QUALITY ASSURANCE FOR WATER-QUALITY ACTIVITIES OF THE U.S. GEOLOGICAL SURVEY IN MONTANA

By J.R. Knapton and David A. Nimick

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CONVERSION FACTORS, ABBREVIATED WATER-QUALITY UNITS, AND ACRONYMS

Multiply	By	To obtain
cubic foot per second (ft^3/s)	0.028317	cubic meter per second
foot (ft)	0.3048	meter
inch (in.)	25.4	millimeter (mm)
mile (mi)	1.609	kilometer
ton per day (ton/d)	0.0105	kilogram per second

Temperatures in degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) by the equation:

$$°F = 9/5\ (°C) + 32$$

Abbreviated water-quality units used in report:

µS/cm, microsiemens per centimeter at 25 °C
mg/L, milligrams per liter

Acronyms used in report:

ADAPS, Automated Data Processing System
ASTM, American Society for Testing and Materials
GWSI, Ground Water Site Inventory
NASQAN, National Stream Quality Accounting Network
NWQL, National Water Quality Laboratory
WATSTORE, Water Data Storage and Retrieval System

Use of trade names in connection with equipment in this report is for descriptive purposes only and does not constitute endorsement of the product by the U.S. Geological Survey.

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ABSTRACT

This report documents policies and procedures of the Montana District of the U.S. Geological Survey for maintaining quality assurance for water-quality activities. The District operates through offices in Helena, Billings, Kalispell, and Fort Peck and provides information needed to address priority water problems within the State. The District staff contributes specialized knowledge to formulating policies and plans for programs and to establishing criteria for determining the projects to be undertaken.

District water-quality work consists of field, laboratory, and office activities. For field activities, selection of the location of a sampling site is closely coordinated with the study objectives. Also, samples are carefully collected and onsite processing is well documented. For laboratory activities, each office in the Montana District operates two to four mobile laboratories and one support laboratory. The National Water Quality Laboratory and cooperating laboratories provide additional water-quality data; analysis of standard reference water samples and replicate samples are methods used to ensure quality assurance. Office activities related to water-quality assurance consist mostly of station description and analysis, records processing, data storage, analytical-results review, and reports preparation.

Some work is a combination of field, laboratory, and office activities. The District participates in a program designed to monitor and assess the quality of measurements made in the field or laboratory. At least once a year, field and laboratory water-quality activities are evaluated according to standard practices. Training is provided to personnel to ensure proficiency.

INTRODUCTION

Water-resources activities of the U.S. Geological Survey in Montana include, among others, investigations of the quality of surface water, ground water, and atmospheric water. These investigations are conducted to document water-quality conditions and to predict effects that might result from environmental changes. The information is important to Federal, State, and local governments and to others that develop, maintain, and manage the water resources. Only with a viable program of quality assurance can such information be used with confidence.

This report documents the policies and procedures that are used by the Montana District of the U.S. Geological Survey to maintain quality assurance for water-quality activities. Policies and procedures described herein are applicable to all water-quality work conducted in the field, in laboratories, and in offices maintained in the State by the Montana District (fig. 1).

The quality-assurance plan is based on the following principles:

1. District water-quality programs and projects are planned efficiently and effectively to provide information needed to solve local, State, and national water problems.

2. Field, laboratory, and office activities are performed in accordance with specified national Geological Survey policies and procedures, supplemented with District policies and procedures.

3. Field, laboratory, and office activities are performed by qualified and experienced personnel who are appropriately supervised.

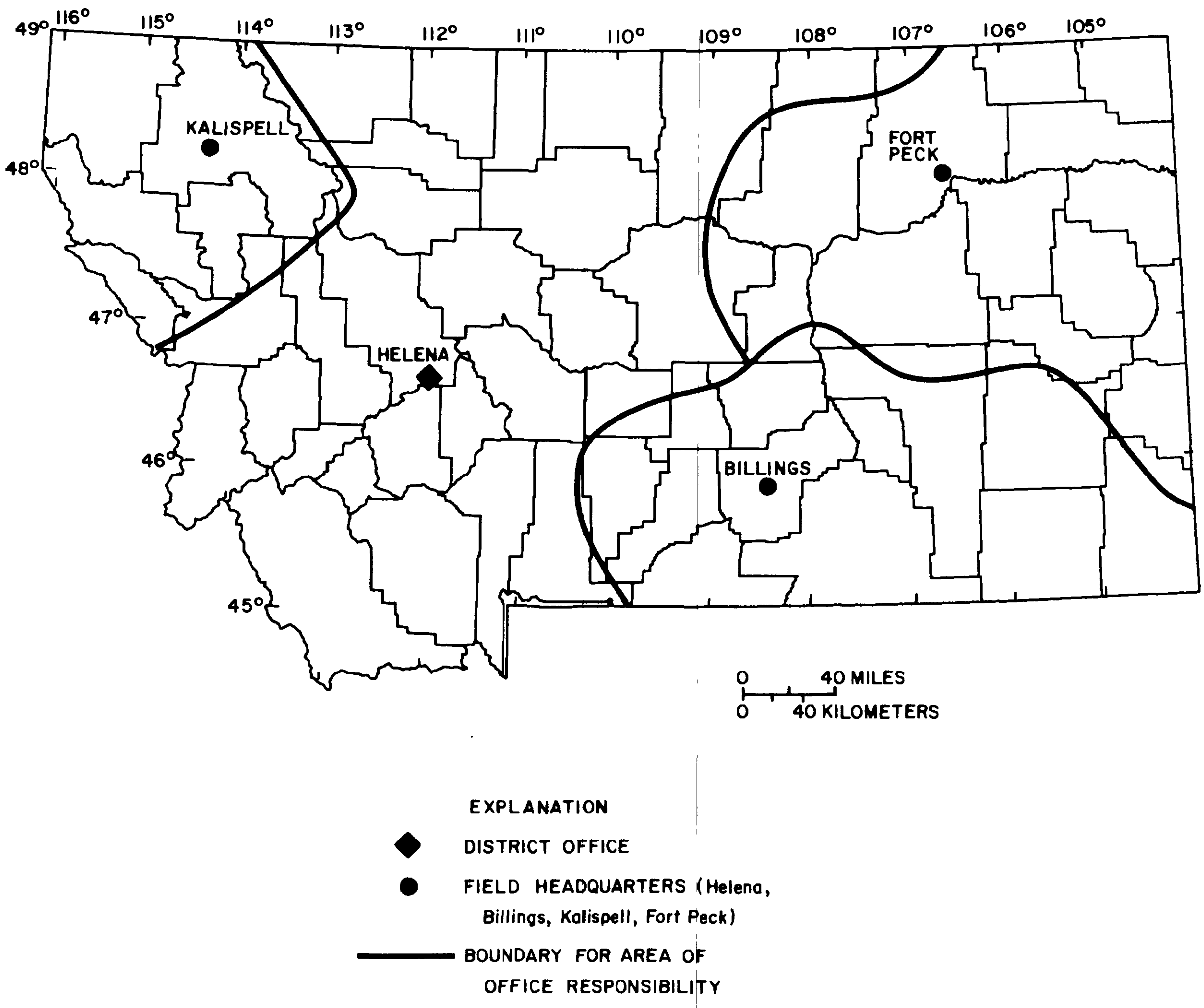

Figure 1.--Location and geographic division of responsibility of offices in the Montana District.

4. All water-quality activities and products receive appropriate and timely review for completeness, reliability, credibility, and conformance to specified standards.

5. Remedial actions are taken to correct any observed or suspected program or project deficiency.

All individuals who either perform or supervise water-quality work are responsible for quality assurance. Ultimately, quality assurance is the responsibility of the District Chief. The positions listed in figure 2 have designated duties in this quality-assurance plan. Periodically, the District Chief circulates a list identifying personnel assigned to these positions.

Recommendations for improving and updating of this plan are the responsibility of all District personnel involved in water-quality work. Modifications are made by the Water-Quality Specialist in consultation with the Chief, Hydrologic Investigations Section and the Chief, Hydrologic Surveillance and Analysis Section. All modifications are submitted to the District Chief for final approval.

