these canals and ditches, streamgages at such sites require significantly less field effort to operate and maintain than streamgages on naturally flowing streams with natural controls, without negative effects on the quality of the information produced. In addition, there are considerable economies in office work, in that the CO SEO diversion- and administrative-record streamgauge records generally require less rigorous post-collection review and editing than either the 225 CO SEO published-record network streamgages or typical USGS streamgages. The main operational objective of the CO SEO diversion- and administrative-record streamgages is to produce the highest quality record possible in real time for real-time water-rights administration. This operational objective differs substantially from that of the 225 CO SEO published-record streamgages or the USGS streamgages, which is to produce the highest quality post-collection record possible for historical and statistical-analysis purposes; this latter objective entails a combination of rigorous field procedures and exhaustive post-collection record-working procedures.

The reported \$7,300 cost per CO SEO streamgage represents an average cost for the entire 400-streamgage CO SEO network. The complexities of separating out the actual cost for the published-record streamgages and the diversion- and administrative-record streamgages precluded a more detailed cost breakdown. However, because of the aforementioned differences in CO SEO network operations, the actual streamgage cost for the 225 CO SEO published-record streamgages would be expected to be higher than \$7,300, and the actual cost of the 175 diversion- and administrative-record streamgages would be expected to be lower. This situation complicates any quantitative comparison of USGS and CO SEO streamgage costs. Had a cost per streamgage for the 225 published-record streamgages been available, it would have been the more appropriate value for comparison to USGS and other non-Federal streamgage costs, because the published-record streamgages are more operationally typical of streamgages in the other non-Federal and USGS networks.

The influence of the diversion- and administrative-record streamgages on the average CO SEO streamgage cost appears to be very strong because including these streamgages substantially lowers the combined average streamgage cost for all the non-Federal streamgage networks included in this analysis. If the CO SEO cost information is omitted from the combined averages, the average for the non-Federal agencies is \$12,600 per streamgage; moreover, the average costs of the non-Federal programs compared to the average USGS costs would be only about 10 percent less. The CO SEO diversion- and administrative-record streamgages affect the operation of the CO SEO network to such an extent that the CO SEO program and approximate costs are not comparable to the other USGS and non-Federal streamgaging programs. For this reason, the CO SEO program is shown separately in tables 1 and 2 and is not included in determining averages.

Differences in data-collection objectives (and possibly other factors) have less extreme effects on costs of the other two non-Federal agencies, but the differences and the network complexities are sufficient that comparability is an issue with their cost information as well. For example, one of the major objectives of the WA DOE program is to provide accurate low-flow data that can be used for reach-specific salmon recovery and water-management decisions in smaller rivers. Consequently, the State has an interest in concentrating its measurements on low flows and smaller rivers. As a result, this objective tends to keep WA DOE's streamgaging cost lower by eliminating many of the expenses associated with flood-data programs. For example, the cost of cableways, dispatching large crews for streamflow measurement during flooding, and indirect estimation of flood-peak data after major flood events are not needed in the collection of these records. Flood-related measurement activity is intense for a few days each year, and the number of trained staff needs to be sufficient to meet these peak demands. Programs such as WA DOE's, which by design, has less interest in the high end of the rating curve for a significant number of its streamgages, are able to operate at a lower cost because the workload involved in collecting low- to

medium-flow measurements is much more regular and more flexible than when high-flow measurements are an important part of the program. In order to compare the WA DOE average per-streamgage cost with that of the USGS, it would be necessary to make adjustment for the fact that the USGS program cost includes the personnel, training, equipment, and other resources required to obtain the high-flow data.

The comparison of USGS streamgaging program cost with the LCRA cost is also complicated, but for different reasons. The LCRA operates a set of streamgages (43) that are generally equivalent to typical USGS streamgages; however, the average cost per streamgage in this analysis is based on 68 streamgages for which the LCRA reports streamflow on its Web site. For 18 of these 25 additional streamgages, the USGS usually collects the high-flow data and some data in the middle flow range, maintains the rating curve, checks and finalizes the data, and publishes the data. The LCRA makes most of the low-flow measurements at these 18 streamgages and performs all the maintenance activities. For another seven streamgages, the LCRA does all the maintenance, and the USGS does all the discharge measurements and rating development with funding provided under a cooperative agreement between the USGS and a third party. Although the LCRA provides funds for the USGS work at these 18 streamgages, the LCRA also has costs associated with the maintenance activities and low-flow measurements. In addition, for the other seven streamgages, the funding comes from outside the LCRA for all but the maintenance activities. These funding and operating complexities confound any cost comparison between the two streamgaging programs unless the cost for the 43 streamgages operated solely by the LCRA can be separated from the 18 streamgages operated in collaboration with the USGS and the 7 funded cooperatively with another agency. Unfortunately, such a separation was not possible given the constraints of this analysis.

