Surface Water Quality-Assurance Plan for the Indiana District of the U.S. Geological Survey

U.S. Geological Survey
Open-File Report 03-460

District Manuscript Version 2003.1

U.S. Department of the Interior
U.S. Geological Survey

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U.S. DEPARTMENT OF THE INTERIOR
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Contents

Contents—Continued

Conversion Factors

Multiply	By	To obtain
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
foot per second (ft/s)	0.3048	meter per second (m/s)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Temperature is given in degrees Celsius (°C), which may be converted to degrees Fahrenheit (°F) as follows:

$$°F = 1.8 \times °C + 32$$

Note: Text in black is the standard template from U.S. Geological Survey Open-File Report 94-382; text in red represents parts completed by the Indiana District.

Surface Water Quality-Assurance Plan for the Indiana District of the U.S. Geological Survey

By James A. Stewart *and* Donald V. Arvin

Abstract

This Surface Water Quality-Assurance Plan documents the standards, policies, and procedures used by the Indiana District for activities related to the collection, processing, storage, analysis, and publication of surface-water data.

Introduction

The U.S. Geological Survey (USGS) was established by an act of Congress on March 3, 1879, to provide a permanent Federal agency to perform the systematic and scientific “classification of the public lands, and examination of the geologic structure, mineral resources, and products of the national domain.” Surface-water activities in the Indiana District are part of the USGS overall mission of appraising the Nation’s water resources. Surface-water information, including streamflow, stage, and sediment data, are used at the Federal, State, and local levels for resources planning and management.

The purpose of this District Surface Water Quality-Assurance Plan (QA Plan) is to document the standards, policies, and procedures used by the Indiana District for activities related to the collection, processing, storage, analysis, and publication of surface-water data.

This plan identifies responsibilities for ensuring that stated policies and procedures are carried out. The plan also serves as a guide for all District personnel involved in surface-water activities and as a resource for identifying memorandums, publications, and other literature that describe in more detail associated techniques and requirements.

The scope of this report includes discussions of the policies and procedures followed by the Indiana District for the collection, processing, analysis, storage, and publication of surface-water data. Specific types of surface-water data include stage, streamflow, sediment, and basin characteristics. In addition, issues related to the management of the computer database and employee safety and training are presented. Although procedures and products of interpretive projects are subject to the criteria presented in this report, specific interpretive projects are required to have a separate and complete quality-assurance plan.

Throughout the QA Plan, various Water Resources memorandums are cited; these memorandums are listed in Appendix 1.

This QA Plan is reviewed and revised at least once every 3 years in order that responsibilities and methodologies are kept current and in order for the ongoing procedural improvements to be documented effectively.

Responsibilities

Quality assurance (QA) is an active process. Achieving and maintaining high-quality standards for surface-water data are accomplished by specific actions carried out by specific persons. Errors and deficiencies can result when individuals fail to carry out their responsibilities. Clear and specific statements of responsibilities promote an understanding of each person's duties in the overall process of assuring surface-water data quality.

The following is a list of responsibilities of District personnel involved in the collection, processing, storage, analysis, or publication of surface-water data.

The District Chief is responsible for:

1. Managing and directing the District program, including all surface-water activities.
2. Ensuring that surface-water activities in the District meet the needs of the Federal Government, the Indiana District, State and local agencies, other cooperating agencies, and the general public.
3. Ensuring that all aspects of this QA Plan are understood and followed by District personnel. This is accomplished by the District Chief's direct involvement or through clearly stated delegation of the tasks associated with this responsibility to other personnel in the District.
4. Ensuring that all publications and other technical communications released by the District are accurate and are in accordance with USGS policy.
5. Implementing USGS and District safety policies.

The Chief of the Hydrologic Data Section is responsible for:

1. Managing the data-collection program by serving as the principle contact between cooperators and the USGS.
2. Managing the budget to assure the data-collection program operates in a fiscally responsible manner.
3. Ensuring that surface-water data collection and analysis activities associated with the Indiana surface-water gaging network conform to the goals and policies of the USGS, the Office of Surface Water (OSW), and the Indiana District.
4. Developing the work plans designed to accomplish the work of collecting, processing, analyzing, and storing Indiana surface-water data; publishing that data in the annual data report; and communicating the contents of those work plans to personnel in the Hydrologic Data Section.
5. Ensuring that records for all surface-water data stations are computed correctly and checked and that 30 percent of all records are reviewed annually. The review should include 10-percent review by the Lead Technicians, 10 percent by the District Surface-Water Specialist, and 10 percent by other districts. A list of the previous year's reviewed records should be maintained to ensure that the same records are not reviewed each year.
6. Ensuring that any identified deficiencies associated in the collection, analysis, or publication of surface-water data are corrected and ensuring that improved methods are instituted.

7. Ensuring that all personnel in the Indiana District involved in the collection, analysis, and publication of surface-water data receive a copy of the Surface Water QA Plan and that they are familiar with its contents.
8. Overseeing the production of the Indiana annual data report.
9. Serving as or assigning a Flood Coordinator.
10. Ensuring that supervised personnel receive appropriate training and, in many situations, providing that training.
11. Ensuring that supervised personnel are aware of and operate in accordance with safety policies established by the USGS and the Indiana District as implemented by the District Chief.
12. Ensuring that the surface-water databases are properly maintained and updated.

The Indiana District Surface-Water Specialist is responsible for:

1. Reviewing all indirect streamflow measurements performed by the District and annually reviewing 10 percent of the surface-water records. Efforts are made to ensure that the same stations are not reviewed in consecutive years.
2. Working with Chief of the Hydrologic Data Section by evaluating surface-water data collection and analysis methods that are applied in the Indiana District and discussing needed improvements in those methods with the Chief of the Hydrologic Data Section.

Senior Technicians are responsible for:

1. Assisting the Chief of the Hydrologic Data Section in the development of work plans.
2. Providing training in data collection, analysis procedures, and instrumentation to individuals assigned to their area or the Hydrologic Data Section.
3. Ensuring that the collection and analysis of surface-water data are done accurately and with minimal loss of data.
4. Reviewing 10 percent of area records on a rotating basis so that different records are reviewed each year, including at least one record computed by each person assigned to their area.
5. Ensuring that data collected by their area are computed, reviewed, and checked in a timely manner so that the data are available in final form 1 month ahead of the District annual data-report publication deadline of April 1.
6. Ensuring that field visitations are scheduled to allow for adequate numbers of measurements to promote the accurate computation of streamflow records.
7. Scanning hydrographers' field notes after each trip and formally reviewing at least two field trips per person in each water year, using the standard review forms to ensure that proper methods are used for data collection and that field trips are completed in a timely manner. The review forms from the formal reviews will be stored in a field-trip review file.
8. Inspecting vehicles yearly to ensure proper equipment is carried and maintained and that the vehicle is in good condition. A copy of the inspection should be filed with the field-trip review forms.

Hydrologic Data Section Quality-Assurance Specialist is responsible for:

1. Planning, scheduling, and conducting field work and office computations of Indirect Measurements. Ensures that measurements are conducted properly and the proper methods are used for computation.
2. Ensuring that the Peak-Flow File is maintained properly by reviewing yearly peaks for each gage; enters the peaks in the database.
3. Helping to quality assure surface-water data by checking a cross section of records worked by others and by communicating any found deficiencies to the original worker of the record.

Project Chiefs are responsible for:

1. Preparing a surface water QA plan for individual projects and submitting the completed plan to the Section Chief and the District Surface-Water Specialist for review (Shampine and others, 1992, p. 2).
2. Ensuring that the collection, processing, storage, analysis, and publication of surface-water data associated with the project meet all standards of policy and procedure presented in this report and the project surface water quality-assurance plan.

The individuals who collect surface-water data are responsible for:

1. Being fully versed with the policies and procedures presented in this report.
2. Collecting, processing, analyzing, storing, and preparing for publication surface-water data in accordance with the policies and procedures presented in this report.

The Field Hydrologic Technician or Hydrologist is responsible for:

1. Ensuring that streamflow-gaging stations operate in a manner that results in minimal loss of stage record.
2. Making discharge measurements of various types correctly and accurately.
3. Installing, servicing, and repairing instruments at streamflow-gaging stations.
4. Storing all data retrieved into the Automated Data Processing System (ADAPS) database.
5. Developing ratings, computing discharge records, and writing station descriptions and analyses in a timely manner.
6. Helping to construct streamflow-gaging stations.
7. Surveying station levels, establishing and periodically confirming elevations of appropriate reference marks in accordance with USGS surveying procedures.
8. Reviewing data from field stations that are displayed on the Website on a daily basis when in the office.

The District Water-Quality Specialist is responsible for:

1. Being knowledgeable of policies and procedures pertaining to the collection, processing, analysis, storage, and publication of sediment data.
2. Reviewing techniques used by District personnel in the collection of sediment data and correcting any deficiencies that are determined.
3. Ensuring that sediment data are correctly stored in the water-quality database.
4. Inspecting vehicles yearly to ensure proper equipment is carried and maintained and that the vehicles are in good condition.

The Surface-Water Database Administrator is responsible for:

1. Ensuring that the software is maintained in proper working order, including software updates.
3. Assisting other personnel in the proper use and application of the database.
4. Maintaining associated software and writing configurations for telemetry equipment and data loggers.
5. Creating all new site files in the database.
6. Checking the function of ADAPS, remote data-access software, and the Internet data-presentation programs each day when present in the office; correcting problems or alerting the proper individuals of problems that need correction.

The District Safety Officer is responsible for:

1. Assisting the District Chief in implementing USGS and District safety policies.
2. Serving as a resource for District personnel seeking information pertaining to safety.
3. Assisting the District Chief in making safety information and training available to District personnel.

Collection of Stage and Streamflow Data

Many of society's daily activities, including industry, agriculture, energy production, waste disposal, and recreation, are closely linked to streamflow and water availability; therefore, reliable surface-water data are necessary for planning and resource management. The collection of stage and streamflow data is a primary component in the ongoing operation of streamflow-gaging stations (referred to in the remainder of this report as gaging stations) and other water-resource studies performed by the USGS and the Indiana District.

The objective of operating a gaging station is to obtain a continuous record of stage and discharge at the site (Carter and Davidian, 1968, p. 1). A conventional continuous record of stage is obtained by installing instruments that sense and record water-surface elevation in the stream. Discharge measurements are made at periodic intervals to define or verify the stage-discharge relation and to define the time and magnitude of variations in that relation.

All personnel involved in the collection of stage and discharge data are informed of and follow the surface-water data-collection policies and procedures established by the USGS and the Indiana District. **The highest priority in collecting streamflow data is employee safety.**

Each field person running field trips should have a minimum of two trips reviewed each year by a Senior Technician. The review should be documented on the standard review form. Employees with less than 2 years of surface-water data-collection experience should have every trip reviewed.

Gage Installation and Maintenance

Proper installation and maintenance of gaging stations are critical activities for ensuring quality in streamflow-data collection and analysis. Effective site selection, correct design and construction, and regular maintenance of a gage can make the difference between efficient and accurate determination of drainage-basin discharge and time-consuming, poor estimations of flow.

Sites for installation of gaging stations are selected with the intent to meet the purpose of each specific gage. Additionally, sites are selected with the intent of achieving, to the greatest extent possible, ideal hydraulic conditions. Criteria that describe the ideal gaging-station site are listed in Rantz and others (1982, p. 5). These criteria include unchanging natural controls that promote a stable stage-discharge relation, a satisfactory reach for measuring discharge throughout the range of stage, and the means for efficient access to the gage and measuring location. Other aspects of controls considered by District personnel when planning gage-house installations include those discussed in Kennedy (1984, p. 2).

The individual responsible for selecting sites for new gaging stations is the Chief of the Hydrologic Data Section, with assistance from the Senior Technicians. The process of site selection includes discussion with cooperators on the purpose of the gage and analysis of terrain with the use of topographic maps, field reconnaissance, and a file search to determine if discontinued stations or partial-record stations existed previously in the area.

The responsibility for ensuring proper documentation of agreements with property owners is held by the Chief of the Hydrologic Data Section. Approval of site design is the responsibility of the Chief of the Hydrologic Data Section. Responsibility for construction of gages is held by the Senior Technician in charge. Inspection and approval of the completed installation is the responsibility of the Chief of the Hydrologic Data Section.

A program of careful inspection and maintenance of gages and gage houses promotes the collection of reliable and accurate data. Allowing the equipment and structures to fall into disrepair can result in unreliable data and safety problems.

It is District policy that a visual inspection is performed at sites by field personnel during each site visit by comparing the inside and outside gage readings. In addition, all equipment are inspected to see that it is in proper working order—battery condition, the physical structure, locking mechanisms, and the general working order of the gage. Inspection of the data collected at a streamflow-gaging station is an important means of ensuring accurate gage data records.

Upon completion of a field trip, personnel should enter data into ADAPS, using the Data Acquisition Code Transfer program (DACTRAN) on the Hydrologic Data Section personal computer (PC) or dataport. The newly collected data then are viewed, using NWIS-WEB. This task should be completed within 3 working days of a field-trip completion as a further check for gage function and as a check that data have been entered properly into ADAPS. The data-entry and NWIS-WEB review ideally should be done on the day of the field-trip completion.

The review of the real-time NWIS-WEB system resides with the Senior Technicians and the hydrographer who operates the gage. In general, all real-time gages are reviewed once each working day by the Senior Technician in charge and by the hydrographer who operates the gage in the field.

To prevent the buildup of mud or clogging of intakes at stilling wells or the orifice at gas-bubbler sites, the intakes are flushed or the orifices are purged during each regular visit for sites that are so equipped. It is the goal of the Indiana District to achieve a continuous and complete record of the stage at each field station. It is critical that problems that result in loss of stage record be dealt with immediately.

It is the responsibility of each hydrographer to correct gage deficiencies immediately. If conditions cannot be corrected on site, the next higher person on the chain of command should be notified, and that person is responsible for initiating a plan of action. Plans are to be made to restore the record of the stage at the earliest possible time.

Stilling wells are pumped annually if a sediment buildup is noticed or if the site has a history of sediment buildup. Gages that do not have on-site pumping equipment but use riser pipes are pumped on an annual basis. Wells that are specially constructed to prevent intake clogging, such as open-bottom wells, are not required to be pumped on an annual basis. Any stilling well that has exhibited a tendency to clog should be pumped on a more-frequent basis to ensure continuous operation.

Lake gages are pumped once every 3 years, or more often if needed. Other maintenance activities performed on a regular basis include ensuring that all gages and recording and transmission equipment are calibrated and functioning properly, checking battery voltage, checking Data Collection Platform (DCP) clock times, installing heaters at appropriate sites during cold-weather periods, and general cleaning and physical upkeeping of gage-house structures.

It is the responsibility of the hydrographer making each site visit to ensure that gages and gage houses are kept in good repair. To ensure these responsibilities are carried out and to minimize the potential for recurrent omissions by an individual, at least one field trip is assigned to a different individual during the year. When problems, such as lagging intakes, are identified during records computation, the hydrographer is informed immediately so that the problem can be corrected.

Although the responsibility to maintain gages and gage houses belongs to the hydrographer who visits the site, it is the responsibility of the Senior Technicians to provide guidance and assistance on attaining the appropriate level of maintenance. It is also the responsibility of all in the Hydrologic Data Section to maintain the District's gages; individuals may be called upon to repair gages that are not their primary responsibility. When an individual hydrographer fails to adequately maintain the gages and gage houses, it is the responsibility of the Senior Technicians to provide specific instruction to that individual or, if appropriate, present the problem to the Chief of the Hydrologic Data Section who initiates corrective actions. It is the collective responsibility of all members of the Hydrologic Data Section to collect accurate gage-height and measurement data.

Measurement of Stage

Many types of instruments are available for measuring the water level, or stage, at gaging stations. There are non-recording gages (Rantz and others, 1982, p. 24) and recording gages (Rantz and others, 1982, p. 32). Because many of the uses for stage data cannot be predicted, it is OSW policy that surface-water-stage records at stream sites be collected with instruments and procedures that provide sufficient accuracy to support computation of discharge from a stage-discharge relation, unless greater accuracy is required (Office of Surface Water memorandum 93.07). Office of Surface Water Technical memorandums from 1969 to 1995 may be found in OFR 95-354 in the District Library or in the Hydrologic Data Section.

In general, operation of gaging stations for the purpose of determining daily discharge includes the goal of collecting stage data at the accuracy of ±0.01 foot (Office of Surface Water memorandum 89.08). An explanation of policy on stage-measurement accuracy as it relates to instrumentation is provided in Office of Surface Water memorandum 93.07.

The types of instrumentation installed at any specific gage house operated by the Indiana District is dependent on the District's and the cooperator's needs for data or telemetry, frequency of update, range of stage, flashiness of the stream, availability of phone and power lines, and other specific data needs associated with the station. It is the goal of the Indiana District to serve 100 percent of its data by telemetry. Types of water-level recorders operated by personnel in this District include: Design Analysis H-500XL;

Handar 550b, 555, 560, 570 models; and Sutron 8200, 8210, and 8400 models. The Sutron 8400 models are the District's primary basic data logger. The other recorders are used when some type of near real-time telemetry is used at the site. Various devices are used to sense stage at Indiana stations; these devices include Handar and Sutron shaft encoders at stilling wells and Paroscientific and Sutron remote pressure transducers.

The responsibility for determining what type of water-level recorders are operated at each gaging station is held by the Chief of the Hydrologic Data Section. Ensuring that new equipment has been installed correctly is the responsibility of the hydrographer who installed the equipment, with guidance or assistance from the Senior Technicians. Proper maintenance of gage instrumentation or replacement, if appropriate, of equipment is the responsibility of the field personnel who service the gage.

Accurate stage measurement requires not only accurate instrumentation but also proper installation and continual monitoring of all system components to ensure the accuracy does not deteriorate with time (Office of Surface Water memorandum 93.07). To ensure that instruments located within the gage house record water levels that accurately represent the water levels of the body of water being investigated, "inside" and "outside" water-level readings are obtained by independent means. For example, at Indiana stilling-well gaging stations, all recording gages are calibrated to agree with an electric-tape gage inside the well house; independent outside readings are made with a wire-weight gage mounted near the gage house or an outside staff gage installed on or near the stilling well. The practice of attaching an outside staff to the stilling well is to be avoided, unless the structure is proven stable (for example, a large concrete well).

At transducer sites, the outside gage is used to calibrate the inside gage. The inside gage readings do not necessarily always equal outside readings, especially if the gages are not in the same pool at all ranges of stage. Whereas inside and outside gage readings do not have to read the same in all cases, the relation between the two for a given stage should be consistent.

Relations between the two gages over a range of stages can be checked for consistency by examining the gage-house 9-207 form. A failure in the consistency of readings nearly always indicates a failure of the system and should be investigated (for example, the problem may be the result of slippage or loose screws on a wire weight, plugged intakes, or orifice problems).

At stations equipped with a stilling well, the base or reference gage usually is an instrument installed inside the gage house; other gages are installed outside the gage house to indicate whether or not the intakes are operating properly (Rantz and others, 1982, p. 53 and p. 64). At bubbler sites, the outside gage is usually the base gage. At all gaging stations, the base gage is identified specifically in the station description.

Personnel servicing the gage are responsible for comparing inside and outside readings during each site visit to determine if the outside water level is being represented correctly by the gages. If a deficiency is identified, personnel servicing the gage are responsible for thoroughly documenting the problem on the field note sheet and either correcting the problem immediately or contacting a Senior Technician or the Chief of the Hydrologic Data Section so that corrective actions can be taken at the earliest opportunity.