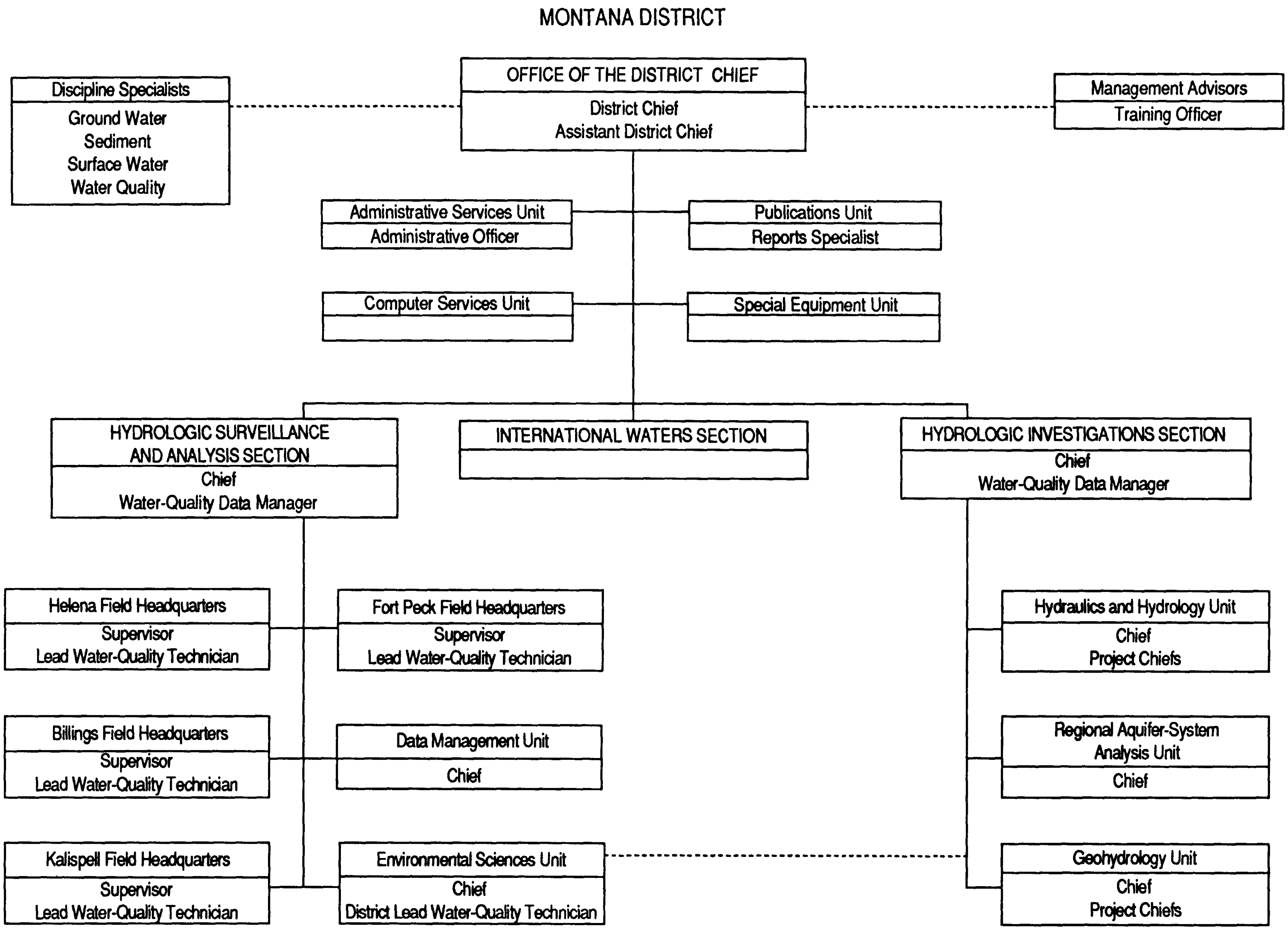

Figure 2.--Organization chart of the Montana District showing positions having designated responsibilities for quality assurance.

QUALITY ASSURANCE

Program and Project Planning

The Montana District conducts its water-quality programs and projects in an orderly and sound manner within the State through offices in Helena, Billings, Kalispell, and Fort Peck. The primary responsibility for ensuring that all water-quality programs and projects in the Montana District are adequately planned rests with the senior staff and the District Water-Quality Specialist, who functions as an advisor to the senior staff. Members of the senior staff are the District Chief, who serves as chairperson; the Assistant District Chief; the Chief, Hydrologic Investigations Section; the Chief, Hydrologic Surveillance and Analysis Section; and the Administrative Officer. Members of the senior staff and the Water-Quality Specialist contribute their specialized knowledge to the formulation of policies and plans for short- and long-term programs and to the establishment and application of criteria for determining the type and scope of projects to be undertaken. They are involved with the following types of program-development and advisory functions:

1. Identifying present and potential major water concerns in Montana.
2. Ascertaining the needs for hydrologic information required to plan, design, and conduct hydrologic studies in Montana.
3. Developing goals for District programs and projects.
4. Developing techniques to effectively propose programs and projects to State and other cooperating agencies.
5. Establishing District policies to ensure overall conformance of program and project proposals to regional and national policies.
6. Evaluating and refining programming goals to ensure continued progress in developing the principles of scientific hydrology.

National program thrusts of priority interest are evaluated annually. The senior staff coordinates program priorities with national priorities to determine project selection and allocation of funds.

The senior staff annually reviews all active programs with cooperating agencies to determine the feasibility of moving personnel and funds to activities of greater national priority. The senior staff also reviews and evaluates all project proposals and maintains for future reference the records of proposals evaluated but not accepted because of priority considerations, shortages of personnel, or lack of funding.

Project Proposal Preparation

A documented proposal is the first stage in the development of a project related to water quality. A project proposal identifies the problems and the need for the study, defines the objectives and scope of the project, and details the approaches to data collection and interpretation that will offer solutions to the problems being studied. The proposal also identifies the number, approximate grades, discipline specialty, availability, and time requirements of full- and part-time personnel as well as time schedules, cost estimates, and report plans. Costs are estimated for salaries, travel, laboratory analyses, equipment, and administrative functions by fiscal year. The purpose of intermediate and final reports and the format and outlet for publication are identified at project conception. Because a project chief may not have been selected at the project-proposal stage of planning, preliminary plans for the project and report generally are formulated by the Chief, Hydrologic Investigations Section, with assistance from the Reports Specialist.

The appropriate discipline specialists and the Chief, Hydrologic Investigations Section review the project proposal. The District Chief gives final District approval.

Work Plan Preparation

After a study proposal related to water quality has been approved, the District Chief, in consultation with other members of the senior staff, selects the project chief and support personnel. The selection is based on the special requirements of the project and the training and experience of the candidates.

The project chief prepares a project description and a work plan that includes a detailed time schedule for each segment of the investigation; both are given to the Chief, Hydrologic Investigations Section. As part of the work plan, the project chief, with advice from the Water-Quality Specialist, designs a data-collection program. Criteria governing the number of sites and the types and frequencies of water-quality measurements depend on the objectives and scope of the project and the quantity and type of available data.

Design of the data-collection program is documented by the project chief and reviewed by the Chief, Hydrologic Investigations Section and the Water-Quality Specialist to ensure that the program is properly designed and that the data can realistically be collected as scheduled. The Chief, Hydrologic Investigations Section, with assistance from the Water-Quality Specialist, reviews the work plan, data-collection activities, and results of the investigation periodically, but no less than quarterly, to ensure that the objectives of the project are being fulfilled. The investigation is adjusted if the reviews indicate deficiencies that could affect the fulfillment of project objectives or the accuracy of the conclusions.

Field-Oriented Activities

Sampling Site Selection

For both surface-water and ground-water studies, the selection of sampling sites is important to the validity of the results. Most sampling sites are selected to provide data that represent conditions in large areas such as major stream basins or regional aquifers. Some sites, however, are selected to provide data for localized conditions such as effects of contamination or contaminant sources. Whatever the reason for sampling, planning of sampling site locations is closely coordinated with the study objectives. After selection of a site, map information including latitude and longitude and section, township, and range is determined. With this information, the site is assigned a permanent station number.

Surface Water

For streams, water-quality stations are located at or near a streamflow-gaging station, if possible, because of the need to relate water quality to discharge (Guy and Norman, 1970, p. 23). Under certain circumstances, a location at or near a gaging station may not be possible. In such instances, a station is located such that stream discharge can be measured and water samples can be collected at all stages of flow to be monitored.

If a sample-collection station is downstream from the confluence of two streams or is downstream from a point source of pollution, collection of a representative sample may be difficult because of inadequate mixing. If the uniformity of water quality in a stream cross section is in doubt, the appropriate number of vertical sections to provide a representative sample in the cross section is determined (Knapton, 1985, p. 3). The determination is made by making onsite measurements (specific conductance, pH, temperature, and dissolved oxygen), collecting suspended-sediment samples at several verticals, and using the information from this cross-sectional "survey" to arrive at the number of vertical sections for the regular sampling program. For some sampling programs, cross-sectional surveys are continued on a routine basis to provide documentation of channel conditions (exhibit A at the back of the report).

Lake and reservoir sampling is based on information needs, but commonly is done in the deepest section. Sounding and bathymetric maps may be needed to determine the proper location. Studies on large lakes or reservoirs often require several sampling locations in the lake (Britton and Greeson, 1988, p. 6).

Ground Water

The selection of wells for ground-water sampling is dependent on many variables such as type of well completion, availability of geological information in drillers' logs, use of water, areal distribution, depth, accessibility, ownership, and sampling purpose(s). The project chief selects sampling locations after consultation with the Water-Quality Specialist and the Ground-Water Specialist. The adequacy of the sampling locations and the sampling program are reviewed periodically, as determined by data needs, by the above designees.