Cost Comparisons

With regard to costs by category (table 1), analysis results show that the single largest difference between the USGS and the non-Federal agencies was in the administrative cost category (USGS costs \$1,300 more). The administrative cost category includes program management, technical oversight, quality assurance, and overhead costs paid to a higher level unit (such as the USGS Bureau assessment).

The fact that administrative charges are nearly 60 percent higher for the USGS compared to the non-Federal agencies' streamgaging programs warrants further discussion. The USGS is required by the Department of the Interior and the Office of Management and Budget to apply full project cost-accounting principles, whereby each customer or project is assessed a fair share of the cost to support the Bureauwide services and infrastructure. For example, costs associated with USGS executive leadership, communications (with the public, Congress, and the media), personnel management, purchasing,

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Table 2. Detailed information for streamgaging program comparison.

[Information provided by the respective agency responsible for the program. These are reported values from each agency only. Differences in data quality and the data-collection process are not accounted for; therefore, direct comparisons should not be made. Abbreviations: USGS, U.S. Geological Survey; CO, Colorado; TX, Texas; WA, Washington; WSC, Water Science Center; FTE, employee full-time equivalent; IT, information technology; <, less than]

Diagnostic indicators	Average USGS WSC	Average for other agencies	CO State Engineer's Office
FTE involved in the streamflow data-collection process	27	11	23
Number of continuous streamgages	293	98	400
Ratio of gages to FTE in streamgaging program	11	10	17
Average salary and benefits for streamgager (nonmanagement personnel) and range	\$63,200	\$71,300	
Discharge measurements made per year per streamgage	9	6	11
Annual onsite streamgage inspections	11	8	9.8
Special trips for streamgage when equipment malfunctions?	Yes	Yes	Yes
Streamgages per field FTE	13	14	15
Field and office labor hours per streamgage	150	110	120
Employee development/training/safety per streamgage	\$260	\$380	\$13
Management/technical oversight FTE for streamgaging program	4	1.7	1.4
Streamgages per management/technical oversight FTE	77	60	290
Management/technical oversight average yearly salary	\$101,000	\$102,000	\$117,000
Management salary cost per streamgage	\$1,200	\$1,400	\$720
Administrative staff FTE needed to support streamgage program	3	1.2	1.5
Average annual salary of administrative staff	\$59,000	\$62,650	\$26,900
Streamgages per administrative staff FTE	110	98	270
Administrative salary cost per streamgage	\$630	\$690	\$180
Overhead from Headquarters/higher office per streamgage	\$1,500	0	\$39
Cost per square foot of space	\$14	\$29	\$12
Square foot of office space per streamgage	110	47	17
Square foot of office space per FTE	1,200	290	190
Total mileage per streamgage	1,000	1,800	1,500
Annual cost per vehicle in fleet	\$6,300	\$7,500	\$6,000
IT salary per gage	\$830	\$1,000	\$420
Average missing record days per year per streamgage	<4	<7	<4

contracts, safety, financial management, and facility costs are proportionately supported by USGS appropriations and reimbursable funding and are included as an administrative charge in the cost of operating streamgages and all other USGS science activities. As shown in table 2, these administrative charges (overhead to a higher organizational level) add an average of \$1,500 to the cost of operating the average USGS streamgage. Accounting practices and funding sources are different for the three non-Federal agencies, and it appears that substantial parts of these administrative costs may not be directly assessed against their streamgaging program.