Ensuring that instrumentation installed at gaging stations is properly serviced and calibrated is the responsibility of the hydrographer who services the instrumentation. The responsibility of ensuring that personnel correctly carry out this duty is that of the Senior Technicians. This responsibility is accomplished by the Senior Technicians inspecting the gages at the time the equipment is installed or soon thereafter, discussing field trips and reviewing field notes with the less-experienced personnel, and reviewing computed records to identify errors or inconsistencies. When deficiencies are identified, the hydrographers correct the deficiency by their own initiative or receive specific instruction from the Senior Technicians.

Hydrographers should carry equipment for most repairs. In the event that expensive dataloggers are needed for repair, the field person should contact the office and advise a Senior Technician of the need for equipment for repairs. Personnel who have questions related to the calibration and maintenance of water-level recorders should contact the appropriate Senior Technician or the Chief of the Hydrologic Data Section. When gages are inspected, any recording gage or telemetry gage that differs from the base gage by 0.015 foot or more is reset to agree with the base gage.

The field hydrographers do not reset gages in adverse conditions, such as surging wells, high-flow stages, or ice in the stilling well. It is important that bubbler gages are not reset during high flow in order to avoid reset errors that might be caused by the effects from drawdown. At stilling wells where data recorders are driven by floats with steel tapes, peak-stage indicator clips are attached to the steel tapes to identify or confirm maximum stages. It is the responsibility of the hydrographer who inspects the gages to ensure that the peak-stage indicator clips are read and reset during each site visit. The readings and associated readings are written on the field note sheet. At remote-pressure-transducer sites, a Crest-Stage Gage (CSG) should be installed to verify the peak stage. It is the responsibility of the hydrographer to check the CSG intakes and ground-cork level to ensure that all peaks are recorded.

Gage Documents

It is District policy that certain documents are placed in each gage house for the purpose of keeping an on-site record of observations, equipment maintenance, structural maintenance, and other information helpful to field personnel. Documents maintained at each gage house include

(1) the most recent rating table;

(2) an up-to-date rating curve;

(3) the most recent station description listing all gages and reference marks at the site and associated elevations, locations of measurement cross sections, information related to extreme events including the potential for channel storage between the gage and measuring section during flood conditions, and other information;

(4) a log (9-207 form) updated by field personnel upon each site visit that describes control conditions and lists gage readings, measurement values, location of measurement, gage-house maintenance, and equipment maintenance;

(5) a bridge-safety plan; and

(6) a job-hazards analysis.

Each gage is a representation to the public of the USGS and therefore should be kept clean and orderly. The hydrographer should clean the gage once a year, at a minimum, and keep the gage-house exterior and surrounding area neat in appearance.

It is the responsibility of the hydrographer who runs the field trip to exchange outdated material with updated gage documents as needed. When field personnel visit a gage house and identify a need to update one or more of the documents, that individual makes note of the needed document on a log maintained in the field data-collection folder or briefcase and uses that log as a reminder to bring the documents on the next field trip. Individuals having questions related to what documents should be kept in a gage house, when the documents should be replaced with newer documents, or appropriate methods of appending logs or plotting measurements should contact the Chief of the Hydrologic Data Section.

Levels

The various gages at a gaging station are set to register the height of a water surface above a selected level reference surface called the gage datum. The gage's supporting structures—stilling wells, backings, shelters, bridges, and other structures—tend to settle or rise as a result of earth movement, static or dynamic loads, vibration, or battering by floodwaters and flood-borne ice or debris. Vertical movement of a structure makes the attached gages read too high or too low and, if the errors go undetected, may lead to increased uncertainties in streamflow records. Leveling, a procedure by which surveying instruments are used to determine the differences in altitude between points, is used to set the gages and to check them from time to time for vertical movement (Kennedy, 1990, p. 1). Levels are run periodically to all bench marks, reference marks, reference points, and gages at each station for the purpose of determining if any datum changes have occurred (Rantz and others, 1982, p. 545).

It is District policy that levels are run at newly installed gaging stations and are run each year for 3 consecutive years. If stability is not seen during the initial 3 years, yearly levels are to continue. Levels are run to established gaging stations once every 5 years if the stations have been proven stable. Gages are reset to agree with levels when the levels indicate a 0.015-foot or more vertical change. When gages are reset, field personnel document the reset by writing the "found" and "left" gage readings on the level note sheet and the time associated with each reading. Outside water-surface elevation and the associated time are determined with level-instrument readings each time levels are run at a gaging station and are written on the note sheet.

When levels are run, each gage or established mark must have two independent shots, requiring a minimum of two instrument setups to complete a circuit. The level loop must close to the starting elevation within 0.003 foot times the square root of the number of turning points (see Kennedy, 1990, p. 4) or the level run is considered to be invalid and the entire set of levels is run again. Even if there are more than 25 turning points, the level loop must close within no more than 0.015 foot or the level run is considered invalid and the entire set of levels is run again. In all instances where there is a gage-height discrepancy that cannot be explained by other means, levels should be run.

Levels are run by use of field methods and documentation methods described in Kennedy (1990). Level procedures followed by District personnel pertaining to circuit closure, instrument reset, and repeated use of turning points are described in Kennedy (1990) and in Office of Surface Water memorandum 93.12. The level instruments are kept in proper adjustment by ensuring accuracy through the use of peg tests as described in Kennedy (1990, p. 13). Peg tests are done periodically on each instrument, typically once each year. If the accuracy of an individual instrument becomes suspect for any reason, however, a peg test is performed immediately. Results of the tests are written in a logbook and kept in the Hydrologic Data Section. A copy of the two-peg test should be kept with the instrument. If an instrument is found to be in error, level runs that involved the erroneous instrument are examined and actions are taken to correct any errors or the level runs are determined to be invalid and the level procedures are repeated.

It is the responsibility of the field-party chief to ensure that all field level notes are checked within 3 weeks of the level circuit. The level information is entered on the level-summary form by the field-party chief after the field notes are checked. The individual who works the station records checks to see that the level information has been entered onto the level-summary form. The level-summary forms for all gaging stations are maintained in a labeled three-ring binder located in the Hydrologic Data Section.

Ensuring that levels are run correctly and that all level notes are completed correctly is the responsibility of the Senior Technicians. Ensuring that levels are run at the appropriate frequency is the responsibility of the Senior Technicians.

Site Documentation

Thorough documentation of qualitative and quantitative information describing each gaging station is required. This documentation, in the form of a station description and photographs, provides a permanent record of site characteristics, structures, equipment, instrumentation, altitudes, location, and changes in conditions at each site. Information pertaining to where the documentation is maintained is discussed in the section of this report entitled “Office Setting.”

Station Descriptions

A station description is prepared for each gaging station and becomes part of the permanent record for each station. It is District policy that the station description is written no later than when the first-year station records are worked. The responsibility for ensuring that station descriptions are prepared correctly and in a timely manner is held by the Senior Technician responsible for that region of the State, although the effort can be delegated by the Senior Technician to individuals involved with establishment of the gage. Station descriptions are updated once every 3 years, or more often if any changes in the equipment or gage structure occur. It is the responsibility of the Chief of the Hydrologic Data Section and the Senior Technicians to ensure that station descriptions are updated as described. When the station records are being worked each year, the station descriptions are inspected by the hydrographer working the station records. Any updates needed in the station description are made at that time. The hydrographer who checks the station records for that year also checks to see that updates, if needed, were made to the station description. In addition, for at least 10 percent of the stations, computed records, including station descriptions, are reviewed by experienced hydrographers from a neighboring USGS District Office as part of a QA Kentucky/Indiana/Ohio rotating-review exchange program.

Station descriptions are written to include specific types of information in a consistent format (Kennedy, 1983, p. 2). Types of information included in the station description are location, access routes, drainage area, establishment history, cooperator identification, descriptions of equipment and gage structure, descriptions of control, statements on measurement cross sections, information on extremes of stage, datum of gage, elevations of reference marks, and a photocopy of an area map. Also included is other helpful information about observers, regulation or diversion of flow, and anything that will assist in collection of data under various conditions and ranges of flow.

A standard form for the original station description of a gaging station can be obtained in the District word-processing program, FrameMaker. The latitude-longitude coordinates and quarter-quarter-section coordinates are determined from 7.5-minute topographic maps or global positioning system (GPS) instruments of proven accuracy. The gage location is plotted on the set of topographic maps maintained by the District as the Master File Maps. The coordinate determinations and the plot on the Master File Map are checked by a Senior Technician or the Chief of the Hydrologic Data Section. Each gaging station is assigned a downstream-order number. The Chief of the Hydrologic Data Section is responsible for assigning these numbers for all USGS gaging-station sites in Indiana.

Photographs

Photographs of gaging stations and control sections are made by field personnel for the purpose of documentation. Gage-house construction; damage to gage structures or equipment resulting from storms, floods, or vandalism; significant changes in control conditions; or supplements to various forms of written descriptions are additional reasons to take photographs in the field. Hydrographers carry digital cameras in their vehicles as part of their regular field equipment to photograph the items mentioned and to document inundated areas, high-water marks, or any other items that may assist the District in data-collection activities.

Each photograph that becomes part of the station record is identified by writing on the back of the photo with a permanent-ink marker the station name or location, stage, date of photograph, name of the photographer, direction of flow, and scene description. Photographs for the current year are placed in the station technical file folder (commonly referred to as the tech folder). Photographs are backfiled in the photograph drawer for the purpose of long-term documentation of control changes or for future reference. Only those photographs that are important to the gage record are kept. Digital photos are kept on a CD-ROM for each specific station.

Direct Measurements

Direct measurements of discharge are made with any one of a number of methods approved by the USGS.

A current-meter measurement is the summation of the products of the subsection areas of the stream cross section and their respective average velocities (Rantz and others, 1982, p. 80). Procedures used for current-meter measurements are described in Rantz and others, 1982, p. 139; Carter and Davidian, 1968, p. 7; and Buchanan and Somers, 1969, p. 1.

When personnel make measurements of stream discharge, attempts are made to minimize errors. Sources of errors are identified in Sauer and Meyer, 1992. These include random errors such as depth errors associated with soft, uneven, or mobile streambeds, or uncertainties in mean velocity associated with vertical-velocity distribution errors and pulsation errors. These errors also include systematic errors, or bias, associated with improperly calibrated equipment or the improper use of such equipment.

For the purpose of efficiency, each field-trip area generally is assigned to a single hydrographer who runs the trip on a regular basis. At least once each year, however, it is the practice of the Indiana District to have a different individual run the field trip and thereby identify and minimize potential systematic errors. It is the responsibility of the hydrographer working the annual records to identify deficiencies found by comparing the measurements. Any deficiencies that are identified are corrected. It is the responsibility of the Senior Technicians to ensure that the corrective actions are carried out.

A discharge measurement made using the Acoustical Doppler Velocity probe (ADV), in the manner similar to a measurement made using a mechanical current meter, also involves the summation of the products of the subsection areas of the stream cross section and their respective average velocities.

District policies related to the measurement of discharge by use of the current-meter method or ADV method, in accordance with USGS policies, include the following (see also Appendix 3, Hydroacoustic Instrumentation—Standards, Policies, and Procedures).

Depth criteria for meter selection.—District personnel select the type of current meter to be used for each discharge measurement on the basis of criteria provided by the OSW memorandum 85.14. Meters are used with caution when a measurement must be made in conditions outside the ranges of the method provided by OSW. Any deviation from those criteria is noted, and the measurement accuracy is downgraded accordingly.

The ADV may be used for most wading measurements. The depth-sampling convention using the ADV is the same as a Price AA meter. ADVs, however, do not have a minimum-depth requirement (with the exception that the probes must be totally submerged). Furthermore, single velocity samples (.6) are used for depths below 2.5 feet, and double velocity samples (.2 and .8) are used for all depths greater than 2.5 feet. Therefore, ADVs can be used for all depth scenarios in place of the AA and the pygmy meters for wading measurements.

The ADV may not work in weed- or leaf-choked channels or clear streams where small signal-to-noise ratios may be a factor. QA for an ADV includes checking the temperature sensor for accuracy once each day. A conventional meter must be used in place of the ADV if one of these problematic situations is encountered and the ADV fails to work.

Low velocities in a cross section traditionally have been a problem for some streamflow measurements because mechanical meters can be inaccurate at velocities below .2 ft/s (foot per second). An ADV meter should be used when velocities in more than five sample sections of a measurement are less than .2 ft/s.

Hydrographers should carry a pygmy and a Price AA meter for wading and/or bridge measurements, and those meters are to be maintained and spin tested according to policies described in the "Acceptable Equipment" section of this quality-assurance plan. For a conventional meter, the following criteria should be followed. An AA current meter may be used to make direct streamflow measurements when depths average 1.5 feet and greater. When depths are less than 2.5 feet, a single velocity sample is taken at .6 total depth. When depths are greater than 2.5 feet, then .2 and .8 samples are taken. These guidelines all assume a standard velocity profile.

If bottom velocities are equal to or greater than the top velocity, a standard profile does not exist. In the case of a non-standard profile, the .2, .6, and .8 shots all must be taken. When average depths are less than 1.5 feet, the pygmy current meter is used. Hydrographers of the Indiana District make their meter selection for specific measurement conditions based on guidance provided by information found in OSW memorandum 85.14, Buchanan and Somers (1969), and Rantz and others (1982).

In shallow-depth/low-velocity situations, if an ADV is not available or will not function, the standard AA meter may be used where the velocities are too slow to be recorded by the pygmy. These situations are to be avoided by looking for cross sections where higher velocity exists. It is recognized, however, that at some sites, during low-flow periods, sections suitable for the pygmy meter cannot be found. A measurement made using an AA meter in these slow-velocity conditions must be downrated; it is always preferable to use an ADV in these situations.

When using conventional meters, it is recommended that a change of meters is not made during a measurement in response to the occurrence of two or more subsections in a single measurement cross section that exceeds the stated ranges of depth and velocity. It is left to the discretion of the hydrographer making the measurement to change meters in situations where overflow conditions create a secondary channel, which effectively creates a different measurement cross section. In such situations, with few exceptions, hydrographers make their decision of a meter change based on the same criteria discussed in the conventional-meter section of the preceding paragraph.

Number of measurement subsections.—The spacing of observation verticals in the measurement section can affect the accuracy of the measurement (Rantz and others, 1982, p. 179). USGS criteria are that observations of depth and velocity be made at a minimum of about 30 verticals, which are normally necessary so that no more than 5 percent of the total flow is measured in any one vertical. Even under the worst conditions, the discharge computed for each vertical should not exceed 10 percent of the total discharge and ideally should not exceed more than 5 percent (Rantz and others, 1982, p. 140). Exceptions to this policy are allowed in circumstances where accuracy would be sacrificed if this number of verticals was maintained, such as for measurements during rapidly changing stage (Rantz and others, 1982, p. 174). Fewer verticals than are ideal are sometimes used for very narrow streams (about 12-feet wide when an AA meter is used and about 5-feet wide when a pygmy meter is used) based on minimum spacing criteria for meters (minimum spacing for an ADV or pygmy is .3 foot, for an AA on a wading rod is

.5 foot, and an AA suspended is 2 feet). Measurement of discharge is essentially a sampling process, and the accuracy of sampling results typically decreases markedly when the number of samples is less than about 25.

Other direct methods of measuring discharge.—It is District policy that USGS and OSW techniques and guidelines are followed when discharge measurements are made with any selected method of measurement. These methods include the use of mechanical instruments and other techniques. The Indiana District does not prohibit the use of other methods of direct measurement, including volumetric techniques or the use of portable weirs and flumes, although those methods rarely are employed. When the need for those methods arises, hydrographers adhere to procedures presented in Rantz and others (1982), Buchanan and Somers (1969), and Kilpatrick and Schneider (1983). When those methods are employed, it is the responsibility of the hydrographers to inform the Senior Technician and the Chief of the Hydrologic Data Section. The Chief of the Hydrologic Data Section should review the methods used by hydrographers to ensure correctness of procedures and results.

Computation of mean gage height.—District personnel use procedures for the computation of mean gage height during a discharge measurement presented in Rantz and others (1982, p. 170). Mean gage height is one of the coordinates used in describing the stage-discharge relation at a streamflow-gaging site.

At each gaging station, one of the gages, separate from the recorder and least prone to accidental datum changes—often an electric-tape gage—is designated as the “reference gage” (Kennedy, 1983, p. 10). At some gaging stations, especially at sites where pressure transducers are installed, the reference gage may be an outside staff gage or a wire-weight gage. The main purpose of the reference gage is to furnish occasional independent water-surface elevations to monitor the accuracy of the other inside gages. The mean gage height for a measurement is based on the reference gage. The reference gage is used throughout the entire range of stage.

Check measurements.—A second discharge measurement for the purpose of checking a first discharge measurement is made when the results of the first discharge measurement are suspect. The results are considered suspect if the measurement does not plot within rating limits—that is, within the range of GOOD, FAIR, POOR—and there are no conditions to justify the results. An example of when a check measurement is not needed would be when a measurement plots to the negative side of the rating while there is backwater caused by leaves lodged on the control, and the results conform to expectations. If, however, a measurement is an outlier and no logical explanation is apparent, then a check measurement should be made.

When check measurements are made, the potential for systematic errors are minimized by using methods described in Rantz and others (1982, p. 346). These methods include using another cross-section location for wading measurements, using verticals offset from the locations of the original verticals used for a bridge measurement, spin testing meters, and other such procedures.

Corrections for storage.—Corrections for storage applied to measured discharges for the purpose of defining stage-discharge relations are those discussed in Rantz and others, 1982, p. 177, and in Office of Surface Water memorandum 92.09.

Questions.—Personnel who have questions concerning the appropriate procedures for making stage and discharge measurements should address their questions to the Senior Technicians or to the Chief of the Hydrologic Data Section.

Field Notes

Thorough documentation of field observations and data-collection activities performed by field personnel is a necessary component of surface-water data collection and analysis. To ensure that clear, thorough, and systematic notations are made during field observations, discharge measurements are recorded by field personnel on measurement form series 9-275 (typically 9-275-F or 9-275-G). Notations are made in the manner presented in Buchanan and Somers (1969, p. 2). Original observations, once written on the note sheet, are not erased. Original data are corrected by crossing the value out then writing the correct value. Some examples of original data on a discharge-measurement note sheet include gage readings, depth, times, peak-stage indicator-clip readings, and meter velocities at sections. Examples of information on a discharge-measurement note sheet that is derived from original data, but is not in itself original data, include computed total discharge, mean gage height, measurement number, and calculated extreme stages that have been determined from a peak-stage indicator-clip reading. Derived data can be erased for the purpose of correction.

It is District policy that all discharge measurements are calculated in their entirety before the hydrographers leave the field site, unless emergency situations exist or it is required to leave a site for reasons of safety. Information required to be included by field personnel on the measurement note sheet includes, at minimum, the initials and last name of all field-party members; date; times associated with gage readings and other observations; gage readings; extreme indicator-clip readings; all items describing the type, location, and quality of the measurement; spin-test comments; cross-section width and area; mean velocity; mean gage height; total discharge; site identification; all observed depth and velocity data.