Sample Collection and Processing

Adherence to proper sample-collection and sample-handling procedures is critical in obtaining water-quality information. If the sample is not representative of the system sampled or if the sample has changed in chemical composition between sampling and analysis, all the care taken to accurately analyze the sample in a laboratory is useless. Because several methods are available for different hydrologic conditions, sampling and onsite processing must be well documented (U.S. Department of the Interior, 1977, Chap. 5, p. 5-7).

Surface Water

The number of vertical sections to be sampled at a water-quality station relates primarily to the collection of a representative sample in the cross section and secondarily to the volume of sample required. If a representative sample can be obtained by sampling at one vertical section, then the volume of sample required is collected at one vertical section near the centroid of flow. However, if samples are collected at a single vertical section, the fact that the analytes being sampled are uniformly distributed throughout the cross section must be clearly documented.

Uniform mixing occurs most frequently with dissolved constituents; however, mixing might not be uniform on large streams or streams with tributaries entering short distances upstream from the sampling site. Seldom is the suspended phase mixed uniformly in the cross section (Guy and Norman, 1970, p. 2-3). Representative sampling for suspended sediment, total constituents, or total-recoverable constituents nearly always requires multivertical depth-integrated samples that are collected by the "Equal-Discharge-Increment" (EDI) or the "Equal-Width-Increment" (EWI) method.

A complete description of sampling techniques is given in the District water-quality field manual (Knapton, 1985) and by Edwards and Glysson (1988). Additional information on types of samplers is given in the report by the Federal Inter-Agency Sedimentation Project (1981). The District surface-water-quality field notes form (exhibit B at the back of the report) has provisions for listing the sampling method and type of sampler. This information is recorded during surface-water sampling.

Care is needed to avoid contamination of samples in all phases of sample collection and processing, especially from sampling and filtration equipment and containers that the sample contacts. As part of quality assurance, sampling equipment is thoroughly cleaned prior to use. Instructions for cleaning samplers, filtration equipment, and containers are given by Knapton (1985). The following items require special cleaning:

1. Samplers (various types).
2. Sampler insert containers.
3. Bacteria collection bottles.
4. Churn sample splitter.
5. Filtration apparatus.
6. Assorted glassware and instruments.

The general policy of the Montana District for onsite rinsing of sample bottles prior to filling is "sample bottles used for inorganic substances are rinsed and heat-processed sample bottles used for organic substances are not rinsed." This policy applies to all but special cases, such as bottles for analysis of suspended-sediment concentration, which are not rinsed with sample water. When rinsing, the rinse water is the same type as that being collected for the particular bottle. A sample bottle for filtered water is not rinsed with unfiltered water.

Samples from lakes and reservoirs generally are collected using Kemmerer or Van Dorn type samplers. Water is brought to the surface for processing. Cleaning procedures are similar to those used in streamflow sampling.

Samples are processed onsite according to instructions (Pritt and Jones, 1989, p. 3-3 to 3-6) provided by the Geological Survey's NWQL. The District Environmental Sciences Unit has the responsibility to provide this information to Field Headquarters and to contact the NWQL for answers to questions. The Environmental Sciences Unit also is responsible for explicit sampling instructions for each water-quality station. Unless delays are caused by pending programs, instructions are to reach Field Headquarters 2 to 3 weeks prior to each new water year[1]. For project work, the above tasks are the responsibility of the project chief.

Ground Water

Sampling methods for ground water are diverse because of the variety of conditions that can exist. No single set of guidelines is applicable to all sampling situations. During the planning stages of a project, all aspects of ground-water sampling are considered in the context of the project objectives, the constituents of interest, and the hydrogeologic system. Concentrations of chemical constituents in water samples from wells can be affected by well design, construction materials, purging techniques, sampler design, and sample-handling methods. The effects of any of these variables are difficult to quantify. Furthermore, independent confirmation of the results of ground-water sampling commonly is not practical or even possible. Therefore, much of the quality-assurance effort for ground-water sampling must rely on careful implementation of sound procedures.

Some guidance on basic concepts and methods of ground-water sampling is available in U.S. Geological Survey publications (Wood, 1976; Claassen, 1982). However, results of more recent research, particularly on sample-collection methods for contaminants and trace constituents, have not been incorporated into official Geological Survey policy and are available only in other literature. Many pertinent articles are referenced in an annotated survey by Dumouchelle and others (1990). Because of the limited guidance available, project chiefs must be aware of recently published research and must communicate with their supervisors, with research advisors in the National Research Program, and with water-quality specialists within the Geological Survey concerning sampling methods and quality-assurance procedures appropriate for specific projects.

Primary concerns considered during sampling are that the sample is representative of water in the aquifer, that sampling equipment is clean and chemically

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[1] A water year is the 12-month period October 1 through September 30. It is designated by the calendar year in which it ends.

inert, and that physical and chemical reactions are not permitted to alter sample chemistry. Representative water samples can be collected from properly constructed wells using appropriate purging techniques. Sampling devices and tubing can be constructed of many kinds of materials; however, each material may have the potential to sorb or leach certain constituents, thereby affecting the sample. Physical and chemical reactions can be induced by temperature and pressure changes as the sample is removed from the aquifer and by aeration caused by sampling devices. For instance, carbon dioxide can degas as pressure drops or temperature rises. Loss of carbon dioxide will raise pH, shift the equilibrium concentration of carbonate species, and affect other chemical constituents. Volatile organic compounds can also be lost from the sample by degassing. In addition, precipitation reactions can occur as changes in temperature or pressure cause a sample to become oversaturated with respect to certain minerals. Introduction of oxygen by aeration can change the oxidation-reduction potential of a water sample. An example of the result of aeration is the oxidation of ferrous iron in samples collected from aquifers having reducing conditions. This oxidation reaction and the subsequent loss of dissolved iron by precipitation of iron hydroxide can happen very quickly. Other cations and anions also can be removed from solution by coprecipitation with iron hydroxide.

The following list outlines several general considerations in developing a plan for ground-water sampling and provides specific guidance where District policy exists. Each of these items is discussed in greater detail in one or more of the articles cited by Dumouchelle and others (1990). Other pertinent references also are noted.

Well-construction materials.--Will the casing material cause changes in constituent concentrations by leaching or sorption? Are well-construction materials, such as grout or bentonite, properly isolated from the aquifer? Will the sand pack cause solute retardation before it fully equilibrates with formation water?

Well purging.--Does the water sample represent formation water (Gibs and Imbrigiotta, 1989)? What effect does the pumping rate during purging have on constituent concentrations (Puls and Eychaner, 1990)? What effect does the position of the pump in the water column have on mixing stagnant well-bore water with water coming into the well? Before collecting samples, current practice is to purge wells until three well volumes are removed and until measurements of temperature, pH, specific conductance, and dissolved oxygen have stable values. "Stable" is interpreted to mean less than a 10-percent change after an additional well-bore volume is evacuated.

Type of sampler.--Will a specific type of sampler alter the water sample, particularly by aeration or degassing (Pohlmann and Hess, 1988)?

Sample-collection-equipment materials.--Will the materials of the equipment affect water chemistry? What constituents are likely to be sorbed or leached? Will oxygen diffuse through the hose or otherwise contact the sample?

Discharge rate.--Will a large discharge rate cause water coming through the well screen to cascade down the screen or cause excessive turbulence of the sample inside the pump and hose? Will a pump with a pulsating discharge cause sample turbulence and aeration?

Sampling chamber.--Will an inline sampling chamber be used? Will the flow rate be small enough to prevent streaming effects on the pH probe? Will the pressure in the chamber be comparable to that in the aquifer? Claassen (1982) noted that samples containing constituents sensitive to oxidation-reduction conditions need to be collected in a completely closed system and that dissolved oxygen may need to be determined. Therefore, current practice is to use an inline sampling chamber for collecting all ground-water samples.

Filling sample containers.--Will the container be filled from the bottom? Will the container be rinsed prior to filling or filled to overflowing?

Onsite sample processing.--How will samples be preserved, handled, and transported? How soon will samples be delivered to the laboratory? Will an inline filter be used? What pore size will the filter have? Water to be filtered is delivered directly from the inline sampling chamber to a plate filter by a peristaltic pump. Use of the filter assembly is discussed by Knapton (1985). Filters with a 0.45 micrometer pore size generally are used in the District, but filters with smaller pore sizes may be appropriate in some trace-element studies (Puls and Barcelona, 1989; Kennedy and others, 1974). For samples to be sent to the NWQL for analysis, onsite processing is outlined in the NWQL Services Catalog, which is updated periodically. All project chiefs must be familiar with the Services Catalog. For samples to be sent to the Montana Bureau of Mines and Geology laboratory for analysis, project chiefs need to contact the laboratory for onsite processing procedures. The maximum holding times from date of sampling to date of analysis are contained in the official parameter-code dictionary maintained in the NWQL computer and are summarized by Jones (1987). Other recommendations for holding times have been made by the U.S. Environmental Protection Agency (1986b) and the American Public Health Association and others (1989).