Another factor contributing to USGS administrative costs is the complexity of managing a largely reimbursably funded streamgaging network. The USGS streamgaging network has more than 800 funding partners nationwide, which distributes the cost of delivering streamflow information to a large stakeholder community. Managing these partnerships requires a substantial amount of time and travel on the part of USGS WSC managers (center directors, data chiefs, and field-office chiefs). This management effort includes time spent in initial discussions of the program with potential new funding agencies, negotiating annual agreements, and making presentations to officials and governing boards (for example, city councils, county boards of supervisors, irrigation districts, or river basin organizations). In addition, fiscal staff at each WSC, prepare and obtain approval of the needed Joint Funding Agreements with each partner. Special legal or business requirements for some partner agencies make many of these 800-plus agreements unique and require multiple time-consuming reviews within the USGS and the funding agency. Although the level of funding-agreement effort varies widely between partners depending on the number of streamgages funded and the partner agencies' information needs, the estimated administrative costs of reimbursable program management may be as much as \$500 per streamgage. Such administrative costs are either nonexistent or relatively small for the non-Federal agencies, who each generally receive most of their funds from either a single internal source or just a few sources—making administration and customer relations less complex. If the approximately \$2,000 additional cost per USGS streamgage (the overhead paid to higher organizational levels and the cost of negotiating reimbursable agreements) were omitted from USGS costs, the average cost of the USGS streamgage would be about 4 percent less than that for the non-Federal agencies.

The cost category making up the second largest difference in average streamgage costs per year was labor for field and office (table 1). Although the non-USGS salaries for streamgagers were higher than USGS salaries (table 2), the USGS spent more time per streamgage in both the field and office, resulting in higher total labor costs. In the cost categories of data management and delivery, and also in the field-equipment category, USGS costs were lower; this is likely because of economies of scale via the USGS National Water Information System (NWIS) database and the Hydrologic Instrumentation Facility (HIF), which purchases and does acceptance testing of equipment in bulk for cost savings.

LCRA's significantly higher cost in the data management and delivery category is largely due to the agency's real-time radio system required for timely operation of a reservoir system during flood events; LCRA estimates that the radio system represents 10 to 15 percent of its total per-streamgage cost. Buildings and utilities, travel, and vehicle average costs were similar for USGS and the non-Federal agencies.

Comparison of the Usefulness and Availability of the Streamflow Information Produced

An appropriate comparison of cost must also include a comparison of products. As mentioned briefly in the previous section of this report and elaborated upon here, program objectives for a network of streamgages or a subset of streamgages within a network can have a dramatic influence on the amount of effort that is appropriate for the process of reviewing, editing, publishing, and archiving streamflow data. Similarly, the types of information products derived from basic streamflow data, the short- or long-term nature of the products, the method of delivery (availability), and the need for consistency with other products all affect quality targets and efforts. From the perspective of the end user, however, what is critical is that the type and quality of information are suited to the intended need—such suitability is referred to as “usefulness” in this report—and that availability of the information also is suited to the need. Streamflow usefulness and availability factors examined in conjunction with the cost analysis are summarized in table 3. A detailed discussion of factors that bear on streamflow-information usefulness (with particular emphasis on USGS requirements) is given in appendix 1.

As is the case with average costs, comparison of USGS and CO SEO information-product usefulness and availability highlights the substantial effects of differences in program objectives and information-product purposes. The USGS produces streamflow records that are used by a vast stakeholder community for a wide variety of purposes. The timeliness and continuity of the data stream, the high level of accuracy, and the standardization of data quality required by these diverse users have an important influence on the methods employed and the level of effort expended by USGS to collect and report streamflow information. Not all streamflow data are collected in a manner similar to that of the USGS nor are the data intended for such a wide variety of applications.

Of the 400 CO SEO streamgages used in the cost comparison, the data quality for 225 is directly comparable to, or some cases exceeds, that of USGS streamflow data. At the time of the analysis, however, there are differences in data availability; for example, the previous 3 days of the CO SEO's instantaneous values are displayed online (compared to 31 days for the USGS), and historical daily values have only recently (summer 2006) become available online.

Table 3. Summary of factors affecting streamflow information usefulness and availability.