Notations associated with miscellaneous surface-water data-collection activities are to be documented on the basis of information written on form 9-275-D (Jan. 1988), the Miscellaneous Field Notes form. All miscellaneous notes are required to include, at minimum, initials and last name of field-party members, date, time associated with observations, purpose of the site visit, the site identification, and any descriptive comments the field personnel consider applicable and appropriate.

A review of field note sheets is required annually at the time station records are completed by the individual who computes the record for each station and the individual who checks the record for each station. Deficiencies found in the content, accuracy, clarity, or thoroughness of field notes are identified and orally communicated by the record worker to the individual who collected the field data or to the Senior Technicians. The deficiencies are remedied by providing specific instructions from the Senior Technicians to individuals who fail to record notations that meet USGS and District standards.

Acceptable Equipment

Equipment used by the Indiana District for the measurement of surface-water discharge has been found acceptable by the USGS through use and testing. An array of acceptable equipment for measuring discharge includes current meters (conventional and acoustic), calculators, timers, wading rods, bridge cranes, tag lines, and others (Rantz and others, 1982, p. 82; and Smoot and Novak, 1968). Although an official list of acceptable equipment is not available, Buchanan and Somers (1969), Carter and Davidian (1968), and Edwards and Glysson (1988) discuss the equipment used by the USGS.

The meters most commonly used by District personnel for measuring surface-water discharge are the Price AA current meter, Price pygmy current meter, ADV current meter, and the Acoustic Doppler Current Profiler (ADCP). Methods followed by District personnel for inspecting, repairing, and cleaning these meters are described in Smoot and Novak for conventional meters (1968, p. 9), Rantz and others (1982, p. 93), and Buchanan and Somers (1969, p. 7). The Indiana District has implemented separate and specific QA plans as appendixes to this plan for the use of the ADCP, ADV, and index Acoustic Velocity Meter (AVM).

The ultimate responsibility for the good condition and accuracy of a current meter rests with field personnel who use it (Office of Surface Water memorandum 89.07). A timed spin test made a few minutes before a measurement does not ensure that the meter will not become damaged or fouled during the measurement. Field personnel must assess apparent changes in velocity or visually inspect the meter periodically during the measurement to ensure that the meter continues to remain in proper operating condition. The Indiana District follows the care and maintenance procedures of vertical-axis current meters as described in Office of Surface Water memorandum 99.06. These procedures include, but are not limited to, the following steps. After a day of use in the field, the pivot and contact-chamber cap are removed to clean and lightly oil the upper and lower bearing surfaces. The bearing surfaces, especially the pivot point, is examined for wear or damage. After cleaning, the meter cups are spun to ensure that the rotation motion does not have a “wobble” and that the cups do not come to an abrupt stop (a timed spin test is not required at the end of every day). General condition of the meter is examined to ensure that the cups, tail fins, or other parts are not bent or damaged. Any needed repairs are made and significant problems are documented in the spin-log book. After each field trip the meters that were used during the trip are spin tested to document condition, disassembled, inspected, cleaned, and repaired, making the meters ready for their next period of use.

Spin tests.—It is District policy that timed spin tests are carried out and documented as described in Smoot and Novak (1968, p. 10). The goal of the spin tests is to ensure that streamflow measurements are made with meters that are in good working order and to provide historical documentation that the meters were in good working order at the time of the field measurements. For vertical-axis meters that are used during a field trip, timed spin tests are conducted prior to the beginning of the field trip and after the end of the field trip. If a field trip extends to more than 1 week, an additional timed spin test is conducted so that no measurements are made beyond 7 working days of the most-recent spin test. If one field trip ends one week and a second field trip begins the following week, a single timed spin test can serve as the test to follow the first trip and to precede the second trip, provided that the 7-work-day rule is not violated. Regarding the spare meters that are carried in field trucks to serve as backup equipment, timed spin tests are conducted on those spare meters at least once a year, whether they are used or not. Provided that spare meters have been appropriately cleaned and stored, according to procedures described in Office of Surface Water memorandum 99.06, a timed spin test is not required for a spare meter immediately prior to its use (especially if the use of the spare meter is required in a rushed, time-sensitive situation). But a timed spin test for the spare meter is required as soon after the measurement as is practical so there is documentation that the measurement was made with a meter that was in good working order. When timed spin tests are made in the field, the test results are written on the associated measurement note sheet. Upon returning to the office, that same information is entered into the spin-test computer database. When timed spin tests are made in the office, the test results are entered directly into the spin-test computer database. It is the computer database that serves as the historical documentation of the timed spin tests. The Senior Technicians ensure that spin tests are conducted appropriately and documented for measurements made in their respective area of the State for which they are responsible. When deficiencies are identified, it is the responsibility of the Senior Technicians to correct the situation by instructing hydrographers on the appropriate spin-test policy.

In addition to the timed spin tests performed prior to field trips, field personnel are required to inspect the meter before and after each measurement to see that the meter is in good condition, that the cups spin freely, and the cups do not come to an abrupt stop. Descriptive notations are made at the appropriate location on the field note sheet concerning the meter condition, such as “OK” or “free” or other such comments. To ensure that field personnel carry out their responsibilities in maintaining the equipment they use, the equipment is inspected annually by the Senior Technicians. If deficiencies are identified, it is the responsibility of the hydrographer who uses the equipment in the field to correct the equipment problem.

It is the responsibility of the Senior Technicians to determine if the deficiency affected the quality of data collected when the defective equipment was in use and, if so, to determine the best course of action in correcting or voiding that data.

The Hydrologic Data Section maintains supplies for the upkeep and repair of all equipment used for direct discharge measurements in the Indiana District. Although the field hydrographers are responsible for maintaining the equipment they use, the Senior Technicians and the Chief of the Hydrologic Data Section provide guidance or assistance whenever the need arises. To ensure the quality of data, any worn, damaged, or defective parts should be replaced immediately with new parts.

Alternative Equipment

New conditions and the development of new technology sometime involve the collection of surface-water data with alternative equipment that has not been fully accepted by the USGS. To demonstrate the quality of surface-water data collected with alternative equipment, thorough documentation of procedures and observations must be maintained.

Indirect Measurements

In many situations, especially during floods, it is impossible or impractical to measure peak discharges by means of a current meter. There may not be sufficient time before flow conditions change for personnel to reach the site to make a direct measurement.

A peak discharge determined by indirect methods is in many situations the best available means of defining the upper portions of the stage-discharge relation at a site. Because extrapolation of a stage-discharge relation, or rating, beyond twice the highest measured discharge at a gaging station is undesirable and may be unreliable, discharge measurements made by indirect methods during periods of high flows are important forms of data (Rantz and others, 1982, p. 334).

The District follows data-collection and computation procedures presented in Benson and Dalrymple (1967). That report includes policies and procedures related to site selection, field survey, identification of high-water marks, the selection of roughness coefficients, computations, and the written summary. The District also follows procedures for measurement of peak discharge by indirect methods presented in Rantz and others (1982, p. 273).

In addition to the general procedures presented in Benson and Dalrymple (1967), the District follows guidelines presented in other reports that describe specific types of indirect measurements suited to specific types of flow conditions. The slope-area method is described in Barnes (1967) and Dalrymple and Benson (1967). The USGS applies the Manning equation in application of the slope-area method. Procedures for selecting the roughness coefficient are described in Arcement and Schneider (1989). The computer-based tool, Slope Area Computation, available to assist in computations of peak discharge with the slope-area method, is discussed in Office of Surface Water memorandum 83.07. Procedures for the determination of peak discharge through culverts, based on a classification system that delineates six types of flow, is described in Bodhaine (1982). The computer-based tool, Culvert Analysis Program, available to assist in computations of peak discharge at culverts, is discussed in Office of Surface Water memorandum 96.04.

At sites where open-channel width contractions occur, such as flow through a bridge structure, peak discharge can be measured with methods described in Matthai (1967) and with the Water-Surface Profile Computation model (WSPRO) (Shearman, 1990). Debris-flow conditions, which are most common in small mountainous basins, are discussed in Office of Surface Water memorandum 92.11.

Determinations of water-surface profiles along a stream channel in association with selected discharges are made when studies are performed that involve delineations of flood plains or when extensions are made to stage-discharge relations at streamflow sites. District personnel are required to follow the procedures associated with step-backwater methods described in Davidian (1984). The computer-based tool used for assisting in the computations of water-surface profiles with step-backwater methods, WSPRO, is discussed in Office of Surface Water memorandum 87.05.

General guidelines that are followed by the District when making indirect measurements include those discussed in Office of Surface Water memorandum 92.10 and in Shearman (1990). Violation of any one of the general guidelines does not necessarily invalidate an indirect measurement (Office of Surface Water memorandum 92.10).

The responsibility for ensuring that indirect measurements are performed correctly is held by the District Surface-Water Specialist. It is required that a review of procedures and documentation be performed on each indirect measurement by the District Surface-Water Specialist before the measurement is considered finalized. All aspects of each indirect measurement are reviewed.

It is a Northeastern Regional Policy that each indirect measurement be sent to the Regional Surface-Water Specialist for review. If deficiencies are found during the review, actions taken to remedy the situation include written comments provided by the reviewer to the Chief of the Hydrologic Data Section, who in turn supervises corrections made to the measurement. Measurements that are questionable and difficult to assess are reviewed by specialists outside the District, and the Chief of the Hydrologic Data Section is responsible for ensuring that deficiencies identified by the outside reviewers are corrected.

Determining when and where indirect measurements are made is the responsibility of the Chief of the Hydrologic Data Section assisted by the Hydrologic Data Section Quality-Assurance Specialist. For this District, it is a general rule that indirect measurements are made at sites when the peak flow at the site is estimated to be at least twice the discharge of the greatest measured flow. Indirect measurements also are made at the discretion of the Chief of the Hydrologic Data Section when the peak flow is less than twice the discharge of the greatest measured flow but when that part of the stage-discharge relation is poorly defined.

It is the responsibility of Hydrologists and Senior Technicians to identify and flag high-water marks. Because the quality and clarity of high-water marks are best soon after a flood, personnel traveling in the field are required to have available in their field vehicles equipment to signify high-water marks, such as nails, plastic markers, spray paint, paint sticks, and survey flagging. Because selection of a suitable reach of channel is an extremely important element in making an indirect measurement, at some streamflow-gaging-station sites the stream reach for indirect measurements at specified ranges of stage has been preselected and that information has been included in the station description.

After each indirect measurement is computed, the graphs, field notes and data, plotted profiles, maps, calculations or computer output, and written analysis associated with the measurement are checked by a qualified hydrographer assigned by the Chief of the Hydrologic Data Section. The information is organized in a single labeled folder and then is filed in the cabinet designated as the indirect measurement file. Long-term storage of each indirect-measurement package includes keeping all computations, graphs, and results in a single file and maintaining that information package in the District Office.

Peak Files

The responsibility of maintaining the accuracy of data contained in the Peak Flow File, including computer database files, lies within the District (Office of Surface Water memorandum 92.10). It is the responsibility of the Hydrologic Data Section Quality-Assurance Specialist to ensure that appropriate indirect-measurement results are entered into the Peak Flow File. It is the responsibility of the Chief of the Hydrologic Data Section to ensure that data in the Peak Flow File are correct. For further discussion on the update and review of the Peak Flow File, refer to the "Database Management" section in this QA Plan.

Crest-Stage Gages

Crest-stage gages are used as tools throughout the USGS for determining peak stages at otherwise ungaged sites, confirming peak stages at selected sites where recording gages are located, confirming peak stages where manometers or pressure transducers are used, and determining peak stages along selected stream reaches or other locations such as upstream and downstream from bridges and culverts. The OSW requires quality-assurance procedures comparable to those used at continuous-record stations for the operation of crest-stage gages and for the computation of annual peaks at crest-stage gages (Office of Surface Water memorandum 88.07).

Currently, the operation of crest-stage gages as stand-alone gaging stations is not part of this District's surface-water program. The use of crest-stage gages is limited to sites where other recording gages are available, and they are used for the purpose of confirming peak stages at those sites. Procedures followed by this District in the operation of crest-stage gages are presented in Rantz and others (1982; p. 9, 77, 78).

Levels are run to the gage every 4 years, or as soon as possible after significant changes in the gage because of damage to the gage, reconstruction, or other similar situations. When extremely high peaks occur, an outside high-water mark to confirm the gage reading is found when possible, is described on the note sheet, and is flagged by a durable indicator so that the elevation of the high-water mark can be determined the next time levels are run.

Field observations are written on the measurement note sheet used for the site inspection and measurement. All field notes are required to include, at minimum, initials and last name of field personnel, date, time of observation, and the crest-stage gage reading.

Artificial Controls

Artificial controls, including broad-crested weirs, thin-plate weirs, and flumes, are built in stream channels for the purpose of simplifying the procedure of obtaining accurate records of discharge (Rantz and others, 1982, p. 12). Such structures serve to stabilize and constrict the channel at a section, reducing the variability of the stage-discharge relation.

Artificial controls are used at some gaging stations maintained by this District. In situations where artificial controls are installed as permanent structures, it is District policy that stage-discharge relations are determined by making current-meter measurements throughout the range of stage at the site if such measurements are practical and possible. If direct means cannot be used, theoretical methods are used and verified by some means of direct measurement, if possible. Portable weir plates and flumes are used by District personnel in such situations as when the measurement cross section is poor and a measurement can be improved by the temporary installation of a flume or weir. These portable devices are applied according to methods described in Buchanan and Somers (1969, p. 57) and Rantz and others (1982, p. 263).

Ensuring the correct design and installation of artificial controls for this District is the responsibility of the Senior Technicians and the Chief of the Hydrologic Data Section. When installing an artificial control, the District personnel take into account the criteria for selecting the various types of controls, the principles governing their design, and the attributes considered to be desirable in such structures (Carter and Davidian, 1968, p. 3; Rantz and others, 1982, p. 15 and 348; and Kilpatrick and Schneider, 1983, p. 2 and 44).

When field inspections of artificial controls are performed, specific information pertaining to control conditions are written on the field note sheets for the purpose of assisting in analysis of the surface-water data. These notes include the date; time; condition of the control; any significant visible changes to the control since the last inspection; and comments about any apparent scour, fill, or debris lodged on the control. Regular maintenance at artificial controls includes cleaning or repairing the structure so that a stable stage-discharge relation is promoted. When problems pertaining to artificial controls are encountered by field personnel, field notes are made to document the problem, and the problems are corrected immediately by field personnel if possible. For gages affected by the control structure, gage readings are taken before any cleaning or repair of the structure is done, and gage readings are taken after the cleaning or repair is done and the flow conditions have stabilized. In situations where the scope of the problem prohibits the field personnel from correcting the problem when first encountered, the Senior Technicians or the Chief of the Hydrologic Data Section are notified so that the necessary corrective actions can be scheduled.

Flood Conditions

Flood conditions present problems that otherwise do not occur on a regular basis. These problems can include difficulties in gaining access to a streamflow gage or measuring site because roads and bridges are flooded, closed, or destroyed. Debris in the streamflow can damage equipment and present dangers to personnel collecting the data. Rapidly changing stage or conditions requiring measurements to be made at locations some distance away from the gage can create problems in associating a gage height to a measured discharge.

The District maintains a flood plan so that high-priority surface-water data associated with flood conditions are collected correctly and in a timely manner. The flood plan describes responsibilities before, during, and after a flood; information-reporting procedures; and field-activity priorities. The flood plan serves as a central reference for emergency communications, telephone numbers for key District personnel, and codes for accessing streamflow gages equipped with telemetry.

It is the responsibility of the Flood Coordinator for ensuring that the flood plan includes all appropriate information, including updated information. Currently, the Chief of the Hydrologic Data Section is the designated Flood Coordinator; the section Hydrologists, the Senior Technicians or Hydrologists, and the District Surface-Water Specialist are the alternates. The flood plan is reviewed by the Chief of the Hydrologic Data Section. A copy of the flood plan is provided to all personnel in the Hydrologic Data Section and other individuals in the District who assist in surface-water activities. Each individual who receives a copy of the plan keeps it in their field vehicle and, if appropriate, near their office desk. It is the responsibility of the Senior Technicians to ensure that appropriate individuals receive a copy of the flood plan and that the individuals who receive a copy of the plan are fully versed on the content of the flood plan.

During a flood, coordination of flood activities is performed by the Flood Coordinator. For personnel who already are not in the field and already have not been contacted by the Flood Coordinator, their first responsibility during flood conditions is to arrive at the office prepared for field duty. For personnel who are already in the field, their first responsibility during flood conditions is to communicate with the Flood Coordinator so that the highest-priority data can be targeted and collected efficiently. Personnel who arrive at a gaging station to find that a flood has occurred are responsible for inspecting the site and gage and establishing the time and stage of the peak. This information is communicated to the Flood Coordinator as soon as is reasonably possible. In general, field personnel are expected to use their skill, judgment, and ingenuity in prioritizing their efforts and collecting the hydrologic data during flood conditions. Timely communication with the Flood Coordinator promotes overall efficiency of flood-data-collection efforts. Safety, however, is considered the highest priority. The District personnel apply methods discussed in Rantz and others (1982, p. 60) for determining peak stage at gaging stations.

District personnel follow policies and procedures stated in a number of publications and memorandums when collecting surface-water data during floods. Techniques for current-meter measurements of flood flow are presented in Rantz and others (1982, p. 159 to 170). Procedures for identifying high-water marks for indirect discharge measurements are presented in Benson and Dalrymple (1967, p. 11). Adjustments applied to make measured flow hydraulically comparable with recorded gage height when discharge measurements are made a distance from the gaging station are presented in Office of Surface Water memorandum 92.09 and in Buchanan and Somers (1969, p. 54). It is the responsibility of all personnel who have questions about particular policies or procedures related to flood activities or who recognize their need for further training in any aspect of flood-data collection to address their questions to the Chief of the Hydrologic Data Section and the Senior Technicians.

Review of District activities related to floods is the responsibility of the District Chief. This review includes seeing that guidelines and priorities spelled out in the flood plan are followed and that the guidelines appropriately address District requirements for obtaining flood data in a safe and thorough manner. When deficiencies are identified by the reviewer, deficiencies are remedied by oral communication to the Flood Coordinator. When appropriate, written memorandums from the District Chief concerning goals and policies are issued to all District personnel for the purpose of better communicating those goals and policies.

Low-Flow Conditions

Streamflow conditions encountered by District personnel during periods of low flow are typically quite different from those encountered during periods of medium and high flow. Low-flow discharge measurements are made to define or confirm the lower portions of stage-discharge relations for gaging stations, as part of seepage runs to identify channel gains or losses, and to help in the interpretation of other associated data. Additionally, low-flow measurements are made to define the relation between low-flow characteristics in one basin and those of a nearby basin for which more data are available (Office of Surface Water memorandum 85.17).

In many situations, low flows are associated with factors that reduce the accuracy of discharge measurements. These factors include algae growth that impedes the free movement of current-meter buckets and larger percentages of the flow moving in the narrow spaces between cobbles. When natural conditions are in the range considered by the field personnel to be undependable, the cross section is physically improved for measurement by removal of debris or large cobbles, construction of dikes to reduce the amount of non-flowing water, or other such efforts (Buchanan and Somers, 1969, p. 39). After modification of the cross section, the flow is allowed to stabilize before the discharge measurement is initiated. The control of the gage is never modified for the purpose of improving a measurement section. In the event that the control of the gage might be modified accidently, thorough documentation of gage readings and associated times are written on the field note sheet so that appropriate shifts or datum corrections can be made at the time of data analysis. To help determine the magnitude of these corrections, gage readings are made prior to any modification of the cross section and after the flow has stabilized. Low-flow measurements ideally should be made, using an ADV to ensure accuracy of the slow velocities that often occur during low-flow measurement.