Onsite measurements.--What onsite measurements will be performed? What calibration standards are required, including those for specific-ion electrodes and colorimetric methods? District policy on which onsite measurements will be performed is in exhibit C at the back of the report. Instructions for using pH, specific-conductance, and dissolved-oxygen meters as well as thermometers are given by Wood (1976) and Knapton (1985). Instructions provided by the manufacturer are read and followed for any equipment.

Quality Control (QC) samples.--What QC samples will be collected and at what frequency? Will replicates, spiked samples, blanks, decontamination blanks, and standard reference samples be utilized? Current District policy requires that duplicate samples be collected for each sampling trip, and that a duplicate sample be collected for every 10 samples or fraction thereof. When a cooperating laboratory is used, an additional sample (triplicate) is collected for every 20 samples or fraction thereof so that one sample may be sent to the NWQL.

Decontamination.--What procedures will be followed to clean all sample collection and handling equipment? Cleaning procedures for sample containers and equipment used in sample collection are described by Knapton (1985).

The method of ground-water sampling, as well as additional information, are documented on the District ground-water-quality field notes form (exhibit D at the back of the report). The form has provisions for recording onsite water-quality measurements and other information relating to sampling conditions and the water sample. Project chiefs ensure that sampling instructions are made available to field personnel and that adequate training and instruction have been provided. The Water-Quality Specialist checks the adequacy of onsite water-quality work on a schedule established by the Chief, Hydrologic Investigations Section and the project chief.

Atmospheric Water

Atmospheric water (rain, snow) from selected locations in the District is collected for chemical analysis. The data-collection program, which is part of the Geological Survey's National Trends Network, includes most of the guidelines of the National Atmospheric Deposition Program. Because atmospheric water has small ionic strength, contamination is a major consideration and analytical techniques are much more precise than in most surface- and ground-water programs. For these reasons, quality assurance is a greater part of the total program compared to routine surface- and ground-water monitoring. Instructions for sampling, measurement of onsite values, and quality-assurance practices are included in separate documentation (Bigelow and Dossett, 1988).

The Water-Quality Specialist is responsible for necessary training in all aspects of the National Atmospheric Deposition Program. As part of that training, documentation of quality-assurance practices is given to site observers and others involved with the program.

Contract Sample Collection

Contract observers, who are adequately trained and closely supervised, are used to collect water samples on a daily or less frequent basis. The responsibility for training contract observers and maintaining quality assurance rests with field personnel assigned to the station and ultimately with Field Headquarters supervisors or project chiefs. Explicit instructions are provided to each observer for sampling, care of sample, and completion of forms and tags. Field personnel have a close working relationship with observers and routine visits are made. When data are questionable, telephone calls are made to determine if problems exist. Safety is emphasized in all work performed by the observer.

In the Montana District, contract observers are involved in three programs: (1) daily stream sampling for specific conductance, (2) daily stream sampling for suspended sediment, and (3) continuous atmospheric deposition sampling (described in the previous section, "Atmospheric Water").

Samples intended for daily specific-conductance analysis can be collected with a weighted bottle sampler at a single vertical section, providing that verification indicates complete stream mixing of the dissolved phase. Complete mixing is verified by measuring specific conductance in cross sections of flow seasonally during the first year of station operation. Field personnel collect "check" samples during each visit to the station and compare the value for specific conductance of the check sample to the value from the observer sample. Similar checks are made for temperature and gage height.

Sediment samples collected by contract observers generally are taken from a single, fixed vertical section called the "daily station." However, on some larger streams, observers may sample as many as three vertical sections. Methods of sampling conform to practices described by Guy and Norman (1970). Sampling instructions are provided to all observers. Before being sent to observers, new or modified instructions are approved by the District Sediment Specialist. After approval or modification, the Sediment Specialist files a dated copy of the instructions in the water-quality station history folder. The field technician works closely with the observer, in person and by phone. The field technician is generally aware of stream conditions and is prepared to modify sampling frequencies, when warranted.

If discrepancies are evident in the observer's work, the observer is notified and additional or remedial training is given. If problems persist or if the work becomes unreliable, the contract is terminated.

Safety is of utmost importance in contract sample collection. Equipment is checked during each station visit and precautions are taken to ensure that conditions are safe. Observers are instructed to use common sense and judgment. During unsafe conditions, observers are instructed not to sample.

Laboratory-Oriented Activities

Mobile Laboratories

Field Headquarters and the Hydrologic Investigations Section each operate two to four mobile laboratories. Some of the mobile laboratories are shared between personnel. However, in all instances, one individual oversees the maintenance of one mobile laboratory. This individual, under the supervision of the Field Headquarters supervisor or the project chief, ensures that required modifications are made to the laboratory and that the physical makeup and condition of the laboratory are such that analytical work and sample processing can be performed with ease, efficiency, and accuracy.

The philosophy of the quality-assurance program regarding mobile laboratories is that "mobile laboratories are maintained to a reasonable degree in the same manner, orderliness, and cleanliness as are fixed laboratories." No distinction is made between analytical results from either laboratory; therefore, to assure compatability, all analytical laboratories are maintained in similar conditions.

After field trips, laboratories are readied for new work by cleaning thoroughly; replacing necessary supplies; replacing malfunctioning equipment; and cleaning and replacing glassware, sample bottles, and sampling equipment.

Support Laboratories

Each office in the Montana District maintains a support laboratory. The support laboratory in the District office is called the District water-quality laboratory. Analytical services provided from these support laboratories are described in exhibit C.

Water-quality equipment and supplies are ordered and received by personnel in the District water-quality laboratory in Helena and are distributed on an "as-needed" basis to Field Headquarters support laboratories in Billings, Kalispell, and Fort Peck. In addition, personnel in the District water-quality laboratory provide services for the Helena Field Headquarters and for project work. Proper procurement and management of supplies are critical to the quality assurance of any water-quality program and to the efficient use of funds. The responsibility for procurement, management, and distribution of supplies lies with the District Lead Water-Quality Technician under the direction of the Water-Quality Specialist.

The water-quality determinations and related activities performed in all support laboratories conform to those enumerated in exhibit C and include the following:

1. Capability to measure time-critical water-quality characteristics for which expected changes in concentrations or levels with time are significant in terms of the precision required by the project objectives. These determinations include specific conductance, pH, temperature, barometric pressure, dissolved oxygen, acidity, bicarbonate, carbonate, alkalinity, and indicator bacteria. Even though most of these determinations are made onsite, the capability must be present in the support laboratories. Specific conductance of daily samples collected by contract observers from a network of sites is determined in the District support laboratory.

2. Provisions for cleaning equipment, performing minor repairs, and making distilled or deionized water.

Various sample bottles and sample preservatives are obtained from the NWQL or from the Montana Bureau of Mines and Geology Laboratory for samples submitted to that laboratory. Specific-conductance standard solutions and various types of samplers and sampling equipment are purchased from the Geological Survey's Hydrologic Instrumentation Facility at the Stennis Space Center, Miss. The Geological Survey laboratory in Ocala, Fla., is the source of bacteria supplies, membrane filters, and other assorted items. Additional supplies and equipment are purchased on the open market, generally through chemical supply houses.

Distilled/deionized water made in each support laboratory is tested for contamination on a schedule established by the Water-Quality Specialist. Samples to be analyzed for specific conductance are sent to the District water-quality laboratory for analysis by instruments used in measuring atmospheric deposition. On a less frequent schedule, samples are collected and sent to the NWQL for analysis of selected trace elements. Cleaning of the distillation apparatus or other remedial actions are conducted if analytical results indicate contamination. All analytical results are stored in the District data base named QAFILE.

A list of water-quality supplies used by the District is maintained by the District Lead Water-Quality Technician. As appropriate, the list includes the following information:

1. Supplier and alternate supplier.

2. Instructions for preparation of solutions and bacteria media.

3. Instructions for use.

4. Shelf life and optimum storage conditions.

5. Special safety precautions, applicable shipping regulations, disposal procedures, and antidotes to chemical poisoning. (For chemicals, a "Material Data Safety Sheet," which is required, contains much of the required information on safety.)

All reagents, standards, media, and other chemicals that are untested or that may need to be retested with time are subject to quality control. The quality control may range from acceptance of the labeled supply to a detailed testing program. Chemicals and solutions are discarded after expiration of their shelf life. The following items are subject to quality control:

1. Items for which ordering specifications are sufficient quality control (for example, most supplies from the NWQL).

2. Items for which the documentation of preparation is sufficient quality control (for example, cleaning solutions).

3. Items requiring a one-time acceptance test or standardization (for example, prepared bacteria media).

4. Items requiring periodic restandardization or testing (for example, titrant solutions).

Each support laboratory has the following supplies and capabilities to meet program and project needs:

1. A supply of calibrated field instruments and standards, where applicable, for use in measuring specific conductance, pH, temperature, dissolved oxygen, bicarbonate, carbonate, and alkalinity.