[CO, Colorado; WA, Washington; POR, period of record; USGS, U.S. Geological Survey; Lat-Long, latitude-longitude; DOE, Department of Ecology; SEO, State Engineers Office; LCRA, Lower Colorado River Authority; WY, water year; QA/QC, quality assurance/quality control]

Agency	Streamflow information Web page	Unit-value data available online ¹	Historic data available online ²	Data available by request (not online) ³	Percent WY 2005 online data provisional as of July 2006 ⁴	Rating curve available online ⁵	Discharge measurements available online ⁶	Average number of discharge measurements in 2005 ⁷	Streamflow statistics available online ⁸	Rating curve development documentation ⁹	Rating curve QA/QC documentation ⁹	Frequency of technical program review ¹⁰	Period of record available online ¹¹	Stream-gage location available online ¹¹	Amount of estimated or lost data ¹²
CO SEO-225 published record streamgages	Real Time: http://www.dwr.state.co.us/Hydrology/flow_search.asp Historic Daily: http://cdss.state.co.us/DNN/ViewData/tabid/60/Default.aspx	Hourly data for 3 days, graphical for 10 days	POR historic daily values available; unit values available for period of 10 days	All unit value data older than 10 days	0%	Yes	If measured in last 10 days, plotted on graph	14-16	Yes	Yes	Annual in-house review	Yes	Yes	Yes	Less than 1%
CO administrative and diversion streamgages	Real Time: http://www.dwr.state.co.us/Hydrology/flow_search.asp Historic Daily: http://cdss.state.co.us/DNN/ViewData/tabid/60/Default.aspx	Hourly data for 3 days, graphical for 10 days	Provisional values for administrative; final available for diversion streamgages	All unit value data older than 10 days	100% administrative; 0% diversion streamgages	Yes	If measured in last 10 days, plotted on graph	3-5	Yes	Yes	Annual in-house review	Yes	Yes	Yes	Less than 1%
WA DOE	https://fortress.wa.gov/ecy/wr/vr/flows/regions/state.asp	Yes-graph current year, tables after	Yes	Online	75-100%	No current rating curves	No	5	Monthly mean, maximum, minimum, mean daily	Yes	Yes	Unknown	Yes	Yes	30%
LCRA	http://hydromet.lcra.org/index2.shtml	Yes-15 days	Yes, not finalized	Yes	0%	No	No	3	No	Use USGS documentation	Use USGS documentation	None	No	No	Unknown
USGS	http://waterdata.usgs.gov/nwis/sw/	Yes-31 days	Yes	Unit value data more than 31 days old	3%	Yes	Yes	8	Yes	Yes	Yes	3 years	Yes	Lat-Long	1%

Questions posed of all agencies regarding streamflow data:

- Are unit value data available online? WA DOE has graph only for current year, tables for past years.
- Are historical data available online? CO SEO unit data available for 10 days, then must be requested. LCRA doesn't provide what the period of record is online, but for about 60% of streamgages POR available.
- If data are not available online, can it be obtained by requesting it?
- What percent of WY 2005 streamflow data still provisional as of July 2006? LCRA has finalized record available by request, but not online. None of the WA DOE 2005 records were final from a random sampling, and 44% of WY 2004 were still provisional (75% other sampling).
- Is the most current rating curve available online? WA DOE has past rating curves available, but not the current rating curve.
- Are discharge measurements available online? CO SEO is plotted with the data if it was made in the last 10 days.
- What is the average number of discharge measurements made at each streamgage in 2005?
- Are streamflow statistics available online? Many WA DOE statistics flagged as estimated.
- Is there written documentation on how to develop and maintain rating curves and how the quality of the rating curves evaluated and maintained?
- What is the frequency of QA/QC reviews by a higher organizational office?
- What is the availability of critical information such as period of record and streamgage location online?
- What is the estimated amount of missing or estimated data for the entire program for WY 2005? WA DOE value is for WY 2004 because all 2005 data is still provisional at the time of analysis. LCRA does not provide flags to show estimated data.

Regardless of these data-delivery differences, the usefulness of the data for these 225 streamgages is highly comparable to that of the USGS data. The remaining 175 streamgages in the CO SEO network are the diversion- and administrative-record gages mentioned in the previous section. About 60 percent of these 175 streamgages are diversion-record gages and are used by CO SEO water commissioners in the real-time administration of State water rights. These streamgages typically have artificial controls, and discharge measurements are made approximately three to five times per year. The substantially reduced number of discharge measurements made at these streamgages is considered appropriate from a data-quality perspective, provided that the artificial controls are stable and well maintained. The annual streamflow records for these streamgages do not receive the same post-collection analysis and adjustment as the records of the 225 published-record streamgages but rather are reviewed for completeness and any obvious data irregularities by the CO SEO water commissioners. The annual records for the diversion-record streamgages are finalized by the water commissioners and made available online. The other approximately 40 percent of the 175 streamgages are considered administrative-record gages, which tend to be located on natural, tributary streams having natural controls. At these streamgages, discharge measurements are also made three to five times per year, although the actual number of measurements varies considerably depending on the stability of the control. At key administrative-record streamgages with unstable controls (such as those with shifting, sandy channels), considerably more frequent measurements are made to enhance the accuracy of the real-time record. These administrative-record streamgages are used by the Colorado water commissioners for the real-time administration of water rights. The records receive little post-collection review and remain provisional. Both the diversion- and administrative-record streamgage data are appropriate for their intended purpose, associated with real-time water-rights administration and water operations. However, these data probably are not as broadly applicable as data collected and analyzed by the CO SEO for its 225 published-record streamgages or by the USGS streamgaging network, both of which tend to monitor mostly natural flow systems. Hence, in terms of information usefulness and availability, this subset of the CO SEO streamgage network is not fully comparable to USGS streamgages.