District policy requires that point-of-zero-flow (PZF) measurements be made by field personnel during periods of low flow at all gages where the low-flow control is recognizable in order to make the PZF determinations. A channel control is an example of where a point-of-zero-flow measurement generally is not made.

It is part of the natural cycle of most streams in Indiana for continual changes to occur on the low-water control, such as the building up and washing off of algae, leaves, or other debris. Generally speaking, field personnel in the Indiana District do not clean those natural controls (weirs and flumes may be cleaned) unless the stage-discharge relation has become ineffectual or undetermined because of that debris. It is left to the discretion of field hydrographers, however, to improve the control if they feel it is appropriate. If the control is modified by cleaning, thorough documentation is made on the field note sheet as to times, gage height, and discharge prior to and following the modification. Those gage heights following the cleaning may be obtained from the automated gage-height record.

The individual responsible for ensuring that District personnel use appropriate equipment and procedures during periods of low flow is the Chief of the Hydrologic Data Section, with assistance from the Senior Technicians. Determination that appropriate procedures are used for data-collection activities during low-flow conditions is accomplished by the Chief of the Hydrologic Data Section and the Senior Technicians discussing field activities with the hydrographers. In addition, the low-flow data are analyzed thoroughly by the hydrographers who work the station records and check those records. Any deficiencies identified at that time are discussed with the individuals who collected the data. In addition, any need for clarification or improvement of procedures is brought to the attention of the Chief of the Hydrologic Data Section who is responsible for communicating or implementing those improvements. The Chief of the Hydrologic Data Section and the Senior Technicians are responsible for providing answers to questions from District personnel pertaining to data collection during periods of low flow.

Cold-Weather Conditions

Surface-water activities in this District include making streamflow-discharge measurements during cold-weather conditions. Cold temperatures, wind, snow, and ice can create difficulties in collecting data. These factors also can create dangers to field personnel. The highest priority in collecting streamflow data during winter periods is employee safety.

For gaging stations where the stream is subject to freezing during the winter, discharge measurements under ice cover and during periods of partial ice cover are useful for analysis and determination of flow throughout winter periods. District personnel are required to follow procedures for discharge measurements under ice cover presented in Buchanan and Somers (1969, p. 42). This same publication includes procedures for discharge measurements made by wading or discharge measurements from cableways and bridges when debris and ice are in the streamflow. District personnel also follow procedures to collect winter streamflow data as presented in Rantz and others (1982, p. 124). Additionally, guidelines on equipment for measurement of flow under ice is provided in Office of Surface Water memorandum 84.05.

Presently, OSW views the preferred metering equipment for discharge measurements for slush-free conditions under ice cover to be a type AA current meter (an ADV may be used) built with a Water Survey of Canada (WSC) winter-style yoke with a conventional metal-cup rotor. For conditions where slush ice is present, the Office of Surface Water views the preferred metering equipment to be the WSC winter-style yoke with a polymer rotor (Office of Surface Water memorandum 88.18). Although polymer rotors are not allowed (Office of Surface Water memorandum 90.01) during all other conditions, the superior ability of the polymer rotor to shed slush ice and retard freezing in ice-covered streams is considered to be more important than the turbulent-flow-related inaccuracies associated with the rotor (Office of Surface Water memorandum

92.04). The OSW also views the regular AA meters with conventional metal-bucket rotors to be acceptable for use in slush-free conditions if cutting the required larger holes through the ice is feasible (Office of Surface Water memorandum 92.04).

District policy on the use of metering equipment on ice-covered streams where slush ice is present is that the Price AA meter is used with polymer cups. District policy on the use of metering equipment on ice-covered streams where no slush ice is present is that the ADV may be used or, in lieu of the ADV, the Price AA meter may be used where general depths are 1.5 feet or greater. When the effective depth of water under ice cover is less than 1.5 feet, an ADV or a pygmy meter is used.

The responsibility for ensuring the correct use of equipment and procedures for surface-water data-collection activities during periods of winter conditions is held by the Chief of the Hydrologic Data Section. This is accomplished by the Chief of the Hydrologic Data Section or Senior Technicians discussing data-collection procedures with hydrographers during the winter periods and responding to any questions they may have. The Senior Technicians or the Chief of the Hydrologic Data Section review the field notes of the newer employees immediately upon their returning from the field. They provide instruction and implement corrections for any deficiencies that are identified. It is the responsibility of the hydrographers involved in collecting surface-water data to ask questions concerning any goals or procedures that they find unclear. Those questions are presented to the Senior Technicians or the Chief of the Hydrologic Data Section.

Processing and Analysis of Streamflow Data

The computation of streamflow records involves the analysis of field observations and field measurements, the determination of stage-discharge relations, adjustment and application of those relations, and systematic documentation of the methods and decisions that were applied. Streamflow records are computed and published annually for each gaging station (Rantz and others, 1982, p. 544).

This section of the QA Plan includes descriptions of procedures and policies pertaining to the processing and analysis of data associated with the computation of streamflow records. The procedures followed by the Indiana District coincide with those described in Rantz and others (1982) and in Kennedy (1983).

Processing of Real-Time Streamflow Data

A necessary and critical element in maintaining accurate streamflow records on a real-time basis is the need for rating analysis and shift application as soon as practicable after a discharge measurement has been made. The Indiana District's policy is that rating analyses and shift applications will be performed using the following procedures for data disseminated on the District's public Web page http://in.water.usgs.gov/.

It is the policy of the Indiana District that real-time data presented on the District Web pages are considered to be provisional and subject to revision. Web-site users are warned of the inherent limitations of provisional data by providing them with prominent clickable headings that link to a page that provides a detailed explanation of the meaning of the term "provisional data." It is a goal of the Indiana District to process, check, and finalize all surface-water records by April 1 of the following water year. In practice, records for a large part of the Indiana streamflow network (including the provisional application of shifts, gage-height corrections, and datum corrections) are up-to-date within 4 weeks of the most recent field measurement. In addition, the Indiana District has agreements with specific cooperators to work records for selected stations on a monthly basis. The records for those stations are worked and up-to-date by the last day of each month; they then are checked, updated, and reviewed along with the remaining Indiana stations by April 1 of the following water year. Although streamflow records are worked during the year as time permits, at this time it is not the policy of the Indiana District to present the real-time discharge computations to Web-site users as absolutely current and up-to-date.

During times of flooding, the use of real-time data is an integral part of improving and maintaining the stage-discharge ratings used for computing streamflow records. The Indiana District flood plan specifies procedures and responsibilities during floods. The Chief of the Hydrologic Data Section serves as the Flood Coordinator. It is the responsibility of the Flood Coordinator to declare a flood emergency based on the criteria spelled out in the flood plan. The plan includes a list of level-one priority stations and level-two priority stations for which high-water measurements are needed to provide definition for the upper portion of the station ratings. The list specifies above what gage height measurements are needed for each site.
The real-time data on the Web, along with projected crest estimates provided by the National Weather Service, are used to help determine to which stations and at what time field personnel are deployed.
It is the responsibility of the Flood Coordinator to direct the deployment of field personnel for the purpose of obtaining field measurements and for the repair of failed equipment. It is the responsibility of the field personnel to call in and report measurement data to the Flood Coordinator and to provide other pertinent field information. The flood measurements are used to update station ratings, shifts, and other aspects of real-time discharge computations. Every attempt is made to make those updates the same day that the measurements are called in.

Web-Page Presentation Format

Indiana real-time data are served from computers located in the Indianapolis office maintained by the District. The National Water Information System Web (NWIS-W) software is used to conform to national USGS standards. Links to real-time streamflow data are displayed prominently on the Indiana District Home Page (http://in.water.usgs.gov/). By clicking on the phrase "Indiana Real-Time Data Daily streamflow conditions at a glance," one accesses a map of Indiana showing color-coded dots that identify the location of streamflow-gaging stations equipped with telemetry and the current flow conditions at each site. Also from the District Home Page, by clicking on the phrase, "Indiana Real-Time Data Grouped by river basin," one accesses a list of Indiana real-time streamflow-gaging stations grouped by river basin. The District Home Page also contains a direct link to a national map showing color-coded dots that indicate the location of gages around the country and the current flow conditions. Any modifications to the District Web site, whether it be the addition or deletion of Web links, the posting of USGS publications, or the addition of new web pages, are approved and executed by the District Web Master. It is the responsibility of the Web Master to ensure that all District Web Pages conform to all USGS Web and publication policies. It is the Indiana District Chief who holds the ultimate responsibility to approve the content of all pages posted on the Indiana District Web site.

Review of Real-Time Streamflow Data

Real-time streamflow data that are disseminated on the public Web page must be reviewed frequently to ensure their quality and to prevent the distribution of erroneous information. The Indiana District utilizes both automated and manual review procedures to meet this objective.

Automated procedures that have been implemented by the Indiana District include the setting of minimum and maximum threshold values for stage and discharge and their rates of change. If exceeded, these settings will initiate warnings of potential errors that will be delivered by e-mail to the appropriate District personnel. The Hydrologic Data Section Quality-Assurance Specialist, the ADAPS database manager, and the Chief of the Hydrologic Data Section are the Indiana District persons designated to receive and act upon these messages.

In addition to the automated procedures, WRD Technical memorandum 99.34 requires frequent and on-going screening and review of Web data, including the at least daily review of hydrographs during normal hours of operation. The Indiana District also requires that all Web pages containing real-time streamflow data are reviewed regularly for accuracy and/or missing data. The real-time streamflow data are scanned visually each work day by the Hydrologic Data Section Quality-Assurance Specialist. The primary goal of the visual check is to identify stations that have failed to transmit the real-time data and to identify real-time data that appear to be in some way erroneous. When problems are identified, the Hydrologic Data Section Quality-Assurance Specialist makes the situation known to the Chief of the Hydrologic Data Section who initiates the actions necessary to correct specific problems. Another goal of the visual check is to identify high water, backwater, or other pertinent conditions so that special measurements can be made to improve the overall records-computation process for the streamflow network.

Error Handling

There are two general types of errors associated with streamflow data that are delivered by the real-time system and disseminated on the Internet. The first are persistent-type problems usually associated with some type of equipment failure whether in data collection or transmission, but could also be related to ice effects. Because of the nature of the problem they generally occur on a continuing basis for more than a single recording interval. The second are the intermittent-type problems, which are often the result of a data transmission error. These often show up as either a zero or an unreasonably large value. It is the policy of the Indiana District that intermittent-type errors, such as extremely large gage-height data transmission errors, are identified as soon as is reasonably possible, and the erroneous data are either deleted or corrected as soon as is reasonably possible. For example, when a data transmission error is identified by the Hydrologic Data Section Quality-Assurance Specialist during the daily visual check of the real-time data, actions are taken immediately by that individual to delete or correct the value and update the real-time web site to reflect the corrected data. In regard to persistent-type problems, it is District policy not to estimate corrected discharges on an ongoing basis during periods of backwater caused by the effects of ice. Web users, however, are warned about the provisional nature of discharges during winter periods. When real-time data shown on the Web for a particular station are clearly in error— resulting from the malfunction of equipment, vandalism at the site, major control damage caused by beaver dam construction, or other similar problems—it is the responsibility of the Chief of the Hydrologic Data Section to decide when data for the site are removed from the Web page. After repairs have been made to the gaging station and the data are determined to be accurate, it is the responsibility of the Chief of the Hydrologic Data Section to decide when posting of the real-time data on the Web is to resume.

Data-Qualification Statements

WRD Technical memorandum 95.19 requires that streamflow data made available on the Web should be considered provisional until the formal review process has been completed. To ensure that everyone who accesses data from the Web are aware of this, data qualification statements must be included at key locations with a clickable heading Provisional Data Subject to Revision on all real-time data pages. It is the policy of the Indiana District that all District Web pages that contain real-time data, or contain data that have not been formally approved as final, present a prominent clickable heading that links to the following explanation:

Provisional data for Indiana

> Recent data provided by the USGS in Indiana--including stream discharge, water levels, precipitation, and components from water-quality monitors--are preliminary and have not received final approval.

Most data relayed by satellite or other telemetry have received little or no review. Inaccuracies in the data may be present because of instrument malfunctions or physical changes at the measurement site. Subsequent review may result in significant revisions to the data.

Data users are cautioned to consider carefully the provisional nature of the information before using it for decisions that concern personal or public safety or the conduct of business that involves substantial monetary or operational consequences.

Information concerning the accuracy and appropriate uses of these data or concerning other hydrologic data may be obtained from the station manager, whose name is shown on the single-station data-summary pages, or from the USGS surface-water specialist in Indiana, care of the webmaster email alias

gs-w-in_NWISWeb_Maintainer@usgs.gov.

Measurements and Field Notes

The gage-height information, discharge information, control conditions, and other field observations written by personnel onto the measurement note sheets and other field note sheets form the basis for records computation for each gaging station. Measurements and field notes that contain original data are required to be stored indefinitely (Hubbard, 1992).

Measurements and other field notes for the water year that is currently being computed are filed in the current year primary folder. Measurements and notes for previous water years are filed in the station-measurement backfile drawer.

It is District policy that, at minimum, all high-water measurements and all measurements that vary from the current rating by 5 percent or more are checked. For conventional measurements, that check includes a check of computations and the procedure, such as stationing, number of sections, use of proper meter, correct gage height, and proper transcription of numbers. For measurements computed using an automated discharge-measurement calculator, only the procedural check will be made. The procedural check may be done by any Hydrologic Data Section member other than the hydrographer who made the measurement. Measurement information is entered and stored in the standard USGS computer software. A printout of the measurement list (Kennedy, 1983, p. 12), grouped by year, is included in the technical file in the station-records filing cabinet.

It is the responsibility of the hydrographer who works the records for each station to ensure that the measurement note sheets are correct, that the information stored in the computer files agrees with the measurement note sheets, and that an updated printout of the measurement list is contained in the technical folder.

Continuous Record

Surface-water gage-height data are collected as continuous record (60-minute, 15-minute, or 5-minute values, for example) in the form of electronic transmissions by telephone, satellite, or values stored in electronic data recorders. At some stations there are backup recorders. Streamflow records are computed by converting gage-height record to discharge record through application of stage-discharge relations. Ensuring the accuracy of gage-height record is, therefore, a necessary component of ensuring the accuracy of computed discharges.

Gage-height record is assembled for the period of analysis in as complete a manner as possible. Periods of inaccurate gage-height data are identified and then corrected (see the section "Datum Corrections, Gage-Height Corrections, and Shifts") or deleted as appropriate. Items included in the assembly of gage-height record and procedures for processing the data are discussed in Kennedy (1983, p. 6), and Rantz and others (1982, p. 560 and p. 587).

Immediately following a data-collection field trip, all surface-water data on Personal Computer Memory Card International Association (PCMCIA) cards or computer medium are entered into ADAPS, using Data Card Transfer (DACTRAN) software. Data transmitted by telephone line or by satellite are entered into the computer by automated computer programs. Raw data are maintained unaltered for future reference on a file on the data-entry personal computer (PC) and on backup tapes created by the SUN computer system. Stage data from the primary recorder known to be erroneous can be overwritten by correct data obtained from a backup recorder, if a backup recorder is maintained at the site.

It is the responsibility of the hydrographer inserting backup record into the primary data-descriptor (dd) record to ensure the correct data are inserted. Any such modification of data should be quality controlled, using graphical methods. Stage data stored in the computer files are used for computing surface-water records and are compared closely with field observations, including observer readings. Observer readings are maintained in the designated file drawer and are grouped by station. All stage data are to be reviewed by the hydrographer, using database graphics routines, immediately after entering data into ADAPS. Any problems with the gages should be reported to the Senior Technicians and corrected without delay.

Records and Computation

The responsibility for working the records for each station is assigned by the Chief of the Hydrologic Data Section, a designated Hydrologist, or Senior Technician, to a specific hydrographer each year. It is the goal that records be assigned to the same individual who operates the field gaging station. In Indiana, because of the operating structure, only a part of the records can be assigned to the gaging-station operator.

The responsibility for checking those computations is assigned to an individual other than the hydrographer who computed the record. The checking assignment usually is made on an as-needed basis.

For a limited number of specific stations, discharges are computed on a provisional basis at the end of each month. For most stations with telemetry, the stage data are loaded into the computer with automated programs, then the discharge is computed automatically; the computations are considered provisional estimates and are subject to change upon further analysis.

Standard procedure requires the assigned hydrographer to compute the record on a semi-current basis. At the point where data are finalized for the annual data report for any one year, provisional record computation should be continued into the next water year and computed up to the next year's ice period. It is a goal that the records computations are to be completed by December 10 of the following water year. All data, computations, graphs, and analyses are checked by a second hydrographer by February 1.

Procedures for Working and Checking Records

Procedures for ensuring the thoroughness, consistency, and accuracy of streamflow records are described in this section of the QA Plan. The goals, procedures, and policies presented in this section are grouped in association with the separate components that are included in the records-computation process.

Gage Height

The accuracy of surface-water discharge records depends on the accuracy of discharge measurement, the accuracy of rating definition, and the completeness and accuracy of the gage-height record (Office of Surface Water memorandum 93.07). Computation of streamflow records includes ensuring the accuracy of gage-height record by comparisons of gage-height readings made by use of independent reference gages, comparison of inside and outside gages, examination of high-water marks, comparisons of the redundant recordings of peaks and troughs by use of maximum and minimum indicators, examination of data obtained at crest-stage gages, and confirmation or updating of gage datums by levels.

Records computation includes examination of gage-height record to determine if the record accurately represents the water level of the body of water being monitored. Additionally, it includes identifying periods of time during which inaccuracies have occurred and determining the cause for those inaccuracies. When possible and appropriate, inaccurate gage-height record is corrected. When corrections are not possible, the erroneous gage-height data are removed from the set of data used for streamflow-records computation. All missing gage-height records should be documented. Specifically, the period and the reason for the missing record should be listed in the station analysis.

In general, data that accurately reflect the stream level should be kept. Examples could include backwater from leaves, ice, or beaver dams. Stage record that does not reflect the stream level (such as stuck float, plugged intakes, buried orifice) should be removed. Periods of mildly lagging intakes may be retained in the unit-value record.

In the Indiana District, the primary computer printouts (referred to in this report as "primaries") are considered work sheets. All discharge measurements and field inspections are noted on the primaries. All periods of ice effect, backwater, faulty record, and the like are noted on the primaries by marking a line through the original daily mean discharge and are annotated by the appropriate estimation symbol.

It is not necessary to hand list estimated discharges on the primary sheet, but they should be machine labeled with an "e" on an attached daily-value (DV) table printout. It is the hydrographer who works the record who is responsible for clearly identifying periods of bad gage-height record; it is the checker, if in agreement, who is responsible for deleting that bad gage-height record from the computer file. For periods when data from the primary recorder are replaced by data from a backup recorder, that change is thoroughly documented on the primary sheet and in the station analysis.

Levels

Errors in gage-height data caused by vertical changes in the gage or gage-supporting structure can be measured by running levels. Gages can be reset or gage readings can be adjusted by applying corrections based on levels (Kennedy, 1983, p. 6).