2. A supply of equipment for use in isolation, incubation, and counting of indicator bacteria.

3. A supply of samplers, sample containers, sample splitters, sample shipping containers (coolers), and chemicals approved for sample preservation and analysis. Most supplies and chemicals are distributed initially from the District support laboratory. The District purchases as many of the chemicals and supplies as possible from within the Geological Survey.

4. An inventory of equipment such as sterilizers, refrigerators, incubators, hotplates, laboratory balances, microscopes, filtering equipment, demineralizers, vacuum pumps, glassware, benches, and tables.

The primary responsibility for operation of the District water-quality laboratory lies with personnel in the Environmental Sciences Unit. Most of the duties are performed or overseen by the District Lead Water-Quality Technician under the direction of the Water-Quality Specialist and the Sediment Specialist. Field Headquarters support laboratories are supervised by Field Headquarters supervisors, and most duties are performed or overseen by the respective Field Headquarters Lead Water-Quality Technicians.

Methodology utilized in the support laboratories conforms to that prescribed by various U.S. Geological Survey publications (Britton and Greeson, 1988; Knapton, 1985). The Water-Quality Specialist or that person's designee annually reviews water-quality activities in each support laboratory to ensure that prescribed guidelines are followed. The results of the reviews are documented and remedial actions are taken when warranted.

The District water-quality laboratory includes the District sediment laboratory. The responsibility for operation of the sediment laboratory lies with personnel in the Environmental Sciences Unit. Suspended-sediment samples collected throughout the District are analyzed for sediment concentration. Selected samples also are analyzed for sand-silt (0.0625 mm) particle-size distribution. When complete particle-size distribution is required, samples are prepared and shipped to the Iowa District laboratory in Iowa City, Iowa, for analysis. Routine duties in the sediment laboratory are performed or overseen by the District Lead Water-Quality Technician under the direction of the Sediment Specialist. Laboratory determinations are made according to procedures described by Guy (1969).

Quality Assurance for the National Water Quality Laboratory

The District's quality-assurance program for the NWQL consists primarily of the Branch of Quality Assurance's Blind Sample Program and the systematic review of analytical results (described in the subsequent section, "Analytical Results Review"). Project work and selected work in the data program also utilize a replicate-sample program. On the basis of special needs, some sampling projects may incorporate other quality-assurance procedures. Examples of such procedures include the use of spiked samples and standard reference water samples, which can be supplied by the Branch of Quality Assurance. The quality-assurance procedures used for the data program and for project work are not necessarily the same, owing to differences in the nature of each program.

Blind Sample Program

The Blind Sample Program is conducted by the Geological Survey's Branch of Quality Assurance, which is independent of the NWQL. Standard reference water samples prepared by the Branch of Quality Assurance are submitted to the NWQL through field offices. The Branch then summarizes results of the program monthly in computer files called QADATA.mm/dd/yy and semiannually in written reports. Precision and accuracy data are available for all constituents for which standard reference water samples are available and for different methods which the NWQL might use for a constituent. The Water-Quality Specialist, and others as designated, review the results from the Blind Sample Program and alert District personnel of analytical deficiencies within the NWQL.

Replicate Sampling Program

For sampling activities utilizing the replicate sampling program, 10 percent of all samples collected are duplicates. All bottles containing duplicate samples are labeled with the same station number and date. The samples are distinguished on the NWQL analytical services request form by the sample-medium code. To prevent login errors at the NWQL, original and duplicate samples are sent to the laboratory in separate boxes or additional labeling is used on the bottles to adequately distinguish bottles containing the original sample from bottles containing the duplicate sample. Analysis of duplicate samples provides estimates of analytical precision for each constituent. These estimates can be compared to precision data compiled by the Blind Sample Program.

Replicate sampling for stations operated under the data program is determined on an individual basis by the Water-Quality Specialist. Upon establishment of a station with little or no historical data base, duplicate samples are collected once within the first few sampling trips. Stations operated under the data program generally are scheduled long term (1 year or more of periodic sampling). After about 1 year of station operation, the data probably are sufficient to permit seasonal comparisons for each new sample. Generally, duplicate samples are not collected after the first year of station operation. Where significant water-quality changes are expected, however, replicate sampling is continued with no less than 10 percent of the samples being duplicates. Likewise for synoptic sampling and other special sampling, duplicates form at least 10 percent of the total samples.

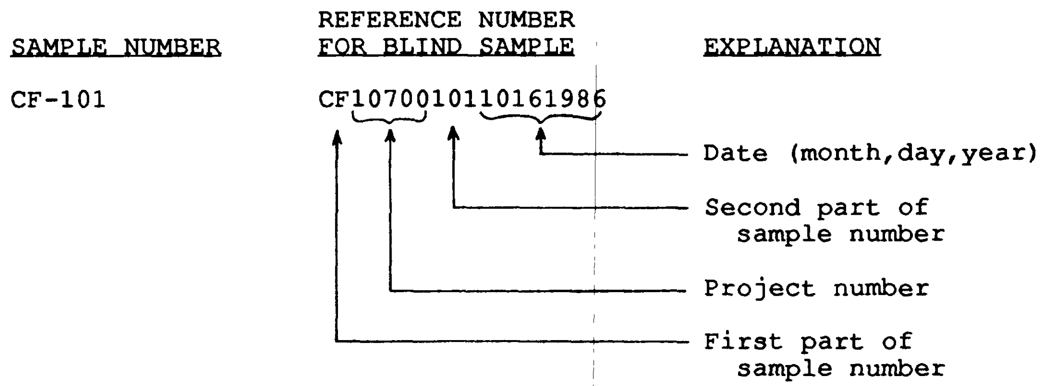
Quality Assurance for Cooperating Laboratories

Guidelines are set forth by the U.S. Geological Survey relating to work and quality assurance for direct-service and contractor laboratories. The responsibility lies with the District for implementing and maintaining appropriate quality-assurance programs. Each program is suited to the types of analyses performed (chemical, physical, biological). The Water-Quality Specialist is responsible for designing quality-assurance programs, with input from the Chief, Hydrologic Investigations Section or the Chief, Hydrologic Surveillance and Analysis Section.

In the past, the laboratory most frequently used by the Montana District outside the NWQL is the one operated by the Montana Bureau of Mines and Geology. Programs of quality assurance for this laboratory include the interlaboratory testing conducted by the Geological Survey Standard Reference-Sample Project and an in-house replicate sample program.

The Standard Reference-Sample Project provides an independent and objective evaluation of the water-quality data from internal U.S. Geological Survey laboratories and about 150 other cooperating laboratories. The Geological Survey directs this program and alerts participating laboratories to deficiencies in analytical operations (Janzer, 1985). The reference samples consist of natural waters that have been preserved by the Quality Assurance Unit of the NWQL according to standard methods and packaged under sterile conditions for shipment. The samples are distributed at regular intervals and analyzed at the cooperating laboratories for major dissolved constituents, nutrients, and trace elements. A statistical evaluation of the data from all the laboratories establishes the most reliable estimate of the true value for each of the constituents determined.

The replicate-sample program specifies that 10 percent of the samples scheduled for analysis at a cooperating laboratory be collected in duplicate. Some water-quality investigations, especially those that collect a small number of samples, may require a larger percentage of duplicate samples. Responsibility for collecting duplicate samples is assigned to field personnel by the Chief, Hydrologic Investigations Section. One duplicate sample is sent as the regular sample; the other is labeled "Blind Sample" and a reference number is entered in the "Comments" section of the laboratory log inventory form. The reference number is determined according to the following diagram:



After laboratory analysis, the results are compared and the cooperating laboratory is alerted to any significant discrepancies. Periodically, triplicate samples are collected, with the third sample being sent to the NWQL; the results indicate how well data from the cooperating laboratory and the NWQL compare. The sampling frequency for triplicate samples is 5 percent.

Instrumentation for Field and Laboratory Activities

Appropriate water-quality instruments are selected in consultation with the District Water-Quality Specialist, who in turn receives guidance from the Regional

Water-Quality Specialist in Lakewood, Colo., and the U.S. Geological Survey's Hydrologic Instrumentation Facility at the Stennis Space Center, Miss. Discussion with other Districts having experience with the same or similar instruments is also helpful. The District Water-Quality Specialist consults with the manufacturer before purchase of any new type of instrument. If specialized instruments are needed, specifications for (a) reliability, (b) precision, (c) accuracy, and (d) ease of calibration, operation, and maintenance are obtained. Friedman and Erdman (1982) describe in detail the quality assurance of instruments and analytical techniques.

Each instrument is inspected and calibrated when it is received from the manufacturer and when it is put into operation after a storage period of more than 2 months. If new instruments are damaged or cannot be properly calibrated, they are returned to the manufacturer. The District Lead Water-Quality Technician maintains records to indicate that the instrument was received and properly calibrated. The District Lead Water-Quality Technician also ensures that each instrument is on the property control list of an individual. The Chief, Hydrologic Investigations Section and the Chief, Hydrologic Surveillance and Analysis Section determine the assignments for property.