The streamflow data collected by the LCRA also differ somewhat from USGS data because of the relatively low frequency of discharge measurements made at each streamgage. LCRA reported that, on average, four discharge measurements are made annually per streamgage, about half of the USGS recommended frequency for maintaining a rating on a natural stream. One reason for the fewer discharge measurements is that many streamgages operated by the LCRA off of the Colorado River main stem are located on channels that are dry for up to 6 months each year, reducing the opportunity to make measurements. Another factor that limits the usefulness of LCRA data is lack of publicly available ancillary information, such as the streamgage latitude and longitude, period of

record, drainage area, current rating curve, or indications when the online data change from provisional to final. Documentation on procedures such as rating-curve development and quality control is contained within LCRA files, but it is not readily available to online users of LCRA streamflow information.

The WA DOE streamgaging program is a relatively new program (most streamgages were installed in the last few years), and the streamflow data are collected with a priority of defining low flows. As a result, high-flow data for many WA DOE streamgages are qualified as estimates. WA DOE considers the quality of their streamflow information to be very important, and they have adopted numerous procedures and policies to ensure that the data meet those standards. Many of these procedures are included in their Quality Assurance Monitoring Plan available publicly online.

Streamflow data collected by WA DOE are readily available through the Web. Both daily mean and 15-minute values for discharge are available for most sites. In addition, for streamgages equipped with satellite telemetry (96 of 129 streamgages), plots of stream stage, discharge, and water temperature are given for the most recent 7-day period. Rating curves also are available through the Web for most of the WA DOE streamgages.

Analyses of the WA DOE streamflow data available on the Web revealed some issues related to rating curves and the production of finalized streamflow data, such that these data were viewed as not fully comparable to USGS data in terms of usefulness. In particular, some of the rating curves found online at the WA DOE public Web pages were not fully developed and (or) were not developed exactly according to USGS methods. Some did not incorporate all available data in the curve development, and some rating curves were extended further beyond measured data than is typically considered technically appropriate by USGS standards. These issues in rating-curve development could have a direct influence on the accuracy of reported streamflow. Although the WA DOE identifies data from extended rating curves as estimates, these estimated data are not always comparable to standard USGS streamflow data, which are more fully supported by high-flow measurements. Another usefulness issue regarding the WA DOE streamflow data is the large amount of provisional data on the Web from previous years. As of early July 2006, data sets for most of the WA DOE streamgages randomly viewed online were marked as provisional for water year 2005 (which ended September 30, 2005), and approximately 44 percent were marked as provisional for water year 2004, indicating that the data had not been verified and were still subject to change. Provisional status adversely affects the usefulness of the streamflow information because of the uncertainty added to any analyses that are based on the information.

Because the WA DOE streamgaging program is relatively new, it is understandable that the program would still be working out some of its procedures. It should also be noted that each member of the WA DOE streamgaging staff services from 5 to 12 more streamgages than the staff for the other agencies included in this analysis, which constitutes as much

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as double the workload. This additional workload may reduce the streamgaging operating costs, but it also may hinder the staff's ability to eliminate the large backlog of provisional data. The USGS is interested in working with WA DOE to review its procedures and determine how personnel can be used efficiently and how data quality and usefulness can be improved.