Procedures for computing records for each station include adjusting gage-height values based on current level data. It is the responsibility of the hydrographer working the station records to ensure that level field notes have been checked, the front sheets of the field notes are complete and correct, the information has been listed in the level-summary file, and the station description and gage-height data have been updated accordingly. The individual computing the record is required to check field notes for indications that the gages were reset correctly by field personnel. If gages have not been reset correctly to agree with the levels, the individual working the record informs the field personnel responsible for the upkeep of that specific station as to the need for correcting the gage setting. This information is communicated either orally or in writing. The individual computing the records makes appropriate adjustments to the gage-height record by applying datum corrections.

Rating

The development of the stage-discharge relation (rating) is one of the principal tasks in computing discharge record. The rating is usually the relation between gage height and discharge (simple rating). Ratings for some special sites involve additional factors such as rate of change in stage or fall in slope reach (complex ratings) (Kennedy, 1983, p. 14).

District personnel follow procedures for the development, modification, and application of ratings that are described in Kennedy (1984). District personnel also follow guidelines pertaining to rating and records computation that are presented in Kennedy (1983, p. 14) and in Rantz and others (1982, Chap. 10-14 and p. 549).

For each gaging station, the most recent digital rating table can be obtained by producing a printout from the electronic file stored in ADAPS, the standard USGS software. In addition, a paper copy of the current digital rating is kept in the technical folder maintained in the filing cabinet with the station files. In the event that a rating is superseded, a copy of the rating being replaced (older rating) is stored in the rating backfile section of the paper file. A graphical plot of the most recent rating can be obtained by generating the graph, using the plotter with the standard USGS software. The current master copy of the plotted rating is maintained in alphabetical order in the rating file drawer. When new rating plots are generated to be used as the work plots, the previous work plots are discarded. Graphical Master Ratings of all previous numbered ratings are retained in the backfile. The addition of TKG2 software allows for the master rating plot to contain the current rating and the previous rating. The master ratings should contain ratings with both curves drawn.

For many gaging stations, rating tables of newly developed ratings are provided to various individuals and agencies that use the gaging-station data. It is the responsibility of the hydrographer who develops a new rating to print five copies of the new rating table and place those copies in the current primary folder. After the rating is checked and found to be correct, the checker provides the appropriate number of copies to the individual in the Hydrologic Data Section assigned to mail those ratings to the appropriate parties.

It is Indiana District policy that no new ratings are distributed outside the District Office until the ratings have been checked.

Rating Numbering

Ratings are stored with sequential identification numbers and any modification to rating-input points, including a change of scale offset, results in a new whole-number rating (such as 52, 53...). If a rating is extended to a new gage height either above or below the current rating, then it should be sequenced by a tenth of a whole number (such as 51, 51.1...).

The goal of policies and procedures pertaining to ratings is to promote efficiency and accuracy in the development and documentation of ratings. It is the responsibility of the hydrographer working the station records to ensure that all measurements for the current year and all high-water measurements for the station are plotted on the current work plot of the rating.

In general, changes in the stage-discharge relation that tend to be temporary changes are addressed through the use of variable-stage shifts. It is, however, left to the discretion of the hydrographer working the station records to determine if changes in the relation are addressed with shifts or if conditions warrant the introduction of a new rating. It is acceptable to introduce new ratings, using software such as RATSEG or BIBER-SKED, particularly if a new curve facilitates the quality and speed of record computation.

In general, changes in the stage-discharge relation that are deemed to be relatively stable warrant the introduction of new ratings, and well-defined trends also warrant new ratings. It is the responsibility of the hydrographer working the records to fully develop the new rating; enter all input values and offsets into the computer, using standard USGS software; and plot the new rating along with the measurement data.

It is the responsibility of the hydrographer checking the station records to ensure that the rating-input points and offsets agree with available measurement data. The checker has the latitude to disagree with the scope and shape of the new rating and with the original decision of introducing a new rating. The checker also can choose to develop a new rating for the station, if appropriate. It is the responsibility of the checker, however, to discuss disagreements with the original records worker. The two must come to a consensus on the appropriate rating to be used. If a consensus is not reached, it is their responsibility to present the matter to a Senior Technician or the Chief of the Hydrologic Data Section who will make a final determination.

Datum Corrections, Gage-Height Corrections, and Shifts

A correction applied to gage-height readings to compensate for the effect of settlement or uplift of the gage usually is measured by levels and is called a “datum correction” (Kennedy, 1983, p. 9). Datum corrections are applied to gage-height record in terms of magnitude (in feet) and in terms of when the datum change occurred. In the absence of any evidence indicating exactly when the change occurred, the change is assumed to have occurred gradually from the time the previous levels were run, and the correction is prorated with time (Rantz and others, 1982, p. 545). Datum corrections are applied when the magnitude of the vertical change is greater than 0.015 feet.

A correction applied to gage-height readings to compensate for differences between the recording gage and the base gage is called a “gage-height correction” (Rantz and others, 1982, p. 563). These corrections are applied in the same manner as datum corrections and by use of the same computer software. Gage-height corrections are applied so the recorded data are made to agree with base-gage data. These corrections are applied when the difference between the recording gage and the base gage is equal to or greater than 0.02 foot. Corrections also should be made at discrepancies of .01 foot if the effect of the change in stage creates a greater-than-5-percent change in discharge.

A correction applied to the stage-discharge relation, or rating, to compensate for variations in the rating is called a shift. Shifts reflect the fact that stage-discharge relations are not permanent but vary from time to time, either gradually or abruptly, because of changes in the physical features that form the control at the gaging station (Rantz and others, 1982, p. 344). Shifts can be applied to vary in magnitude with time and with stage (Kennedy, 1983, p. 35). It is the policy in the Indiana District that shifts are applied in the form of variable-stage shifts, using standard USGS software. Shifts are applied when field measurements rated “GOOD” indicate a temporary deviation of 5 percent or greater in discharge from the current rating. Shifting allowances change to 8 percent for measurements rated “FAIR.” For those measurements rated “POOR,” it is on a case-by-case basis as to how much weight the measurement is given or if it is used at all.

The hydrographer who works the station records documents the shifts by describing the shift magnitude and time of application in the station analysis and by including the shift-analysis printout and the shift-bar-diagram plot with the station analysis. The shift-diagram points should be plotted on a copy of the work rating so that the hydraulic logic of the shift curve can be seen. It is the responsibility of the checker to ensure that the logic and procedures used in developing and applying the shifts are correct and that the shifts are documented fully.

Datum corrections, gage-height corrections, and shifts for each station are entered in the standard USGS data-processing software and are stored as finalized data upon completion of the District’s records-working process. The hydrographer who works the station records ensures that recorded gage heights and computed discharges represent a logical and smooth transition between water years. The checker also ensures the quality of the transition between water years. Datum corrections, gage-height corrections, and shifts are documented in the station analysis, and associated graphs and computer printouts are attached to the station analysis as part of the permanent record. This documentation is maintained indefinitely for future reference.

Hydrographs

A discharge hydrograph is a plot of daily mean discharges versus time. The date is aligned with the horizontal axis, and the discharge is aligned with the logarithmic vertical axis. In the process of computing station records, this hydrograph is a useful tool in identifying periods of erroneous information, such as incorrect shifts or datum corrections. Additionally, hydrographs are helpful when estimating discharges for periods of undefined stage-discharge relation, such as during backwater or ice conditions, and in estimating discharges for periods of missing record.

Information placed on the hydrograph for each gaging station includes, at minimum, the station name, station number, water year, date the hydrograph was plotted, drainage area, plot of daily mean discharge data, plots of measurements, indications of datum corrections and shifts, the name of the streamflow stations with which the hydrograph was compared, periods of missing record, estimated discharges for days of missing record, periods of ice effect, estimates of discharge during periods of ice effect, and the maximum instantaneous discharge for the water year. All hydrographs are plotted on a standard-size form and standard log cycles so that the dimensions of the graphs are uniform for all gaging stations.

The hydrographer who works the gaging-station record is responsible for completing the hydrograph. The checker ensures that the hydrograph is complete and correct. Plots typically are made on the District's large format plotter.

The Indiana District uses a long-established color-code system in plotting the hydrograph. Computed daily means are plotted in black pen or gray pencil (mostly machine plots). Ice estimates are plotted in red and indicate "b" days. Estimates for periods of missing record are plotted in blue and are "a" days. The annotation of "a" or "b" days is not mandatory, but it is important to distinguish between good gage-height record and bad gage-height record so that the checker correctly will delete the bad gage-height record.

Comparing the hydrograph of one gaging station to those of nearby gaging stations is an effective means to evaluate the validity of shift, datum, or gage-height-correction applications; identify periods of faulty gage-height data; and estimate discharges for periods of missing record or periods of no stage-discharge relation. Hydrographic comparison, as described in Rantz and others (1982, p. 575), is a component of records computation for each streamflow-gaging station in Indiana. Hydrographs for stations during the year for which records are being worked are maintained in alphabetical order in the designated file drawers located in the Hydrologic Data Section. After records are worked, checked, and finalized, each hydrograph is folded and placed in the backfile folder for the respective station for future reference.

In general, the Chief of the Hydrologic Data Section and the Senior Technicians provide instruction and assistance in training District personnel on the goals and methods of hydrographic comparison. Individuals with questions about hydrographic comparison or questions about which specific sites are appropriate for comparison should address their questions to the Chief of the Hydrologic Data Section and the Senior Technicians.

Station Analysis

A complete analysis of data collected, procedures used in processing the data, and the logic upon which the computations were based is documented for each year of record for each station to provide a basis for review and to serve as a reference in case questions arise about the records at some future date (Rantz and others, 1982, p. 580). Topics discussed in detail in the station analysis include, but are not limited to, equipment, hydrologic conditions, gage-height record (including when and why record is missing), datum corrections, rating, discharge, special computations, hydrographic comparison, a listing of ice-affected periods, and remarks concerning the quality of the records. The station analysis is written by the hydrographer who works the records. If only parts of the year are worked, such as when records for a station are worked 1 month at a time for provisional purposes, the analysis is updated for that specific part by the hydrographer working the station records.

The hydrographers writing the station analysis should use the standard word-processing package (FrameMaker) available on the USGS computer. Regardless of whether or not the analysis is complete or incomplete, a hard copy of the station analysis is kept in the primary folder for the water year currently being computed. Completed and checked analyses for previous years are grouped in a separate folder in the station backfile. Included with the hard copy of the station analysis are all graphs of variable stage-shift diagrams, a printout of the shift analysis, a printout of the computer-generated year-end summary, and printouts of the datum and shift applications. The hard copy of the analysis, signed and dated by the original records worker and the checker, is considered the permanent document for the station file; the electronic file stored in the word processor is considered the temporary working file.

It is the responsibility of the hydrographer who works the station record to ensure that the computation process is comprehensive and complete and that all aspects of the process are documented fully in the station analysis and associated material. Likewise, it is the responsibility of the checker to ensure that all aspects of the records-computation process for the station were carried out correctly and completely and that the documentation is clear, complete, and accurate.

In the event that the checker disagrees with any of the methods or interpretations used, it is the checker's responsibility to discuss any potential changes with the hydrographer who worked the station records. If a consensus cannot be reached between the two parties, it is their responsibility to present the problem to the Chief of the Hydrologic Data Section who will make the final determination. It is the responsibility of the Chief of the Hydrologic Data Section to ensure that station analyses are prepared properly and filed.

Winter Records

Computing records that represent winter periods for gaging stations involves procedures that are not applicable to records that represent other times of the year. The formation of ice in stream channels or on section controls affects the stage-discharge relation by causing backwater; the effect varies with the quantity and nature of the ice, as well as with the discharge (Rantz and others, 1982, p. 360). During some conditions the recorded gage-height data may be accurate, although the actual stage-discharge relation may be undeterminable and unstable. An example of this condition would be when surface ice forms on the stream, but the stilling well remains unfrozen and the water level in the stilling well represents the backpressure caused by the ice in the channel. During other conditions, the recorded gage-height data are inaccurate, resulting in periods of missing gage-height record. An example of the latter would be when a stilling well or the intakes to the stilling well are frozen.

The individual computing the station record is responsible for identifying ice-affected periods, documenting those periods in the station analysis and the hydrograph, and estimating daily mean discharges for the period. That individual also identifies periods of faulty or missing gage-height record, documents those periods in the station analysis and on the hydrograph, estimates daily mean discharges for the period, and enters those estimates into the daily-values computer file. The individual identifies what specific unit-value gage height should be considered faulty record and what eventually should be deleted from the unit-values computer file; that individual clearly indicates the period on the primary computations sheets.

The hydrographer who checks the winter records is responsible for confirming that the determinations of ice-affected periods, periods of faulty gage-height record, and estimated daily mean discharges are correct. If the checker is in agreement on what periods of gage-height record are faulty, the checker is responsible for deleting the faulty unit-value gage height from the unit-values computer file. The checker is responsible for discussing any disagreements with the original records worker. If the two cannot reach a consensus on corrective actions that address the disagreement, Senior Technicians or the Chief of the Hydrologic Data Section are responsible for making the final determination.

In general, the checker is responsible for making corrections to the data files and documentation. For more extensive broad-scale changes, however, the original records worker modifies or corrects the station records. For periods when unit-value gage heights are correct but there is no stage-discharge relation, neither the unit-value gage heights nor the unit-value discharges are deleted, even though the unit-value discharges are superseded by estimated daily mean discharges.

Hydrographers who work station records for winter periods use a combination of recorded gage-height data, precipitation and temperature data, and other environmental information that may be available. Although ice-affected discharge measurements are representative only for a specific site at a specific time, those measurements are helpful for determining a general range of discharge for estimating daily means for selected time periods for certain nearby gaging stations.

Unit-value plots are used for identifying streamflow patterns associated with the occurrence of ice. Hydrographic comparison with nearby gaging stations is useful in estimating daily mean discharges. Nearby gaging stations are useful, particularly in hydrographic comparison for winter periods when those stations tend to remain unfrozen as a result of large amounts of ground water entering the flow system, of heat from power plants or similar facilities entering the flow system, or of relatively warmer outflows being released from reservoirs. Records from nearby gaging stations also are useful if the discharges are computed by an acoustical gage. Generally, records are considered poor for days that discharges are determined by estimation.

Indiana Hydra Protocol

Hydra is a new and powerful tool in ADAPS that can be used to expedite the task of record estimation. While this tool is a potential time saver, it is also a potential source of error because of its data-modification abilities. The user then must be conservative and avoid overwriting periods of valid data. Keeping in mind these precautions, the following is the policy for using Hydra.

Unit-Value Estimates

In general, unit-value gage height typically should not be estimated. The exception to this rule is that unit-value gage heights can be estimated if there is a high degree of confidence that little or no loss of accuracy will result from the estimation and the period to be estimated is less than 12 hours. In this case, the resultant daily mean discharge computed from this record is not labeled “estimated.”

In any event, a copy of the original unit values must be preserved as a paper copy for the checker or reviewers to see. There may be exceptions to the 12-hour rule, such as if a peak stage is available during the missing period. The exceptions should be approved by the Hydrologic Data Section Quality-Assurance Specialist. The unit-values part of Hydra then is used to replace very short periods of missing gage-height record and is not to be used to generate extended periods of gage-height record.

Daily-Value Estimates

Daily mean discharges may be estimated, using Hydra in the same manner that estimated record has been done traditionally. The new procedure differs from the old in that the estimated part of the hydrograph is stored automatically by ADAPS. The hydrographer estimating the daily mean discharge must hand plot the original daily mean values from the primary record printout onto the hydrograph so that the checker and reviewer may see the original rating-produced discharge along with the estimated discharge.

A software program named MISTE resides inside Hydra under the edit header and can be used to create a regression-curve estimate of daily discharges. This program is particularly useful if the original data are missing and an estimate must be made. MISTE provides a method of writing the program-derived daily values into the Hydra program as a reference curve. The reference curve can be pasted into the STUDY CURVE, and then peaks can be modified for the final estimate. The program is a time saver because the values are not key punched by hand in the database but are written by MISTE.

Furnished Records

Surface-water data collected under the supervision of other agencies, organizations, or institutions are received by this office. These data are used for comparisons of flow with nearby gaging stations and for publication in the annual data report.

Daily mean discharge data provided by other agencies are compared with data collected by the Indiana District at nearby gaging stations. Those values are entered into the computer file for long-term storage. Data tables and correspondence from the furnishing agency are placed in the station primary folder for future reference. The agency that furnished the data is identified in the annual report when the data are published.

Daily-Values Table

With few exceptions, for each gaging station operated by the USGS, a discharge value is determined and stored for each day. The daily-values table generated by use of the records-computation software represents what discharge values are stored for each day of the water year.

Daily mean discharges are one of the major products of the records-computation process. It is the responsibility of the hydrographer who works the records to determine that the calculated daily mean discharges accurately represent the actual streamflow conditions. It is responsibility of that hydrographer to ensure that the daily-values table, which includes those values stored in the daily-values computer file, contains the correct data. In addition, it is that individual's responsibility to ensure that the correct values stored in the daily-values table also are contained in the hydrograph, working primaries, and the publication-ready manuscript. In turn, the checker confirms the accuracy of this information. A hard copy of the daily-values table is included in the station primary folder. The finalized daily values are stored in the standard USGS computer database, ADAPS, for future retrieval and analyses. The hydrographer who works the records updates the progress board upon completion of the station records. The checker then updates the progress board accordingly when the checking process has been completed.

Manuscript and Annual Report

When records computation for the water year has been completed, and the data collected and analyzed by District personnel have been determined to be correct and finalized, the surface-water data for that water year are published along with other data in the District's annual data report. The annual data report is part of the series entitled "U.S. Geological Survey Water Data Reports." Information presented in the annual data report includes daily discharge values during the year, extremes for the year and period of record, and various statistics. Additionally, manuscript station descriptions are presented. Information contained in the manuscript includes physical descriptions of the gage and basin, history of the station and data, and statements of cooperation.

In preparing the annual data report for publication, the District follows the guidelines presented in the report, "WRD Data Reports Preparation Guide," by Charles E. Novak, 1985 edition.

Manuscripts for publication in the annual data report are produced, using the word-processor program available in the USGS computer system. The table of daily-values and streamflow statistics presented in the report are loaded directly into the manuscript files from the computer data files. Potential data-transfer errors are minimized with the use of these automated production tools. Each information statement and data value presented on each page of the draft is checked and rechecked, followed by a detailed review of the entire report.

To reduce the potential for systematic errors, a different person executes each step of the checking and reviewing process. A copy of the final printed report is reviewed by the Chief of the Hydrologic Data Section and the Senior Technicians. The ultimate responsibility for presenting complete and accurate information in the station manuscripts and the remainder of the annual data report belongs to the District Chief. It is the Chief of the Hydrologic Data Section and the Senior Technicians, however, who oversee all facets of the data collection, data analysis, and report-production process. Therefore, it is the Chief of the Hydrologic Data Section and the Senior Technicians who play the primary role in ensuring the quality of the information contained in the annual data report.

District Checkoff List

The status of progress on records computation for each gaging station in the State is posted in a single, highly visible location in the Hydrologic Data Section. A list of gaging-station names is on a large board mounted on the wall. Each gaging-station name is followed by a series of blank squares. The hydrographers computing or checking gaging-station records place their initials in the blanks to indicate the completion of specific phases of the records-computation process. Checkers, because they are not predesignated, must list their first initial in the checked record square while in the process of checking. When the checker completes the record, the full initials of the checker are placed in the square.