Thermometers

Initial checking.--When received from the manufacturer, new thermometers are checked in a constant-temperature water bath at two temperatures (about 0 and 20 °C) using an ASTM-certified thermometer or equivalent. Field-grade thermometers must agree within 0.5 °C and laboratory-grade thermometers must agree within 0.2 °C. Thermometers that fail to meet the quality-control standards are not used.

Calibration.--Each support laboratory has a certified laboratory-grade thermometer that is used only for checking field-grade thermometers. An individual is assigned the duty of checking and record keeping. Personnel routinely working onsite during the year have their thermometers checked semiannually. Personnel seasonally working onsite have their thermometers checked prior to the field season and semiannually until the work is completed. A log book is maintained in each office with individual names and the dates of checks. The Water-Quality Specialist or a designee examines the log annually and also checks the certified laboratory-grade thermometer against another certified laboratory-grade thermometer from the District support laboratory.

Once a thermometer is checked, it is tagged with tape having the date recorded on it. The dates on tagged thermometers are not to be older than 6 months, and non-tagged thermometers are not to be used. This procedure is also applicable to thermometers stored in gage houses and thermometers present with other equipment, such as conductivity meters. Personnel maintain no more than two field-grade thermometers. Laboratory-grade thermometers for onsite use are assigned only to personnel working with temperature recorders or only for special purposes.

Thermometers used by contract observers are examined quarterly by the field personnel who are responsible for the station operation. The liquid column is examined for splits and the temperature is compared between the thermometer of the observer and the thermometer of the field person. If problems are detected, the District Lead Water-Quality Technician is notified and a replacement thermometer is immediately sent to the observer. (For more information, see Stevens and others, 1975; Knapton, 1985.)

Conductivity Meters

Several models of conductivity meters are used in the District to measure specific conductance; they include both portable (battery powered) and laboratory (110-volt, alternating-current powered) models. In addition, specific conductance is measured onsite using multiparameter instruments. Both electrode and cup-type cells are common. Water samples from throughout Montana have had a range in specific conductance from a few microsiemens per centimeter for atmospheric water to tens of thousands of microsiemens per centimeter for some surface and ground water.

Initial checking.--When received from the manufacturer, all conductivity meters are checked against at least three standard solutions throughout a temperature range of 0 to 30 °C. The instruments must measure within 3 percent or 3 µS/cm, whichever is larger, of the standard solution or the instrument is recalibrated. The standards used represent the extremes and mid-range of expected onsite measurement. All conductivity cells purchased independently are checked upon receipt. Any thermometer or thermister supplied with instruments must meet the conditions described in the section "Thermometers."

Calibration.--All conductivity meters are checked for calibration once daily (prior to the first measurement) and at each new site visited during the same day. Two standard solutions are selected that closely bracket the expected measurement(s). If a wide range is expected for multiple samples, more than two standard solutions are used. The meter is recalibrated if the error is greater than the larger of 3 percent or 3 µS/cm. Results of the meter check are recorded in the space provided on each field form used during the day or, for project work, in instrumentation notebooks. Instruments in support laboratories that are used for routine measurement of samples are calibrated similarily, and calibration results are recorded in a laboratory quality-assurance log book.

Conductance standard solutions used in the Montana District have expiration dates; standard solutions are not used after the given date. All thermometers used with conductivity meters are checked routinely according to instructions under the section "Thermometers." (For more information, see Knapton, 1985, p. 41-47.)

Generally, multiparameter conductivity meters and monitors are checked as described above. However, additional manufacturer's instructions are followed when appropriate.

pH Meters

Digital pH meters of several types are used throughout the District. In addition, pH is measured using multiparameter instruments that may have differing or additional instructions. Electrodes cause the most errors in measured pH. Instructions from the manufacturer are followed in the care and use of all electrodes.

Initial checking.--All newly purchased pH meters are checked according to instructions received from the manufacturer. The check requires the use of standard buffer solutions.

Calibration.--Prior to measuring pH at a sampling station, buffer solutions (most likely pH of 7 and 10) that bracket the expected sample value are chosen. Meters then are calibrated to the buffer solutions. When both alkalinity and pH are to be measured on the same sample, the meter is checked with buffer solutions of pH equal to 7, 10, and 4. Each instrument may require a specific procedure for calibration; if so, procedures in the instruction manual are followed. Buffer solutions are prepared before the start of each field trip and are frequently changed during extended trips. Results of the field check are recorded in the space provided on the field sheet or, for some project work, in the instrumentation notebook. (For more information, see Knapton, 1985, p. 47-51.)

Dissolved-Oxygen Meters

The methods used in the Montana District for determination of dissolved oxygen commonly are iodometric and electrometric. The iodometric method (modified Winkler) is a titrimetric procedure that requires no meter. The electrometric method uses a meter with a membrane-type electrode. Electrometric measurements are made using both individual and multiparameter meters.

Initial checking.--All meters and recorders are checked and calibrated according to instructions from the manufacturer.

Calibration.--Air calibration is the usual method of calibration for most field instruments used in the Montana District. Air calibration is accomplished by placing the oxygen probe in water-saturated air inside of an air-calibration chamber. The dissolved-oxygen concentration is based on the solubility of oxygen in water at the prevailing atmospheric pressure, the temperature of the air inside the calibration chamber, and the salinity of the water to be measured. However, with some multiparameter meters, air calibration is not possible and meters are calibrated by comparison with measurements made using the modified Winkler method. Regardless of the method used, instruments are calibrated at each sampling station and periodically throughout the day (or night) if used at one location for extended periods. Prior to each field trip and following electrode membrane changes, the electrode is inserted into an oxygen-free solution of sodium sulfite to ensure calibration at 0.0 mg/L. (For more information, see Knapton, 1985, p. 56-66.)

Bacteria Incubators

Although the precise accuracy of thermometers built into an incubator presently cannot be easily checked, errors of more than 0.5 °C can be detected by enclosing a field-grade thermometer in the unit during operation. The field-grade thermometer is calibrated against the certified thermometer at 35.0 and 44.5 °C. With this method, incubators are checked no less than once every 4 months during routine use. (For more information, see Britton and Greeson, 1988, p. 3-171; Knapton, 1985, p. 66-77.)

Temperature Monitors

Temperature monitors used in the District consist of electronic-mechanical systems attached to automatic digital recording units.

Initial checking.--Upon purchase, receipt after repair, and prior to installation, the systems are attached to automatic digital recording units. The units are calibrated according to instructions given in the manual from the manufacturer.

Calibration.--At each station visit, water temperature is measured with a laboratory-grade thermometer as near to the probe as possible. Calibration is required if the temperature of the recording unit differs from that of the thermometer by more than 0.3 °C. However, if the field person judges that the temperature differs at the probe and at the point of measurement, calibration may be deemed unnecessary. This decision, which requires knowledge of the stream, is documented on the tape leader. If probe simulators are used for calibration, adherence to the above procedures is required. Tape leaders are completed according to standard procedures and tapes are removed at each scheduled visit. (For more information, see Gordon and Katzenbach, 1983.)

Multiparameter Water-Quality Monitors

Most of the quality-assurance requirements for single-parameter measuring instruments are applicable to water-quality monitors. The standard solutions used and the calibration requirements are essentially the same. The U.S. Geological Survey "mini monitor" is the water-quality monitor commonly used by the Montana District. The monitor is leased from the Geological Survey's Hydrologic Instrumentation Facility.

Initial Checking.--Prior to installation of any water-quality monitor, the unit is calibrated in the support laboratory. Standard solutions used in testing have values near the expected values at the monitoring site.

Calibration and Servicing.--After installation, the monitor is calibrated according to the instructions provided in the instrument manual. The frequency of inspections for maintenance and servicing is basically dependent on the characteristics of the water being monitored. Algae growth on the electrodes and sediment coating are the main causes of measurement drift, especially for dissolved oxygen. After initial installation, frequent visitations are made until familiarity is gained and a servicing schedule is established. Local observers may be hired to provide systematic electrode cleaning and to report malfunctions.

An inspection form is completed for each servicing trip. The form documents procedures and values obtained during electrode cleaning and calibration. The form includes the following minimum information:

1. Station number, station location, and name of inspection personnel.
2. Date and time: WT (watch time), CT (clock time), TT (tape time).
3. Parameter values before electrode cleaning.
4. Parameter values after electrode cleaning.
5. Calibration checks using standard procedures.
6. Parameter values after calibration.
7. Remarks pertinent to monitor operation.

Miscellaneous Instruments

Several instruments are used in the District for special types of water-quality work. Multiparameter instruments are used for previously described measurements and, where possible, are maintained and calibrated according to previous instructions. Some pH meters are used with specific-ion electrodes for special projects. Instructions from the manufacturer for maintenance and calibration of the electrodes are followed. The same is true for all other special instruments that have not previously been discussed. These include the following:

1. Multiparameter reservoir-profiling instrument.
2. Transmissometer.
3. Photometer and relative irradiance meter.
4. Automatic water samplers.
5. Digital titrator.
6. Portable spectrophotometer.