Conclusions

This analysis should help the USGS and stakeholders understand the differences between the streamgaging program and products of the USGS and the program and products of other agencies. The results of the analysis indicate that the three non-Federal agencies had streamgaging costs that were less than those of the USGS. The results also indicate that the types of streamgages operated, the frequency with which discharge measurements were made, and the methods of developing rating curves and calculating stream discharge often were

substantially different from typical USGS methods. These differences likely account for part of the cost difference. The analysis also indicates that the USGS has an administrative cost disadvantage because of the full project cost-accounting principles that the agency operates under and the additional administrative burden of the USGS reimbursable-program business model.

The USGS plans to work with the CO SEO, WA DOE, and LCRA to examine more closely the workflows and approaches that enable these agencies to produce streamflow information at a lower unit cost than the USGS. Although some of that difference may be attributed to differences in the types of streamgages operated and procedures for working the streamflow records, careful examination of these agencies' workflows and processes will be a valuable and welcomed benchmarking effort for the USGS.

The production of streamflow information is a costly undertaking, and the USGS will continue to search for approaches to improve efficiency and reduce costs. The USGS greatly appreciates the support of the CO SEO, WA DOE, and LCRA in helping with this comparison.

Appendix 1. Data-Usefulness Factors

As with nearly all information products, the value of streamflow information depends upon a need for the information and the usefulness of the information in meeting that need. The usefulness, and therefore, the value, of streamflow information depends on three characteristics of the information: (1) the quality of the information; (2) the availability of the information in the form and timeframe needed; and (3) the availability of ancillary information about the information product, such as how and where the information was obtained. The uses of streamflow information are many and varied (National Hydrologic Warning Council, 2006), and they include protection of life and property through streamflow forecasts; engineering design of bridges, culverts, and treatment facilities; daily to seasonal management of water-resource systems to meet customer needs and satisfy regulatory requirements; water-resource appraisal, allocation, and planning; determination of the effects of land use, water use, and climate changes; aquatic-habitat assessment and protection; water-quality evaluations, assessments, and planning; and recreation safety and enjoyment.

The following is a discussion of the three usefulness characteristics of information as they apply to stream discharge measured continuously throughout the year. References to U.S. Geological Survey (USGS) policies and procedures are cited where appropriate. Many of these USGS policies and procedures have been adopted by the three non-Federal agencies that participated in this streamgage-cost and information-product analysis.

1. Quality of Streamflow Information

The quality of streamflow information depends on many factors, from the equipment used to the skill of the individual interpreting the raw data. The vast majority of continuous-record streamgages in operation today do not measure streamflow directly but rather measure the water-surface elevation and estimate streamflow on the basis of a rating curve—a mathematical relation between the water-surface elevation and streamflow at the streamgage site. The factors that affect the quality of the streamflow information include the following:

- A. Accuracy to which the water elevation is measured. USGS policy is to measure elevation to an accuracy of 0.01 foot (ft) (U.S. Geological Survey, 1989b, 1992; Corbett and others, 1943; White and others, 1998).
- B. Number of streamflow measurements made to develop and maintain the accuracy of the rating curve. USGS average is 8 to 10 measurements per year (Rantz and others, 1982).
- C. Extent to which discharge measurements cover the range of streamflow at the streamgage. USGS attempts to obtain measurements that cover the range of flow (high and low flows) every year for the life of the streamgage but uses only qualitative measures to rate the success of doing this (Corbett and others, 1943; Rantz and others, 1982).
- D. Accuracy of the streamflow measurement. Accuracy is variable and affected by many factors. The USGS attempts to achieve a difference of no more than 5 percent from the rating curve when the measurement is plotted on the curve. If the difference is more than 5 percent, another (check) measurement is indicated to verify the first measurement (Corbett and others, 1943; Rantz and others, 1982).
- E. Accuracy of the streamflow-velocity measurement equipment. USGS policy is to test equipment before and after each measurement and occasionally at the USGS Hydrologic Instrumentation Facility (HIF) (Corbett and others, 1943; Rantz and others, 1982; Smoot and Novak, 1968; Buchanan and Somers, 1969; U.S. Geological Survey, 1989a).
- F. Stability of the stream channel at the location of the streamgage. As a rule, the more stable the channel is, the more accurate the information will be (Rantz and others, 1982; Carter and Davidian, 1968).
- G. Stability of the recording gage (used to measure the water-surface elevation) relative to elevation of a base gage (a more stable gage that usually requires a physical measurement and thus not suitable for use as a recording gage) and stability of the base gage relative to land-surface datum. USGS policy is to check the recording gage against the base gage with every discharge measurement and to survey the base gage every 3 years, with expected closure within 0.001 ft (Kennedy, 1983; Carter and Davidian, 1968).
- H. Experience and skill of the individual developing and adjusting the rating curve on the basis of the raw water elevation and streamflow measurements. Experience and skill are variable, but all rating curves are reviewed after each measurement, and most USGS Water Science Centers (WSCs) have two reviews of the complete record (each rating curve) annually (Rantz and others, 1982; Carter and Davidian, 1968).