Review of Records

After streamflow records for each station have been computed and checked, records for no less than 10 percent of the District's gaging stations are reviewed by experienced individuals from neighboring Districts as part of a quality-assurance leadership exchange program. A total of 30 percent of Indiana records are to be reviewed yearly in some form. The goal of the review is to ensure that proper methods were applied throughout the process of obtaining the surface-water data and computing the record. The findings of the review for each gaging station are provided in writing and verbally to the Chief of the Hydrologic Data Section. The written findings are maintained in the technical folder for future reference by the Chief of the Hydrologic Data Section.

It is the responsibility of the Chief of the Hydrologic Data Section to ensure that any deficiencies identified in the review are corrected and that actions are taken to prevent the recurrence of those deficiencies. It also is the responsibility of the Chief of the Hydrologic Data Section to ensure that positive aspects of the review are communicated to District personnel to reinforce the continued use of correct methods and procedures.

Crest-Stage Gages

Currently in the Indiana District, crest-stage gages are maintained only for the purpose of confirming peak gage heights at bubbler streamflow-gaging stations, and peak-stage-indicator (PSI) clips are used to confirm peaks at stilling-well sites. At these sites, the primary record is obtained by automatic recorders. The peaks determined by the crest-stage gages are used as backups and for comparison to ensure the quality of the recorded peaks. The field data pertaining to the crest-stage gage are included on the station-measurement note or inspection sheet. It is the responsibility of the hydrographer who works the station record to compare each peak value at the crest-stage gage to the corresponding peak value obtained with the primary recorders. If a difference between the two values exists, the hydrographer working the records must determine the reason for the difference and thoroughly document the situation in the station analysis.

It is the responsibility of the hydrographer who works the station record to compare each peak value at the crest-stage gage to the corresponding peak value obtained with the primary recorders. If a difference between the two values exists, the hydrographer working the records must determine the reason for the difference and thoroughly document the situation in the station analysis. If the difference is determined to be incorrect gage calibration or other similar equipment-related deficiency, the records worker informs the person who collects the field data at that station as to the need for corrective action at the gage. In addition, the records worker applies corrections as necessary to the computed record.

It is the responsibility of the checker to ensure that the peak values at the crest-stage gages were compared to recorded data and that proper corrective actions, if needed, were incorporated into the station records.

Office Setting

Maintaining surface-water data and related information in a systematic and organized manner increases the efficiency and effectiveness of data-analysis and data-dissemination efforts. Good organization of files reduces the likelihood of misplaced information; misplaced data and field notes can lead to analyses based on inadequate information, with a possible decrease in the quality of analytical results.

This section of the QA Plan includes descriptions of how station folders, reference maps, levels documentation, and other information related to surface-water data are organized and maintained. Additionally, this section provides an overview of how work activities are designed to be carried out within the office setting.

Work Plan

It is the responsibility of the Chief of the Hydrologic Data Section, with assistance from the Senior Technicians, to assign duties associated with the collection, analysis, storage, and publication of surface-water data, unless the data pertain to a separate project.

For individual projects that include the collection of surface-water data, the project chiefs are required to establish their own work plan and quality-assurance plan. Project chiefs are responsible for ensuring that all aspects of the project associated with surface-water data collection, analysis, and storage meet the standards presented in this publication.

Assignments of the hydrographers responsible for working specific stations and checking specific stations are posted on the station-progress board. The list of gaging stations and records assignments also is used to track the status of computation for those stations. The scheduling of field work and most day-to-day office work is delegated to the Senior Technicians.

File Folders for Surface-Water Stations

This section of the QA Plan describes the location and makeup of hard-copy files associated with surface-water data. Some of the types of documentation discussed in this section are maintained in file folders and some are stored in filing-cabinet drawers located in the Hydrologic Data Section. Information pertaining to files maintained in computer storage can be found in the "Database Management" section of this report.

For each gaging station, a separate set of file folders is maintained in a set of filing cabinets located at the north end of the Hydrologic Data Section. Files are grouped by station name in alphabetical order. Folders containing long-term documentation are grouped with the folders containing current information. Extraneous items are removed from the current files after records for all gaging stations are determined by the Chief of the Hydrologic Data Section to be finalized for that water year. The hydrographer assigned the record for the next year is responsible for ensuring that appropriate documentation is filed correctly and that unnecessary notes and work sheets are discarded.

The set of current files and documentation for each station are grouped as follows:

> Primary folders.—The primary folders contain primary-computation printouts and working plots, such as graphed data of stage and discharge. For convenience in working the station record, the primary folder for the year that is currently being worked contains further information, including the recent measurements and field notes, the in-progress station analysis, the computer-generated shift analysis, the shift and datum printouts, and the computer printout of the measurement list.
>
> Technical folder.—The technical folder contains a printout of the current digital stage-discharge rating; station documentation that includes a copy of the station description; the comprehensive measurement list (commonly referred to as the 9-207); important correspondence with the cooperator or observer concerning the technical aspects of the gage; and any other technical documentation pertaining to the history, operation, or modification of the gage.
>
> Graphs of ratings.—The master graphs of the ratings in current use are kept, unfolded, in a series of wide file drawers. Graphs are stored by station name in alphabetical order. When new ratings are introduced or when working graphs become too cluttered from plotted measurements or temporary curves, the older graphs are discarded and new graphs are produced. A master rating is backfiled when a new numbered rating is produced. The current rating as well as the previous rating should be plotted on the master rating.
>
> Discharge hydrographs.—The discharge hydrographs, representing the year for which records are being worked, are kept, unfolded, in a series of wide file drawers. The hydrographs are stored by station name in alphabetical order. After the records for the year are determined to be finalized, the hydrograph for each station is folded and placed in the hydrograph backfile folder.

The set of backfiles is grouped for each station as follows:

> Primary folders.—The primary folders are maintained with the station file in the District Office for at least 2 years. Every few years (generally 3 to 4), the primaries of previous years are stored on the office mezzanine. Data older than 7 years are sent to the archives for storage.
>
> Measurement notes.—Measurement notes are kept in labeled file drawers, grouped by station in alphabetical order. The measurements are filed in chronological order. The measurement file is separate from the set of folders grouped by station. The measurements are maintained indefinitely in the District Office.
>
> Station analysis and miscellaneous computations.—A labeled folder for each station contains all station analyses and specialized comments or analyses for previous years.
>
> Discharge hydrographs.—A labeled folder for each station contains the discharge hydrograph for previous years.

Rating.—A labeled folder for each station contains a digital printout of each discontinued stage-discharge rating. For some of the oldest stations, the earliest ratings are hand written rather than computer generated. These earliest ratings also are maintained for all stations.

General folder.—A folder is maintained that contains the station description, correspondence, and memorandums associated with the station.

It is the responsibility of each individual who uses the file folders and the information contained in them to ensure that all materials are maintained appropriately. The individual who removes a file folder from a cabinet ensures that the folder is returned, intact, to its proper location. The files are not removed from the office. The only exception to this policy is when the Chief of the Hydrologic Data Section permits removal on specific instances for unusual circumstances. It is the responsibility of the Chief of the Hydrologic Data Section to assign duties associated with the backfilling and reorganizing of materials.

Field-Trip Folders

The Indiana District maintains a separate folder for each field trip. These folders are kept at a single, highly visible location in the Hydrologic Data Section. The folders are three-ring binders that contain a list of all sites included in the respective field trip and copies of the station descriptions for each of the stations, including surface-water and ground-water sites. Contained in the folder for each site along with the station description are a map of the area with the site plotted on the map and detailed descriptions of any special circumstances pertaining to data collection at the site.

The purpose of the folders is to provide a comprehensive overview of the trip so that field personnel essentially can run any trip at a moment's notice. It is the overall responsibility of the Senior Technicians to ensure that the field-trip folders are kept up-to-date for their assigned section of the State. It is incumbent upon the hydrographer who regularly runs the specific trips, however, to update the file folders as any changes occur.

Levels

Level note sheets, with completed summary front sheet, for the current year are kept in the current primary folder. After records are finalized for that year, the level note sheets are filed in the series of drawers labeled for that purpose located in the Hydrologic Data Section. The level notes are grouped by station name in alphabetical order and are filed in chronological order. Summaries of the field notes are entered on sheets and are kept by station name in alphabetical order in a set of three-ring binders. The purpose of these summaries is to maintain a composite record of any changes in elevation over time of any gages or reference marks.

Station Descriptions

Station descriptions for all gaging stations currently operated are maintained in a set of three-ring binders and in a computer file. The binders, along with the level-summary binders, are kept on a shelf in the Hydrologic Data Section. Similar but separate binders are maintained for lake stations and ground-water stations. A separate binder contains station descriptions for all discontinued streamflow-gaging stations. A copy of the station description also is kept in the general folder of the station backfile, in the current technical folder, in the field-trip folder, and in the field folder maintained in the gage house. The station description maintained in the three-ring binders is considered the official document of record.

It is the responsibility of the individual who updates that document to see that copies are made available to update those in the other locations just mentioned. A record of all station descriptions should be kept in the backfile.

Discontinued Stations

Station descriptions, station analyses, stage-discharge ratings, correspondence, and other documentation associated with discontinued stations are maintained in a specific, labeled filing cabinet located in the Hydrologic Data Section. Folders are grouped by station, and the stations are arranged in alphabetical order. File folders containing primary computations associated with the discontinued stations are archived. A three-ring binder contains the station descriptions for the discontinued gaging stations, and a second binder contains the level summaries for those stations.

Map Files

A set of 7.5-minute topographic maps representing coverage of the entire State are maintained for the purpose of identifying the location of all surface-water- and ground-water data-collection sites. Each observation site is plotted on the appropriate map. This set of maps is referred to as the Master File Map Set. A second set of 7.5-minute topographic maps is maintained for the purpose of delineating surface-drainage areas. No map from either set is allowed to be removed from the office unless permission is granted by the District Chief. It is the responsibility of the Chief of the Hydrologic Data Section to ensure that these map sets are updated when new stations are established. This responsibility generally is delegated to the hydrographer leading the effort to establish each station. Individuals who require work maps can obtain the maps from the District Library. When the map needed is not in stock, the map can be ordered by the District Secretary.

Archiving

All personnel are directed to safeguard all original field records containing geologic and hydrogeologic measurements and observations. Selected material not maintained in field offices are placed in archival storage. Detailed information on what records have been removed to archival centers should be retained in the District or project office (Water Resources Division memorandum 77.83). The types of original data that should be archived include, but are not limited to, recorder charts and tapes, original data and edited data, observer's notes and readings, station descriptions, analyses, and other supporting information (Water Resources Division memorandum 92.59 and Hubbard, 1992, p. 12). At this time, there is an agreement between the USGS and the Federal Records Centers (FRC) of the National Archives and Records Administration to archive original-data records (memorandum from the Chief, Branch of Operational Support, May 7, 1993).

Surface-water information is sent to the FRC from the Indiana District every 3 to 4 years, or more often if the volume of material is sufficient. The ultimate responsibility for ensuring that all appropriate materials are archived is held by the District Chief. This responsibility is delegated to the Chief of the Hydrologic Data Section, who is responsible for deciding what information is sent to the FRC, for ensuring that the information is properly packed and logged, and for ascertaining that the information is received by the FRC. Archival duties have been delegated from the Chief of the Hydrologic Data Section to one of the Senior Technicians, referred to in this report as the "Archive Master."

Records of exactly what has been archived are maintained in a three-ring binder maintained by the Archive Master. Personnel who have questions concerning archiving procedures should address their questions to the Archive Master or the Chief of the Hydrologic Data Section. Personnel who receive requests for information that require accessing archived records should work with the Archive Master in obtaining the appropriate material from the FRC. Although the Archive Master is responsible for assisting in the retrieval of the records and for maintaining accounts of what is removed from the FRC and what is returned, the responsibility for fulfilling the request, in general, does not fall upon the Archive Master.

For projects outside the purview of the Hydrologic Data Section, it is the responsibility of the individual project chief to ensure that all original data and other appropriate records are forwarded to the FRC. This is accomplished by working with the Archive Master. Records associated with individual projects generally are not archived until months or years after the project is completed and all associated published reports have been distributed.

Communication of New Methods and Current Procedures

The content of all policies issued through memorandums by Water Resources or OSW are communicated by the Chief of the Hydrologic Data Section to all personnel in that section. In some instances, this is accomplished by verbal communication at quarterly meetings (or more often, if an immediate need exists), and in some instances by electronic mail to all personnel. All technical memorandums are not necessarily issued directly to all personnel, but they are made available to all personnel. A file of Water Resources and OSW memorandums is maintained by the District.

The responsibility for ensuring that District personnel collecting surface-water data are well informed of new and current procedures is held by the Chief of the Hydrologic Data Section. It is the responsibility of project chiefs to keep abreast of current policies and procedures and to seek pertinent procedure and policy information from the Chief of the Hydrologic Data Section. The Senior Technicians are responsible for assisting in the effective communication of that information to personnel of less experience.

Collection of Sediment Data

Surface-water activities in the District include the collection, analysis, and publication of sediment data. The District operates in adherence to policies related to sediment set forth by the OSW.

Responsibility for the sediment discipline was transferred from the Office of Water Quality (OWQ) to the OSW in 1985 (Office of Surface Water memorandum 92.08). The policies and procedures related to sediment followed by the District are described in selected Water Resources publications and in memorandums issued by OSW, the Office of OWQ, and Water Resources. Techniques adopted by the USGS and followed by this District are presented in Knott and others (1992). The District also follows procedures presented in three publications for the series, Techniques of Water-Resources Investigations of the U.S. Geological Survey (TWRI):

Book 3, Chapter C1—Fluvial Sediment Concepts by H.P. Guy (1970).

Book 3, Chapter C2—Field Methods for Measurement of Fluvial Sediment by H.P. Guy and V.W. Norman (1970).

Book 3, Chapter C3—Computation of Fluvial-Sediment Discharge by George Porterfield (1972).

Although no additional TWRI chapters have been written to supersede the above-mentioned reports, Open-File Report 86-531, Field Methods for Measurement of Fluvial Sediment by T.K. Edwards and G.D. Glysson (1988), essentially replaces Book 3, Chapter C2 (Water Resources Division memorandum 71.73, Office of Surface Water memorandum 88.17, and Office of Surface Water memorandum 93.01).

A summary of memorandums issued since 1971 related to sediment and sediment transport is provided in Office of Surface Water memorandum 92.08. A summary of documentation that describes instrumentation and field methods for collecting sediment data is provided in Office of Surface Water memorandum 93.01.

Sampling Procedures

District personnel collect suspended-sediment data by using sampling methods that include the single vertical method, the Equal Discharge Increment (EDI) method, the Equal Width Increment (EWI) method, and the point-sample method. Automatic pumping-type samplers are used. For installation and use of automatic pumping-type samplers, the District follows the criteria described in Edwards and Glysson (1988, p. 32).

Field methods for sediment sampling are documented in Office of Surface Water memorandum 93.01. Water samples obtained for the analysis of sediment concentration and particle size are not composited (Office of Surface Water memorandum 93.01 and Office of Water Quality memorandum 76.17). For samples that are split, the cone splitter is used (Office of Water Quality memorandum 80.17).

Policy for the collection and publication of bedload data is provided in Office of Surface Water memorandum 90.08. This memorandum supersedes policy and guidelines provided in previous Office of Water Quality memorandums 76.04, 77.07, 79.17, and 80.07, as well as Water Resources Division memorandum 77.60. Among the policies stated in Office of Surface Water memorandum 90.08, which are followed by the District, is one stating that three cross-sectional procedures are used for bedload sampling: the Single Equal Width Increment (SEWI) method, the Multiple Equal Width Increment (MEWI) method, and the Unequal Width Increment (UWI) method. Additionally, it is stated in Office of Surface Water memorandum 90.08 that it is the responsibility of the field personnel to select the procedure that is optimal for the local condition. Bedload samples in some situations are analyzed individually and in other situations are analyzed as a composite. Until sampling variability for a particular site is understood by those analyzing the data, all samples are required to be analyzed individually.

The individual in the District responsible for scheduling sediment-collection activities at specific sites is the Chief of the Hydrologic Data Section or the project chief who manages specific sediment studies. The individual responsible for ensuring that District personnel use correct procedures to collect sediment data is the District Water-Quality Specialist. This individual establishes whether or not correct procedures are being used by discussing current procedures with individuals involved in sediment-data collection and, when necessary, reviewing pertinent memorandums and procedures with them. Any deficiencies found in the procedures are corrected through instruction provided by the District Water-Quality Specialist. Any deficiencies identified as a result of lab analysis are communicated by the District Water-Quality Specialist to field personnel so that corrected procedures are implemented. Answers to questions from District personnel concerning sediment-sampling techniques are provided by the District Water-Quality Specialist.

Field Notes

District personnel are required to fill out note sheets each time a site is visited for the purpose of sediment sampling. The employee completes the note sheet in its entirety before leaving the site. Original observations written on the note sheets are not to be erased; data are corrected by crossing out the original observations and writing the correct information near the original value. The goal of placing information on the field note sheet is to describe the equipment and methods used during the site visit as well as to describe relevant conditions or changes (Office of Surface Water memorandum 91.15). For each site visit, information included on the note sheet includes, at minimum, site-identification number and name, names of field personnel, date, time, gage height, discharge information, sampling equipment used, method, and—if applicable—observer information.

Upon completion of each field trip, field notes are placed in the current file folder for the station. Field notes are checked during the process of working the sediment record for the station. All data are checked thoroughly prior to publication.

Equipment

Care and maintenance of the sediment-data-collection equipment is the responsibility of the field personnel who use the specific equipment. Parts replacement and repair of damaged equipment is accomplished by replacing the damaged part of the equipment. Replacement parts generally are obtained from the District laboratory technician. It is the responsibility of the project chief to ensure that appropriate equipment is used at all sampling sites. The project chief is responsible for discussing equipment applications and techniques with the District Water-Quality Specialist and for ensuring that the appropriate applications and techniques are used. Sampling equipment is selected based on the constituents that are being investigated, the type of analyses that are to be performed, and site conditions, including velocity and maximum depth of water. The District follows equipment-design criteria and guidelines referenced in Office of Surface Water memorandum 93.01.

Sample Handling and Storage

The quality of sediment data provided by a sediment laboratory is affected by the quality of the samples received from the field (Knott and others, 1992, p. 2). District personnel are required to prepare sample labels, analysis instructions, and sample documentation according to guidelines presented in Knott and others (1992).

Prior to when sample containers are obtained for use on field trips, they are stored in protective crates with the containers tightly sealed. During field trips and prior to use, sample containers are stored in the field vehicle, in protective crates, with the containers tightly sealed. Once the containers have been filled with sediment samples, the samples are stored for the remainder of the field trip in the field vehicle, shielded from direct sunlight in protective crates, with the containers tightly sealed. After the field trip, samples are stored in protective crates, in the dark, in the District cooler, with the containers tightly sealed. Proper storage, in a cool, dark place decreases the rate of organic growth and evaporation within the sample bottle (Knott and others, 1992, p. 5).

High-Flow Conditions

High-flow conditions at most streams, unless the streams are subject to the effects of backwater, are associated with high-energy conditions. The sediment load and particle sizes associated with high flows are significant factors in sediment studies performed by the District. To ensure that field personnel are aware of their responsibilities in obtaining sediment samples at appropriate sites during high-flow conditions, specific statements pertaining to sampling requirements at specific sites are stated in the site description, copies of which are included in the field folders located in the gage house and in the field-trip folders located in the District Office. In addition, verbal instructions are provided by the project chief or the Chief of the Hydrologic Data Section to the individual assigned to collect the samples.