Instrument Maintenance

Maintenance of instruments is of foremost importance in quality assurance and in prolonging instrument life. The person to whom a piece of equipment is assigned is responsible for its maintenance. Maintenance includes:

1. Keeping the equipment clean.
2. Making minor adjustments as needed.
3. Changing batteries when necessary.
4. Reporting problems to the District Lead Water-Quality Technician and returning the instrument for repair when it is malfunctioning.

One function of periodic reviews is inspection of the condition of instruments. Responsibility for the reviews rests with the District and Field Headquarters Lead Water-Quality Technicians. These personnel notify supervisors and the District Chief of any improper maintenance of instruments.

Office-Oriented Activities

Quality assurance is as important in office-oriented activities as in other parts of water-quality work. Included in office-oriented activities are station description and analysis, records processing, quality-assurance-data storage, analytical-results review, and reports preparation.

Station Description and Analysis

Surface Water

A station description is prepared for each station sampled on a regular or periodic basis. The station description includes the location, road log, gage reference point, drainage area, hydrologic characteristics, and other pertinent information. This information is provided to personnel in the Data Management Unit, in advance of sampling, for the purpose of assigning a station number and establishing a header file. Data Management personnel ensure that the description is filed in the station history folder. A copy also is retained in the originating office. Field Headquarters supervisors or project chiefs are responsible for providing station descriptions.

Station analyses are completed annually for permanent or periodic stations. Sampling methodology, evaluation of sampling site, sampling conditions, and pertinent remarks are addressed in the analyses (exhibit E at the back of the report). The Field Headquarters supervisors are responsible for ensuring that station analyses are completed and sent to the District Office. The Chief, Environmental Sciences Unit is responsible for review of the station analyses and for filing the station-analysis forms in the water-quality station history folder.

Ground Water

The description of a sampled well or spring is documented by completion of the GWSI Site Schedule (Form 9-1904-A) or Spring Schedule (Form 9-1904-B). As much information as can be obtained is added to the schedule at the time of inventory. Included are site identification, location by latitude and longitude, water level, well-construction information, and aquifer information. For springs, a sketch showing the sampling point also is drawn. Project chiefs are responsible for entering site-schedule and spring-schedule information into the GWSI computer files and for storing the schedules in District files.

Records Processing

Sediment Records

Field Headquarters are responsible for computing the records of daily sediment stations within their area of operation. Records are computed according to instructions described by Porterfield (1972) and instructions from the Sediment Specialist. The records are reviewed by the Sediment Specialist. Specific aspects of this process follow.

Field Headquarters personnel plot the sediment-concentration curves and determine cross-section coefficients for the year from daily suspended-sediment records. Then, the Sediment Specialist provides a preliminary record review. The Field Headquarters personnel address any modifications needed, complete the record computation, and transmit the records to the Sediment Specialist for final review. Any unsatisfactory records are returned to the Field Headquarters for reworking. Records that meet the required standards are submitted to the Water-Quality Data Manager, Hydrologic Surveillance and Analysis Section for entry into District computer files and into the Geological Survey's National Headquarters WATSTORE system.

Analytical results from non-daily sediment stations are submitted to the Sediment Specialist or a designee for review and comparison with other water-quality values from concurrent chemical samples; copies are sent to respective Field Headquarters for inspection. There, sediment data are compared to total and total-recoverable concentrations of trace elements as well as to nutrients, turbidity, and other constituents that might be affected by sediment. Upon completion of review, analytical results are submitted to the Water-Quality Data Manager, Hydrologic Surveillance and Analysis Section for entry into computerized water-quality files. The Sediment Specialist is responsible for the computation of sediment loads after final water discharges are submitted from the Field Headquarters. The Chief, Hydrologic Surveillance and Analysis Section annually establishes deadlines for completion of sediment records and for submittal of final stream-discharge records that are needed to complete the sediment records.

Continuous Monitors

Digital monitor tapes are removed from recorders by Field Headquarters personnel at each scheduled station visit. Tape leaders are completed prior to removal of tapes. After return to the office, the tape is scanned for missing or anomalous punches, and translation information is entered onto the tape leader. Tapes are transmitted to the Chief, Data Management Unit for entry into the District's computer files.

After entry into the computer files, raw data on hard copy or terminal screens are scanned by Field Headquarters personnel for anomalous values, dates, and times. Preliminary updating, if required, is done at this time. Next, personnel activate the ADAPS program, which merges raw data with the rating table for conversion to absolute values. The data, which in most instances includes minimum, maximum, and mean values, as well as all hourly values, are printed on paper copy. All values are inspected and the data are further updated, if required. The record is submitted to the Field Headquarters supervisors or their designees for office review. Once any corrections are incorporated into the record, the paper copy is transmitted to the cooperating agency, if requested. Any records that are transmitted to a cooperating agency at this stage are stamped provisional.

When the records are completed after the end of the water year, paper copies are submitted to the Environmental Sciences Unit for final review. If satisfactory, the record is forwarded to the Chief, Data Management Unit for inclusion in the annual water-data report. Deficient records are returned to Field Headquarters for reworking.

Analytical Data

Entry, storage, and retrieval of water-quality data in the District and WATSTORE computer files are the responsibility of the Water-Quality Data Managers. Weekly execution of the computer program QWLAB (Maddy and others, 1989) results in the NWQL analytical data being entered into the District computer files. From those files, the data are regularly transmitted to the WATSTORE file. Field values and sometimes data from cooperating laboratories are entered into the WATSTORE files from District terminals.

In the Hydrologic Surveillance and Analysis Section, sufficient checks are made by the Water-Quality Data Manager throughout the year and at the end of the year to ensure that onsite and analytical data are accurate in both District and WATSTORE files. Final water-discharge data corresponding to time of collection of water samples are provided by Field Headquarters on a priority basis and updated in the computer files by personnel in the Section. After all data for the water year are updated, data for a complete water year are retrieved from the District computer files for each station. This retrieval is submitted to the Water-Quality Specialist for final review and approval. After approval, data for the water year are ready for inclusion in the annual water-data report.

In the Hydrologic Investigations Section, water-quality data are similarly processed, reviewed, and approved by the designee of the Chief of the section. Working schedules may differ from those of the data program, owing to report deadlines, the period of data collection, and the quantity of water-quality data. Water-quality samples from project work may be analyzed by the Montana Bureau of Mines and Geology Laboratory. If so, the project chief and the Water-Quality Data Manager will ensure that these data, after approval, are entered into the District computer files and WATSTORE files.

Water-quality data to be entered into the Daily Values computer file are first approved by the Chief, Environmental Sciences Unit and then entered into the

District computer files and WATSTORE files by the Chief, Data Management Unit. Water-quality data are retrieved from the District computer files and WATSTORE files and are checked against original records. Retrievals are made prior to publication, or more frequently if problems are suspected.

Quality-Assurance-Data Storage

The Branch of Quality Assurance has developed a system for storing quality-assurance data obtained from field activities. The data are stored in a separate data base named QAFILE. Quality-assurance samples are identified by special medium codes and sample types and can be related to specific environmental samples by using the same station number, date, and time. Parameter and remark codes are available to further identify the type of data stored for each quality-assurance sample. Artificial site identifications are specified by the Water-Quality Specialist to identify certain trip blanks, reference materials, and spiked solutions.

Analytical-Results Review

Water-Quality Data Managers retrieve analytical results from the NWQL weekly by executing the computer program QWLAB (Maddy and others, 1989). The primary print-outs are submitted to the Water-Quality Specialist or the Chief, Hydrologic Investigations Section. The Water-Quality Specialist has the ultimate responsibility for review of all water-quality data from the Hydrologic Surveillance and Analysis Section. The Water-Quality Specialist may delegate review of appropriate analyses to Field Headquarters Lead Water-Quality Technicians, who have a suitable background and have demonstrated competency to perform this duty. The Chief, Hydrologic Investigations Section has the ultimate responsibility for review of all water-quality data collected by the Hydrologic Investigations Section. The Chief may assign this review entirely or in part to the Water-Quality Specialist, unit or project chiefs, or other competent personnel. Onsite analytical results (field forms) are reviewed in the same manner as previously described.

All analytical results (laboratory and field) are reviewed for accuracy and acceptability within 7 working days after receipt by the designated individual, using analytical experience and knowledge of water quality of streams, reservoirs, and aquifers throughout the State and methodology presented in the following reports:

1. Methods for determination of inorganic substances in water and fluvial sediments (Fishman and Friedman, 1989).

2. Methods for the determination of organic substances in water and fluvial sediments (Wershaw and others, 1987).

3. Methods for determination of radioactive substances in water and fluvial sediments (Thatcher and others, 1977).

4. Study and interpretation of the chemical characteristics of natural water (Hem, 1985).

5. Standard methods for the examination of water and wastewater (American Public Health Association and others, 1989).

6. Quality criteria for water (U.S. Environmental Protection Agency, 1986a).

7. Quality assurance practices for the chemical and biological analyses of water and fluvial sediments (Friedman and Erdman, 1982).