10 Qualitative Comparison of Streamflow Information Programs of the USGS and Three Non-Federal Agencies

- I. Comparability (consistency) of streamflow information from different streamgages and from different regions of the country is a factor of the methods used and quality-assurance procedures. USGS conducts a technical review of the surface-water (streamflow) program of each USGS WSC every 3 years to ensure data quality and consistency nationwide and to ensure that standardized published techniques are followed by USGS staff (White and others, 1998).
- J. Rate at which data are reviewed and become final or approved. The current standard for the USGS is that all data from a water year should be final and approved by April 1 of the next year, 5 months after the end of the water year.
- K. Amount of information lost due to equipment failure or other factors, which affects the quality because data then must be estimated. The USGS has decreased the amount of lost data to less than 1 percent over the last 10 years by using automated and manual monitoring of the real-time data. In addition, the USGS makes every effort to have a complete dataset (for example, USGS field technicians make discharge measurements under ice) to ensure a complete dataset even when the stage-discharge relation is not valid.
- (as daily mean streamflow) is available to the public online in tabular format or in graphical format for the entire period of record for more than 24,000 streamgages nationwide.
- D. The information should be available at the time step in which the data were collected (daily, hourly, or more frequently). USGS streamflow information is available in the unit values used when the data were collected during the previous 31 days—this information is available on demand from USGS Web pages (most at 15-minute intervals); unit values are also available from USGS WSCs back to the early 1990s for most streamgages. All daily values from the beginning of the record to the most recent full day are available online. The USGS has recently placed a large amount of historical and current unit-value streamflow information (an estimated 5 billion unit values) online (<http://ida.water.usgs.gov/ida/index.cfm>).
- E. The information should be available when needed most, such as during times of extreme weather conditions when computers can be down because of power outages. The USGS has three redundant servers in Virginia, South Dakota, and California to receive and disseminate streamflow information. If a server goes down, the information will still be available through one of the other servers.

2. Data Availability

The usefulness of streamflow information depends on the availability of accurate information in a timely manner and the ease and reliability of access to the information. Factors affecting availability include the following:

- A. For real-time streamflow information available on the Web, the frequency of data transmission from the streamgage and the delay before the information is updated on the Web pages. Most USGS streamgages transmit hourly or every 4 hours, but some transmit more frequently. The interval from the time of transmission to availability on USGS Web pages is about 7 minutes on average.
- B. The accuracy of automatically delivered real-time information can be influenced by instrument error or other factors during data storage and transmission. USGS policy is to check all real-time records once per work day and use automated data-checking software to look for data spikes or exceedingly rapid changes in the incoming stage data.
- C. Historical streamflow information should be as readily available online as real-time streamflow information and in user-convenient formats. USGS historical streamflow information

3. Ancillary Information

The availability of ancillary information about the streamflow data is important for assessing the data quality, conducting data analyses, and judging data comparability. The following are examples of the type of ancillary information that makes the streamflow information more valuable:

- A. Documentation of processes, procedures, and techniques used to ensure the quality of the streamflow information obtained. Each USGS WSC has a written Surface-Water Quality-Assurance Plan, and the USGS has published a series of reports describing accepted data collection techniques and methods that are required to be used nationwide in the USGS.
- B. Information about the streamgage, such as name, identification number, location, elevation, drainage area, period of record, and start and end date. USGS provides this information online for all streamgages.
- C. The current stage-discharge rating curves and the discharge measurements used to create the rating curves. USGS provides the discharge measurements online, and rating curves are available from a rating depot for download.

- D. Data summaries, such as statistics of mean daily streamflow, mean monthly streamflow, mean annual streamflow, and the annual peak streamflow. The USGS provides this information online for all streamgages.
- E. Other information obtained at the streamgage, such as precipitation and water-quality data. All data obtained by the USGS at a streamgage are available online with the streamflow information.

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