The individual responsible for ensuring that sediment samples are obtained during opportunities provided by high-flow conditions is the project chief, except in situations where that responsibility for specific sites has been delegated to the Chief of the Hydrologic Data Section. It is their responsibility to provide the Flood Coordinator with any pertinent instructions or data requirements prior to the high-flow events.

The individual responsible for ensuring that the proper sampling equipment and methods are used during high-flow conditions is the individual who collects the sample. It is, however, the responsibility of the project chief to ensure that proper training has been provided to the individual who collects the sample.

The District Water-Quality Specialist is responsible for providing answers to District personnel who have questions concerning high-flow sampling equipment or sampling procedures.

Cold-Weather Conditions

Sediment-sampling activities in this District include obtaining samples during periods of subfreezing temperatures. During cold-weather conditions, field personnel should take every precaution to ensure their personal safety. Additionally, field personnel should attempt to ensure that equipment is not damaged by floating slabs of ice and that nozzles are not clogged with ice crystals.

When floating slabs of ice pose the danger of damaging sampling equipment, such as during spring breakup, field personnel may manage only to obtain surface samples between the floating slabs of ice (Edwards and Glysson, 1988, p. 86). The procedure is noted on the field note sheet and sample label. When anchor ice and frazzle ice are present, it may be necessary to move the sampling equipment quickly through ice crystals to avoid clogging the nozzle. This procedure is also noted on the field note sheets and sample label.

Site Documentation

A station description is prepared for each new sediment-sampling site. At sampling sites where streamflow-gaging activities occur, the description of sediment activities is included in the gaging-station description. A list of elements included in each station description, along with an explanation of what items are included with each element, is presented in the attachment to Office of Surface Water memorandum 91.15. At sites where sediment samples are collected but other streamflow data are not collected, the station descriptions are structured similarly to those for streamflow-gaging stations and contain similar information (Kennedy, 1983, p. 2). At sampling sites where gage houses have been installed, station descriptions are kept in the gage house for the purpose of providing field personnel with information pertinent to sediment-sampling procedures for that particular site. Station descriptions are included in the field folder and are maintained in the office files. Each description includes specific information explaining where the site samples are to be taken and what method is to be used.

The responsibility of ensuring that field copies of station descriptions located at gage houses are kept current is held by the hydrographer assigned to regularly run each respective field trip. Station descriptions are kept current by the hydrographer who processes the sediment-station data. Station descriptions are reviewed by the project chief to ensure that they are current. These reviews are made annually. When a deficiency is identified during the review of station descriptions, the deficiency is corrected by the reviewer informing the individual who worked the sediment record and providing that individual with suggestions on how the deficiencies can be corrected. The individual who worked the record is responsible for making the correction.

At sampling sites with a gage house, a log of sampling activities is kept. The hydrographer who collects the sample writes into the log information that includes the date and mean gage height of when the samples were collected, the location where samples were taken, and any other information that might assist those who will conduct future sampling at the site.

Processing and Analysis of Sediment Data

Sediment and associated streamflow data are compiled to produce sediment records for specific sites. Data processing of periodic measurements consists of four steps: tabulation, evaluation, editing, and verification (Office of Surface Water memorandum 91.15). The District follows the considerations and guidelines presented in Porterfield (1972), Guy (1969), and Office of Surface Water memorandum 91.15 in carrying out these four steps.

Sediment records are worked on an annual basis. The project chief is responsible for ensuring that sediment records are worked correctly and that all sediment data stored in the computer files agree with measurements and laboratory results. The District Water-Quality Specialist is responsible for reviewing sediment records and for instituting all corrective actions when a deficiency is identified.

The responsibility for ensuring that appropriate procedures are applied correctly in processing sediment data is held by the project chief. During the time the sediment data are being processed for the year, field notes and work sheets for each site are maintained in the current station folder. After the record has been completed, field notes and work sheets are maintained in the designated sediment file folder. The sediment-measurement data also are maintained in the standard USGS computer files.

Sediment Laboratory

A sediment laboratory is not operated in the Indiana District.

Sediment-Station Analysis

A sediment-station analysis is written for each sediment station operated by the District each water year. The sediment-station analysis is a summary of the sediment activities at the station for a given year. The analysis describes the coverage of sampling, the types of samples and sampling, changes that might affect sediment transport or the record, and the methods and reasoning used to compute the record. Information included in the sediment-station analysis is presented in a thorough manner so that the checker and the reviewer can determine from the analysis the adequacy of the activities in defining the record and in accomplishing the objectives defined for the station (Office of Surface Water memorandum 91.15).

Elements included in each sediment-station analysis are listed in Office of Surface Water memorandum 91.15, along with descriptions of the elements and examples. The sediment-station analyses are maintained with the station file.

It is the responsibility of the hydrographer who writes the station-sediment analysis to ensure the adequacy of the written analysis and to correct any deficiency in the material identified by the checker or the reviewer. The sediment-station analyses of previous years are maintained as part of the station backfile.

Sediment-Analysis Results

It is the responsibility of the hydrographer who collected the sediment sample to ensure that the analytical results are received from the sediment laboratory and that the data are entered into the water-quality database. It is the responsibility of the project chief to inspect the analytical results, identify situations where the integrity of the sample may be in question, address any deficiencies that are identified, and ensure the publication of the sediment data.

Sediment data are published in the annual data report or in individual project reports. Sediment data are organized and reported as described in Novak (1985) and in Office of Surface Water memorandum 91.15.

Sediment-Data Storage

All sediment field notes and written analytical results from the sediment laboratory are kept in the station folder. The project chief is responsible for ensuring that the integrity of the station folder is maintained. Included in the station folder with the field notes and analyses results are the graphs, tables, station description, sediment-transport curves (if appropriate), work notes, and ancillary data.

It is the responsibility of the hydrographer who collects the sediment data to enter the measurement data and analytical results into the computer files, unless the project chief has specified alternative data-entry arrangements.

It is the responsibility of the project chief to ensure that the data stored in the computer files are correct. If an error or a deficiency is identified in a data or project review, it is the responsibility of the project chief to institute the correction.

Database Management

The overall process of storing surface-water data collected at continuous-record gaging stations includes entering the unit-value stage data into computer files, using ADAPS, the standard USGS database; computing corresponding discharge values; computing daily mean discharges based on those unit discharges; and storing those daily means in ADAPS.

In addition, instantaneous peak discharges and the associated peak gage heights are determined for each gaging station and stored in the Peak Flow File. Sediment data are stored in computerized water-quality files.

Ultimately, it is the responsibility of the District Chief to ensure that surface-water data files are updated and that the data are correct. The Chief of the Hydrologic Data Section, however, oversees all aspects of data entry and data management, except in situations pertaining to water-quality files and specific project files.

The hydrographer who collects the unit-value stage data is responsible for entering the data into the computer system. Depending on the equipment that is used at each site, generally the data are entered manually, automatically by satellite, by downloading electronic signals through a personal computer or data card, or by interrogation and retrieval of electronic signal through telephone lines.

The task of entering the unit values into the computer can be delegated by the Chief of the Hydrologic Data Section to individuals other than those who collect the original data. It is the responsibility of the hydrographer who computes the records to ensure that the correct data are contained in the appropriate files for each gaging station and for ensuring that the correct daily mean discharges are stored for each station.

A second individual independently checks to see that the appropriate data are contained in appropriate computer files for each station. The responsibilities of maintaining the local computer programs and files and for updating the national database are assigned to a specific individual by the Chief of the Hydrologic Data Section.

The responsibility of updating the Peak Flow File and ensuring that the data contained in the Peak Flow File are correct is held by the Hydrologic Data Section Quality-Assurance Specialist. After streamflow records for a water year have been computed and checked and the data have been finalized, the Hydrologic Data Section Quality-Assurance Specialist ensures that the Peak Flow File is updated to include the published peak discharges and gage heights for each gaging station for the most recent year. Following the computer-update procedure, that individual ensures the correctness of the data by comparing all stored values for that updated year against the published values.

It is the responsibility of the Chief of the Hydrologic Data Section to ensure that the updates to Peak Flow File are carried out correctly.

It is the responsibility of the project chief to ensure that all sediment data are stored correctly in the water-quality database.

Publication of Surface-Water Data

The act of Congress (Organic Act) that created the U.S. Geological Survey in 1879 established the Survey's obligation to make public the results of its investigations and research and to perform, on a continuing, systematic, and scientific basis, the investigation of the geologic structure, mineral resources, and products of the National domain (U.S. Geological Survey, 1986, p. 4). Fulfilling this obligation includes the publication of surface-water data and the interpretive information derived from the analyses of surface-water data.

Publication Policy

The USGS has created specific policies pertaining to publication of data and interpretation of those data. All personnel, including those of this District, are required to abide by these policies. A brief summary of goals, procedures, and policies are presented in U.S. Geological Survey (1986, p. 4–37).

All information obtained through investigations and observations by the staff of the USGS or by its contractors must be held confidential and not be disclosed to others until the information is made available to all, impartially and simultaneously, through Director-approved formal publication or other means of public release, except to the extent that such release is mandated by law (U.S. Geological Survey, 1986, p. 14). With the approval of the Director, hydrologic measurements resulting from observations and laboratory analyses, after they have been reviewed for accuracy by designated USGS personnel, have been excluded from the requirements to hold unpublished information confidential (U.S. Geological Survey, 1986, p. 15).

All interpretive writings in which the USGS has a proprietary interest, including abstracts, letters to the editor, and all writings that show the author's title and USGS affiliation, must be approved by the Director before release for publication. The objectives of the Director's review are to final check the technical quality of the writing and to make certain that it meets USGS publication standards and is consistent with policies of the USGS and Department of the Interior. Director's approval ensures that (1) each publication or writing is impartial and objective, (2) has conclusions that do not compromise the USGS's official position, (3) does not take an unwarranted advocacy position, and (4) does not criticize or compete with other governmental agencies or the private sector (U.S Geological Survey, 1991, p. 10).

Types of Publications

Various types of book publications released by the USGS are available in which surface-water data and data analyses are presented. Publications of the formal series include the Water-Supply Paper, the Professional Paper, the Bulletin, the Circular, the Techniques of Water-Resources Investigations, Special Reports, and Selected Papers in the Hydrologic Sciences (U.S. Geological Survey, 1986, p. 42). Publications in the informal series include the Water-Resources Investigations Report, the Open-File Report, and the Administrative Report (U.S. Geological Survey, 1986, p. 52). Included in the Open-File Report series are data reports. Surface-water data collected by this district are published each year in a hydrologic-data report that belongs to the annual series entitled “U.S. Geological Survey Water Data Reports.” Factors considered by the District when deciding which form of publication should be utilized in presenting various types of information are presented in Green (1991, p. 14).

Review Process

Procedures for publication and requirements for manuscript review are summarized in U.S. Geological Survey (1991, p. 36–41). This District fulfills those requirements for review and approval of reports prior to printing and distribution. All reports written by USGS scientists in connection with their official duties must be approved by the Director. At least two technical reviews of each report are required (U.S. Geological Survey, 1991, p. 36). Competent and thorough editorial and technical review is the most certain way to improve and assure the high quality of the final report (Moore and others, 1990, p. 24). Principles of editorial review and responsibilities of reviewers and authors are presented in Moore and others (1990, p. 24–49). Open-File Reports are not required to receive editorial review but are reviewed for policy and reproducibility (U.S. Geological Survey, 1991, p. 36). Most Open-File Reports published by the Indiana District receive editorial review.

It is the policy of the Indiana District for authors to provide written responses to all significant comments and suggestions provided by colleague reviewers. The responses are provided to the colleague reviewers prior to the time that the draft report is submitted for approval by the Director for publication. Review and response correspondence and marked draft copies of each report are kept with the draft report that is submitted for approval. These same materials are grouped as a report file and maintained for future reference.

After the report is published, the project chief or other District staff retains the option to maintain these materials in the District Office as an information resource. If it is determined that the materials are no longer needed on a current basis in the District Office, the materials are archived.

The ultimate responsibility for presenting complete and accurate information in the Indiana District’s annual data report belongs to the District Chief. It is the Chief of the Hydrologic Data Section, however, who oversees all facets of the data-collection, data-analysis, and report-production process. Therefore, the Chief of the Hydrologic Data Section plays the primary role in ensuring the quality of the annual data report.

In preparing the annual data report for publication, the District follows the guidelines presented in the USGS publication, WRD Data Reports Preparation Guide by Charles E. Novak, 1985 edition. The authority to approve the annual data report for publication has been delegated by the Director to the District Chief.

Discussion of the steps taken to ensure the quality of the data that are included in the annual report is presented earlier in this report in the section, “Procedures for Working and Checking Records,” under the heading, “Manuscript and Annual Report.”

The Chief of the Hydrologic Data Section oversees the thorough review of the final reproducible copy of the report provided by the District to the printer. In addition, the Chief of the Hydrologic Data Section oversees the thorough review of the printed report provided by the printer to the District. At least 10 percent of the printed reports are selected from throughout those provided by the printer, and they are reviewed for print quality. If the printed reports are found to contain incorrect information or if the print quality is found to be poor, the deficiencies are corrected or reprints are made before any copies are distributed. The Chief of the Hydrologic Data Section is responsible for ensuring that deficiencies are corrected.

Safety

Performing work activities in a manner that ensures the safety of personnel and others is of the highest priority for the USGS and the Indiana District. Beyond the obvious negative impact unsafe conditions can have on personnel, such as accidents and personal injuries, they also can have a direct effect on the quality of surface-water data and data analysis. For example, errors may be made when an individual's attention to detail is compromised when dangerous conditions create distractions. So that personnel are aware of, and follow, established procedures and policies that promote all aspects of safety, the District communicates information and directives related to safety to all personnel by individual and group in-house training, verbal and written communication between supervisors and staff, and public display of materials listing responsibilities and procedures. Specific policies and procedures related to safety can be found posted on the Safety bulletin board and by request from the District Safety Officer. It is the responsibility of each employee to attend the required safety training provided by the Indiana District, adhere to USGS and District safety policies, and contribute to the development of District policies by communicating the need for improvements to their supervisor. Supervisors are responsible for promoting safe practices in the work place and addressing safety issues pointed out by those they supervise.

An individual has been designated as Safety Officer by the Indiana District. The Safety Officer's duties include assisting the District Chief in making safety policies and procedures known to District personnel. The District Safety Officer attends safety training provided through and by the USGS to increase the Safety Officer's awareness of safety issues, requirements, and procedures.

Personnel who have questions or concerns pertaining to safety or who have suggestions for improving some aspects of safety, may direct those questions, concerns, and suggestions to their supervisor or the District Safety Officer.

Training

Ensuring that personnel obtain knowledge of correct methods and procedures is a vital aspect of maintaining the quality of surface-water data and data analysis. By providing appropriate training to personnel, the District increases the quality of work and eliminates the source of many potential errors.

It is the goal of the Indiana District for all personnel involved with surface-water data collection and analysis to have, at minimum, all the skills and information necessary for carrying out their duties in an efficient and effective manner. To achieve this goal, training on many levels is provided to personnel, and training is actively promoted by the District Chief and all District supervisors and discipline specialists.

The primary responsibility for ensuring that personnel receive appropriate training is held by each supervisor. This responsibility includes maintaining awareness of training opportunities and scheduling that training. Training includes formal courses presented by the USGS, local universities, and other organizations or institutions. An extremely important form of training includes one-on-one instruction provided by the more experienced personnel. In the Hydrologic Data Section, the Senior Technicians play a primary role in providing on-the-job training to complement the formalized instruction.

A detailed record of the formal training for all personnel is maintained by the District administrative staff. A training plan is discussed between each individual and the supervisor on an annual basis. All personnel are encouraged to make training needs known to the supervisor during those discussions or at any time during the year.

Summary

Information included in this District Surface Water Quality-Assurance Plan documents the policies and procedures of the Indiana District that ensure high quality in the collection, processing, storage, analysis, and publication of surface-water data. Specific types of surface-water data discussed in this report include stage, streamflow, sediment, and basin characteristics. The roles and responsibilities of District personnel for carrying out these policies and procedures are presented, as are issues related to management of the computer database and issues related to employee safety and training.

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Appendixes

Appendix 1. Water Resources Division Memorandums Cited

Office of Surface Water memorandum 2002.03
Office of Surface Water memorandum 2002.02
Office of Surface Water memorandum 2002.01
Office of Surface Water memorandum 2000.07
Office of Surface Water memorandum 2000.03
Office of Surface Water memorandum 99.06
Office of Surface Water memorandum 96.04
Office of Surface Water memorandum 96.02
Office of Surface Water memorandum 93.12
Office of Surface Water memorandum 93.07
Office of Surface Water memorandum 93.01
Office of Surface Water memorandum 92.11
Office of Surface Water memorandum 92.10
Office of Surface Water memorandum 92.09
Office of Surface Water memorandum 92.08
Office of Surface Water memorandum 92.04
Office of Surface Water memorandum 91.15
Office of Surface Water memorandum 90.08
Office of Surface Water memorandum 90.01
Office of Surface Water memorandum 89.08
Office of Surface Water memorandum 89.07
Office of Surface Water memorandum 88.18
Office of Surface Water memorandum 88.17
Office of Surface Water memorandum 88.07
Office of Surface Water memorandum 87.05
Office of Surface Water memorandum 85.17
Office of Surface Water memorandum 85.14
Office of Surface Water memorandum 84.05
Office of Surface Water memorandum 83.07
Water Resources Division memorandum 99.34
Water Resources Division memorandum 95.19
Water Resources Division memorandum 92.59
Water Resources Division memorandum 77.83
Water Resources Division memorandum 77.60
Water Resources Division memorandum 71.73
Office of Water Quality memorandum 80.17
Office of Water Quality memorandum 80.07
Office of Water Quality memorandum 79.17
Office of Water Quality memorandum 77.07
Office of Water Quality memorandum 76.17
Office of Water Quality memorandum 76.04
Memorandum from the Chief, Branch of Operational Support, May 7, 1993

Appendix 2. Hydrologic Data Section Surface-Water Electronic Archiving

This addendum to the Indiana District Surface Water Quality-Assurance Plan documents the archiving of electronic files related to surface-water activities of the Hydrologic Data Section.

All electronic files will be archived, grouped by streamflow-gaging station and water year. This will facilitate offloading data for an entire water year for “permanent” archival purposes. The directory structure is documented below.

Archive Directory Structure

The directory structure is:
/datas/archives/WY2XXX/station#

where WY2XXX is the current water year and station# is the unique 8-digit downstream order number for each individual gaging station

EXAMPLE: /datas/archives/WY2002/05536190

Subdirectories:

The new subdirectories for each station are:

- measurements
- sensor
- edl
- levels
- lrgs
- nwql
- photos
- stanalysis

Description of Subdirectories:

- measurements—contains subfolders for each measurement made in the water year. The folders will have the following naming convention:
  NNN.MMDDYY.XXXXXXXX

  where:

  NNN is the measurement number

  MMDDYY is the year month and date of the measurement

  XXXXXXX is the type of measurement made

  flowtracker = Flowtracker ADV measurement

  riversurveyor = Sontek RiverSurveyor ADP measurement

  riogrande = RD Instruments Rio Grande ADCP measurement

  aquacalc = JBS Instruments AquaCalc measurement

  boogiedopp = Nortek BoogieDopp measurement

  EXAMPLE: A Flowtracker measurement number 555 made at Hart Ditch at Dyer on February 23, 2002: 555.022302.flowtracker

- sensor—any programming or diagnostics information for sensors installed at the gage
  (For example any ArgChecks performed at a site that has a Sontek Argonaut.)
- edl— datalogger program files
- levels—any electronic level notes or summaries
- lrgs—lrgs data files
- nwql—any water-quality files
- photos—digital photos taken at the station
- stanalysis—Station Analysis with other documentation used for working the record

In addition to the station# directories, there is a "software" directory under each water-year directory (/datas/archives/WY2002/software). The software directory includes software used to process electronic files (for example, the WinRiver software used to process RDI ADCP files).

Responsibilities

It is the responsibility of the individual who generates an electronic file to archive the file in a timely manner. Persons who generate edl, sensor, level, measurement, or other applicable files in the field should archive the files according to this addendum within 5 working days of returning to the office. Occasionally, edl or sensor files are created in the office prior to implementation in the field—such files should be archived within 5 working days of their creation.

It is the responsibility of the individual who works the station record to complete the archiving of electronic files associated with the record, such as station analysis. The archived files should be kept current as modifications are made. For example, if a station analysis is started early in the water year and updated from time to time throughout the year, the archived station analysis should be the most recent version. Final archiving for the water year should be done within 1 month after the station records are finalized. It is the responsibility of the Chief of the Hydrologic Data Section to ensure that archiving has been done for all appropriate streamflow-gaging stations each water year.

Appendix 3. Hydroacoustic Instrumentation—Standards, Policies, and Procedures

This addendum to the Indiana District Surface Water Quality-Assurance Plan presents standards, policies, and procedures used by the Indiana District specifically related to hydroacoustic instrumentation. Many standards, policies, and procedures documented in the main body of the Surface Water Quality-Assurance Plan apply to the use of hydroacoustics. These include, for example, maintenance of gaging-station infrastructure, site documentation, and general records-working procedures. This addendum documents standards that are unique to the hydroacoustic instruments used by the Indiana District. It is expected that this addendum will be updated as the use of hydroacoustics increases and as new instruments, software, and firmware are introduced. This addendum is subdivided by instrument category:

1. Acoustic Doppler current profiler (ADCP or ADP)
2. Acoustic Doppler velocity meter (ADV)
3. Index-velocity meter

General

The District Hydroacoustic Specialists are responsible for:

1. Advising the Chief of the Hydrologic Data Section, the District Surface-Water Specialist, and Project Chiefs on all aspects of the use of hydroacoustic current meters.
2. Updating District users of hydroacoustic instruments on new policies and recommended procedures pertaining to the use of those instruments.
3. Updating District users of hydroacoustic instruments on instrument software and hardware upgrades.
4. Updating District hydroacoustic quality-assurance documents.
5. Advising the Chief of the Hydrologic Data Section on personnel training.
6. Helping users of hydroacoustic instruments to troubleshoot malfunctions and take corrective actions.
7. Reviewing data, procedures, methods, and documentation regarding hydroacoustics.
8. Designating specific District personnel as qualified users of hydroacoustic instruments.

Acoustic Doppler Current Profiler

Acoustic Doppler current profilers are used by the Indiana District to make medium- and high-water discharge measurements. The District has three RD Instruments Rio Grande ADCPs (one 1200 kHz and two 600 kHz) and a 5-MHz Sontek RiverSurveyor ADP. All ADCP operators read and become familiar with the information contained in the following policy memorandums and reports:

- Open-File Report 95-701, Quality Assurance Plan for Discharge Measurements Using Broadband Acoustic Doppler Current Profiles, Lipscomb
- Open-File Report 01-01, Discharge Measurements Using a Broad-Band Acoustic Doppler Current Profiler, Simpson
- OSW Technical memorandum 96.02, Interim Policy and Technical Guidance on Broadband ADCPs
- OSW Technical memorandum 2000.03, Software for Computing Streamflow from Acoustic Profiler Data

- OSW Technical memorandum 2000.07, National Coordination and Support for Hydroacoustic Activities
- OWS Technical memorandum 2002.01, Configuration of Acoustic Profilers (RD Instruments) for Measurement of Streamflow
- OSW Technical memorandum 2002.02, Policy and Technical Guidance on Discharge Measurements using Acoustic Doppler Current Profilers
- OSW Technical memorandum 2002.03, Release of WinRiver Software (version 10.03) for Computing Streamflow from Acoustic Profile Data

ADCP Quality-Assurance Folder

An ADCP Quality-Assurance Folder is maintained by the designated District Hydroacoustic Specialist. The folder is placed in the Hydrologic Data Section and contains the following:

1. A list of ADCPs and serial numbers
2. ADCP maintenance logs
3. Current firmware and software for each ADCP
4. A list of trained operators in the Indiana District
5. Quality-assurance logs
6. Archival procedures and examples
7. A processing and reviewing guide

Field Procedures

1. Prior to going into the field, the operators ensure that: the ADCP is in working order with the latest approved firmware; their laptop contains the latest approved software; they have sufficient space on the PCMCIA memory card, CD-R, or Zip disks for temporary backups; and they have a working laser range finder for measuring edge distances.
2. Each day the ADCP is used, a diagnostic test is performed and the results are recorded. The filename of the diagnostic test is included on notes of any measurement made with the ADCP that day.
3. Prior to each measurement, a moving-bottom check is performed by holding the position of the ADCP in the part of the river thought most likely to have the largest sediment load (usually near the zone of largest flow). The moving-bottom check is recorded and archived with the rest of the measurement-data files. The test should last at least 5 minutes. If the position of the ADCP cannot be held precisely, a moving-bottom check of 10 minutes or more might be needed to differentiate actual boat movement from apparent upstream movement caused by a moving-bottom condition.
4. The estimates used for edge distances shall always be measured. Distance may be measured, using a laser range finder, tag line, or rule.
5. When using an RD Instruments Rio Grande with WinRiver software, operators use the Configuration Wizard to set up the measurement. If any settings other than the Configuration Wizard settings are used, the reasons for the user settings are explained on the measurement note sheet.
6. The depth to the transducer below water surface shall always be verified before each measurement.

7. In accordance with OSW requirements, if all of the first four transects are not within 5 percent of the mean, at least four additional transects shall be made. Note: There are exceptions for unsteady flow.
8. After each measurement, or at least once a day, all measurement data and diagnostic tests are backed up temporarily on a removable medium such as a PCMCIA flash card (recommended), CD-R, or Zip disk.

Office Post-Field Procedures

ADCP measurements are processed, archived, and reviewed within 5 working days after returning from the field. Data are archived in accordance with the Hydrologic Data Section Archiving Addendum. An example of data archival for ADCP measurements can be found in the ADCP Quality-Assurance Folder.

The ADCP operator is responsible for archiving all ADCP measurement and diagnostic files, processing all measurements, entering the measurement data into the database, and finding a trained ADCP operator to review each measurement.

The reviewer of an ADCP measurement is responsible for ensuring that correct methods were used to collect and process the measurements, measurement notes are accurate, measurement data have been archived correctly, and that the measurement notes have been filed. If any changes are made during the review process, the changes should be discussed with the original ADCP operator, the database updated, and measurement notes filed.

Acoustic Doppler Velocimeter

Acoustic Doppler velocimeters (ADVs) designed for use with a standard USGS top-setting wading rod are used by the Indiana District to make wading discharge measurements. The make and model ADV used for this application is the SonTek Flowtracker. At the time this addendum was prepared, a draft Office of Surface Water Technical memorandum was under review by the USGS Hydroacoustic Workgroup (HAWG). The following recommendations are taken from the draft memorandum. Note that these are interim guidelines to be followed until the memorandum officially is released.

Field Measurements

1. Prior to use of the Flowtracker, the users familiarize themselves thoroughly with the instrument by reading the Flowtracker Handheld ADV Technical Documentation, including the Introductory Documentation, Operation Manual, and Principles of Operation. Users also familiarize themselves with the Flowtracker handheld controller, including all keypad operations, prior to collecting field data.
2. Prior to and after a field trip, the users perform a full diagnostic test on the ADV, called an ADVCheck, using the manufacturer’s Flowtracker Software. The test procedures are described in the Flowtracker Operations Manual. The software displays signal-strength plots for each ADV receiving transducer. The Flowtracker Operations Manual describes the ADVCheck and provides examples of good and problem signal-strength plots. If signal-strength plots indicate a possible malfunction, the Flowtracker is not used to collect field data. In all instances every diagnostic test is logged to a file. All diagnostic files are archived electronically. In the event of an instrument malfunction, diagnostic files can be provided to the manufacturer for troubleshooting. If a malfunction is suspected or if there has been a shock to the probe (such as striking a hard object), an ADVCheck is performed prior to further collection of field data.

3. Prior to each discharge measurement or velocity-collection run, the user checks the ADV, using the handheld controller Systems Functions Menu. The following items are checked:

   - System clock—the clock displays the correct date/time.
   - Recorder status—there is adequate data-storage capacity for the discharge measurement or velocity data run.
   - Temperature data—the ADV probe is immersed in the stream and the temperature noted. At least once daily, the temperature recorded by the ADV is checked against a temperature reading from an independent source, such as a digital thermometer. It is very important for velocity and discharge accuracy for the ADV to record water temperature accurately. A 5-degree (Celsius) error in temperature would result in a 2-percent error in velocity and discharge measurement. The user ensures that the temperature has stabilized prior to start of data collection. The temperature is noted on the discharge-measurement note sheet.
   - Battery data—the battery voltage is checked to ensure adequate capacity for the discharge measurement or velocity data run.
   - Signal-to-noise ratios—the Flowtracker technical memorandum recommends that SNRs be greater than 10. Analysis of field data indicates that SNRs can be as low as 3 and adequate data still can be collected. However, data collected with SNRs below 10 are scrutinized carefully, using other quality-assurance parameters described in the Measurement Quality-Assurance section of this memorandum. If low SNRs appear to be causing data-quality problems, a different measurement section might be investigated. Backscatter can change with measurement location.

4. If the Flowtracker is being used in water other than fresh water, the salinity at the data-collection location is measured with an approved sensor, and the measured salinity is entered in the handheld controller Setup Parameters Menu. A 12 parts-per-thousand error in salinity can result in a 2-percent error in velocity and discharge measurement.

5. The Flowtracker is designed for mounting on a standard top-setting wading rod. It is recommended that an offset bracket available from the Flowtracker manufacturer be used to mount the Flowtracker probe head to the wading rod. Without the bracket, the Flowtracker sample volume is located about 4 inches from the wading rod. With the bracket, the sample volume is located about 2 inches from the wading rod, closer to the point of depth measurement. The bracket was designed to move the sample volume as close to the wading rod as possible while remaining outside the flow disturbance caused by the wading rod.

6. When mounting the Flowtracker, special care is taken to protect the cable from abrasion. The cable is very prone to environmental noise that can degrade measurement quality.

7. The Flowtracker probe head should be oriented so that the longitudinal axis passing through the center transmitting transducer is parallel to the tagline, and the receiving arm with the red band should be downstream. Effort is made to hold the wading rod level so that the sample volume does not strike a boundary.

8. To avoid striking a boundary, the user should have a sense of where the sample volume is located.

9. All policies and recommendations for making wading discharge measurements with Price-type current meters are followed when using Flowtrackers, with the exception of the minimum recommended velocity thresholds and the application of alternative means of measuring velocities in the vertical (Rantz, 1982, p. 132).

10. The minimum recommended velocity threshold for the Flowtracker is 0.1 ft/s; the instrument velocity error at 0.1 ft/s is approximately 4 percent. If measured velocities are less than 0.1 ft/s, the measurement should not be rated better than "fair."

11. The one-point (0.6 times depths) vertical-velocity method is used for depths equal to or less than 2.5 feet. For depths greater than 2.5 feet, the two-point (0.2 and 0.8 times depth) method is used. If, when using the two-point method, the 0.2 measured velocity is less than the 0.8 velocity, or if the 0.8 velocity is less than half of the 0.2 velocity, the handheld controller screen informs the user, and the user then has the option to measure the velocity at the 0.6 position (three-point method). The user, in this situation, should measure velocity at the 0.6 position.

12. Special care is taken with the Flowtracker to protect the probe head. If the probe receiver arms are bent or the transducers scratched, the unit is no longer usable and needs to be repaired by the manufacturer. The unit always should be transported by securing it in the manufacturer's carrying case to prevent damage. Other maintenance considerations included Operator's Manual also are followed.

13. It is recommended that measurement files recorded on the handheld controller be downloaded at least once a day for backup purposes.

14. Standard USGS measurement notes may be used to document the discharge measurement.

Measurement Documentation

For each measurement run of discharge or velocity, a file with a .WAD extension is generated and stored on the handheld controller. The .WAD file is downloaded from the controller, then the Flowtracker software is used to extract four files from the .WAD file:

.CTL file—an ASCII file containing the Flowtracker configuration.

.DAT file—an ASCII file containing 1-second velocity component and signal-to-noise ratios.

.SUM file—an ASCII file containing station information and summary statistics from each measurement.

.DIS file—an ASCII file containing a discharge-measurement summary.

A paper copy of the .DIS file is printed and attached to the measurement note sheet for filing. All four extracted electronic files plus the .WAD file are archived permanently as specified in the Hydrologic Data Section Surface-Water Electronic Archiving appendix. The .WAD file contains important data that are not extracted with any of the four files and could be valuable for instrument diagnostics in the event of malfunctions.

Measurement Quality Assurance

The following is a list of recommendations for using Flowtracker parameters to help assess the quality of discharge measurements. These parameters are not available with Price-type meters. Guidelines for using the parameters are:

- Velocity standard error—If the average standard error for the measurement exceeds 8 percent of the mean measurement velocity, the measurement should be rated no better than “fair.” If the standard error exceeds 10 percent of the mean measurement velocity, the measurement should be rated no better than “poor.”

- Boundary flag—There are four possible boundary flags assigned to each station: “best,” “good,” “fair,” and “poor.” A boundary flag of “best” does not guarantee a lack of boundary interference (see the Flowtracker Technical Documentation). If the ADV sample volume was striking a solid boundary, a “best” flag likely still would be displayed, but the measured velocity could be biased toward zero.

- Velocity spikes—An excessive number of velocity spikes (more than 10 spikes per measurement) could be cause to downrate the measurement.

- Flow angles—A good measurement section typically shows some flow-angle variations, but with angles less than 20 degrees.

Periodic Quality-Assurance Checks

Each Flowtracker must be checked for discharge-measurement accuracy at least annually and also after any hardware or firmware changes. The check consists of making a discharge measurement at a site where the Flowtracker-measured discharge can be compared with a known discharge derived from some other source. Appropriate sources of comparison discharge would be discharge obtained from a stable discharge rating, or discharge measured with a second Flowtracker or mechanical meter known to meet USGS calibration standards.

Index-Velocity Meter

The Indiana District uses acoustic velocity meters (AVMs) and acoustic Doppler velocity meters (ADVMs) installed at gaging stations to index mean channel velocities for the computation of records of discharge.

Personnel who use index-velocity instruments for the production of discharge records obtain training by attending the Office of Surface Water class “Streamflow Records Computation using Hydroacoustic Current Meters and Index-Velocity Methods” that is offered periodically.

Installation

1. A thorough site reconnaissance is required prior to installation of an index-velocity meter at an existing gaging station or establishment of a new index-velocity-meter station. The site reconnaissance includes channel surveys and the collection of velocity and temperature profiles. The channel bed is characterized for stability. The site hydraulics are analyzed carefully for factors that potentially could cause rating instabilities. Other considerations include protection of the instrument, power/communications cable-length limitations, and adequate power supply. The data collected from the reconnaissance are used to ascertain the success of using an index-velocity meter. For ADVMs, aspect ratios (range/depth) and bridge-pier wake-turbulence zone can be computed to see if the ADVM sample volume will reach a zone of stable velocities. ADVM installation considerations are documented in Morlock, Nguyen, and Ross (2002, p. 8–10).

2. Gage-site-selection criteria documented in Rantz and others (1982, p. 5–9) remain applicable for index-velocity sites.

3. The index-velocity-meter deployment program is recorded and archived. If the index-velocity-meter deployment program can be saved, the deployment program is archived. Some index-velocity-meter programs cannot be saved directly. In these instances, a screen capture of the instrument deployment can be used to save the program parameters. A paper copy of the pertinent parameters is placed in the gage-house folder.

Field Procedures

The following procedures are followed during visits to stations equipped with index-velocity meters:

1. A temperature reading from an independent source, such as a digital thermometer, is taken near the instrument. The temperature is recorded in the field notes along with the time of the reading.

2. For ADVMs, a beam-amplitude diagnostic test is run and logged in a file. All such files are archived according to the Hydrologic Data Section Surface-Water Electronic Archiving appendix. Beam-amplitude checks are an invaluable diagnostic and quality-assurance tool. The beam-amplitude checks must show that the ADVM sample cell is free of obstructions and is sized so that beam amplitudes at the end of the sample cell are a minimum of 5 counts above the instrument noise level. If these criteria are not met, the ADVM sample cell must be adjusted until the requirements are met. All sample-cell changes must be noted on the station log and in field notes and the new instrument deployment saved. If the sample-cell size changes significantly, a new index-velocity rating likely is needed.

3. If the gage does not have data telemetry or if all logged parameters are not transmitted, the data logger data are downloaded for each site visit and the data are input to NWIS at the office.

4. At least once annually, the standard cross section is checked to ensure that the channel geometry has not changed significantly. For channels with known scour or fill potential or for channels with the potential for dredging, the standard cross section may need to be checked more frequently. If possible, discharge measurements can be made at the standard cross-section location. The advantage of this approach is that for every measurement, the standard cross section is checked.

5. The frequency of discharge measurements is dictated by stability of the stage-area and index-velocity ratings and by the range of measurements used to define the ratings. Changes in index-velocity instrumentation or changes to existing instrument program parameters (for example, ADVM sample-cell-size changes) likely necessitate the need for a new index-velocity rating and, hence, more-frequent measurements to establish the new rating. It may be possible to reduce measurement frequency once stable ratings have been established for a wide range of flows. For example, the District maintains several stations on tributaries of Lake Michigan that are subject to rapidly changing bidirectional flow; at these sites, it is possible to measure discharge over a large percentage of the flow range during a single site visit. All sites, however, must be measured at least four times a year.

Data Quality Assurance

All data-quality parameters available are used to assess the quality of the velocity (and stage) record used to generate discharge records. For AVMs, these parameters include percent good signal and speed-of-sound. For ADVMs, these parameters can include cell end, velocity standard deviation, velocity y-component, water temperature, and signal strength (average backscatter amplitude). Unit-value plots are valuable for examining these quality-assurance parameters.

Discharge Computation:

The same general USGS policies and recommendations that apply to stage-discharge methods used to produce discharge records apply to index-velocity methods. Thus, guidelines for the production of streamflow records presented in the section entitled Processing and Analysis of Streamflow Data outlined in the Indiana District Surface Water Quality-Assurance Plan apply to index-velocity methods. Polices and recommendations regarding stage data, such as the editing or deleting of unit values, apply to velocity unit values as well. Likewise, guidelines for records documentation, including the station analysis, daily-values tables, and other supporting materials, are applicable to index-velocity records.