The methodology includes but is not limited to the following:

1. Comparison of the sum of cations with the sum of anions (cation-anion balance).

2. Comparison of determined and calculated values for dissolved solids.

3. Comparison of specific conductance with the sum of cations or anions.

4. Comparison of specific conductance with determined and calculated values for dissolved solids.

5. Comparison of specific conductance and values for selected major constituents with expected results from regression curves.

6. Comparison of values for constituents and properties with statistical summaries obtained from previous analyses.

7. Comparison of values for dissolved constituents with values for total-recoverable constituents.

If an error in a laboratory analysis is detected or suspected, the questionable value is noted on the computer copy (primary printout) and a computer message is transmitted to the Quality Assurance Section of the NWQL requesting a rerun. The rerun request is recorded on the primary printout and in the "Rerun Notebook." Once the analysis has been rerun and the results transmitted to the District, the reviewer does one of the following: (1) accept the original value, (2) update the rerun value, or (3) delete both original and rerun values. The decision is noted on the primary printout and the Water-Quality Data Managers are informed. The Water-Quality Data Managers then modify the computer files as needed.

Reviewers of data are responsible for notifying the Water-Quality Specialist of each exceedence of a Maximum Contaminant Level listed in the Primary Drinking-Water Regulations (U.S. Environmental Protection Agency, 1989a). In turn, the Water-Quality Specialist notifies appropriate State and Federal designees. Judgment dictates whether laboratory reruns are made prior to notification of the designees.

All water-quality data from field forms are checked by either the project chief or the Field Headquarters Lead Water-Quality Technicians. The field forms then are transmitted to the Water-Quality Specialist or the Chief, Hydrologic Investigations Section or the appropriate designee for final review. The duplicate copy of the laboratory log inventory form accompanies the field form through review. Questionable values or information from the field is directed to the attention of the field analyst. All data that remain questionable are deleted. After final review, field forms and duplicate laboratory log inventory forms are transmitted to the respective Water-Quality Data Managers. Water-Quality Data Managers are responsible for the final check of the field form, the entry of onsite-parameter values into the District computer files and into WATSTORE, and the entry of sample data into the record book.

Results of specific-conductance measurements in the District support laboratory from daily observer samples are forwarded to the Water-Quality Specialist for review, with copies to the appropriate Field Headquarters. The results are reviewed using knowledge of stream characteristics, past record, and climatic conditions. Copies, with appropriate comments, are returned from the Field Headquarters to the Water-Quality Specialist only when problems are suspected.

Results of suspended-sediment concentrations and size analyses from the District sediment laboratory are reviewed by the Sediment Specialist. The results are reviewed using knowledge of sediment characteristics of streams throughout the State and knowledge of methodology prescribed in sediment reports in the series, "Techniques of Water-Resources Investigations of the United States Geological Survey" (Guy, 1969, 1970; Guy and Norman, 1970). The analytical results are reviewed within a reasonable time and are transmitted by certified mail to the appropriate Field Headquarters for computation of sediment records.

Reports Preparation

Data Reports

Water-quality data from continuing stations monitoring streams, reservoirs, and atmospheric deposition and data from wells and springs are published in the annual water-data report series, "Water Resources Data, Montana" (U.S. Geological Survey, issued annually). However, water-quality data for specific areas may be published in separate data reports if the need arises. The separate reports may include data contained in the annual report and may originate in either the Hydrologic Surveillance and Analysis Section or the Hydrologic Investigations Section.

Data included in the annual report are compiled and submitted for final publication by the Data Management Unit. The Water-Quality Specialist provides advisory assistance in all phases of the work. The annual report is prepared in accordance with instructions issued by the National Headquarters. These instructions are presented in considerable detail to ensure uniformity in format throughout the Geological Survey.

Station manuscripts are prepared and checked by the Water-Quality Data Manager, Hydrologic Surveillance and Analysis Section. Tables are formated by computer programs and merged with the manuscripts and other hydrologic data. Review of the report is provided by the Water-Quality Specialist, with approval from the Chief, Hydrologic Surveillance and Analysis Section. Final review and approval are by the District Chief. Other data reports are processed in much the same manner as the annual report.

Interpretive Reports

District interpretive reports are the basic means of communication between the investigator and the public. Interpretive reports are prepared according to guidelines presented in the following reports:

1. Suggestions to authors of the reports of the United States Geological Survey (Bishop and others, 1978)

2. Water Resources Division publications guide (Alt and Iseri, 1986)

3. Style manual (U.S. Government Printing Office, 1984)

Interpretive reports define the objectives of the study, present theory and methods used in meeting the objectives, interpret the findings, and present conclusions. These reports commonly contain a summary of quality-assurance and quality-control procedures as well as all relevant data. To ensure that District water-quality aspects of interpretive reports meet the project objectives, the Water-Quality Specialist functions as a consultant to the project on water-quality issues. The Water-Quality Specialist advises the Chief, Hydrologic Investigations Section of any problems that arise.

The Reports Specialist provides guidance in ensuring that the report is of acceptable technical and editorial quality and that guidelines for report preparation are followed. These responsibilities include but are not limited to the following:

1. Advises personnel on techniques of report preparation, review, and processing.

2. Assists authors and supervisors in the preparation of manuscripts, including illustrations.

3. Directs work of editorial, typing, and drafting staff in the preparation of manuscripts, including illustrations.

4. Personally reviews and (or) arranges for others to review reports in preparation to ensure adherence to Geological Survey policy and technical adequacy.

5. Coordinates with the Training Officer all training activities related to report preparation, review, and processing.

The Water-Quality Specialist or a designee reviews water-quality sections of interpretive reports; the Ground-Water Specialist and the Surface-Water Specialist also are involved if the report addresses the subjects of ground water or surface water. The author, with advice from the Reports Specialist and, when appropriate, the Water-Quality Specialist, selects at least two colleague reviewers--one of which resides outside the District--for technical review of prepared manuscripts. The reviewer is selected carefully on the basis of discipline specialty.

The author considers and responds to all comments and criticism from each colleague reviewer before the report is reviewed by the section chief, Assistant District Chief, and the District Chief. If no major policy, technical, mechanical, or editorial errors are present, the report is transmitted to the Regional Office and (or) National Headquarters for approval.

National Field Quality-Assurance Project

The Montana District participates in the Geological Survey's "National Field Quality-Assurance Project" in which water samples are periodically sent from the Ocala, Fla., laboratory to analysts in the Montana District for measurement of specific conductance, pH, and alkalinity. This program is designed to monitor and assess the quality of these measurements routinely made within the District.

All District personnel performing field or laboratory water-quality work participate in this program. Participants annually receive a sample set of unknown quality and perform measurements using instruments assigned to them for routine work. Results of the measurements are returned to the Ocala laboratory for compilation. The measurement values are returned to analysts along with a "most probable value" for the sample and a ranking of satisfactory, marginal, or unsatisfactory. Rankings are based on percentage differences from the most probable value.

For those results that are marginal or unsatisfactory, analysts review procedures and check instruments against known standard solutions to determine the reason for unacceptable results. Analysts whose results are unsatisfactory receive a different sample set of unknown quality for a second evaluation. The Water-Quality Specialist maintains a record of each participant's results and is responsible for ensuring that remedial training is provided when warranted.

Periodic Activities Review

For quality assurance in the Hydrologic Surveillance and Analysis Section, the Water-Quality Specialist or a designee visits each Field Headquarters at least once each year. The support laboratory and all mobile laboratories are inspected for safety, orderliness, cleanliness, and equipment maintenance and accuracy. In addition, during the annual visit, provisions are made to accompany at least one individual to the field for evaluation. Field techniques are evaluated according to standard practices. Written documentation and recommendations are submitted to the Field Headquarters supervisor within 2 weeks of the visit, and copies are sent to the District Chief and the Chief, Hydrologic Surveillance and Analysis Section.

Field Headquarters Lead Water-Quality Technicians review annually, or more frequently if necessary, the onsite techniques of personnel involved in the collection of water-quality data. Results of the reviews are documented and submitted to the Field Headquarters supervisors. The need for additional training or remedial action is determined by the supervisors in consultation with the Water-Quality Specialist. Support laboratories and mobile laboratories are inspected no less than monthly. Results of the inspections are communicated verbally to the Field Headquarters supervisors.

Onsite water-quality techniques for project work are reviewed on an individual project basis. During the planning stage of a project, the Chief, Hydrologic Investigations Section, the project chief, and the Water-Quality Specialist develop a plan to review water-quality onsite techniques. The extent of the onsite reviews is determined by the quantity and type of water-quality work to be performed and the experience and background of project personnel. Training may be necessary prior to any onsite work.

Training

The responsibility to ensure that personnel involved in water-quality activities are adequately trained in prescribed practices and procedures is shared by the Training Officer, Water-Quality Specialist, and appropriate Field Headquarters supervisors or project chiefs. The training, which varies according to individual needs, generally consists of a combination of on-the-job training, District seminars or workshops, and courses developed and directed by the Office of Water Quality of the National Headquarters and conducted at the Geological Survey's National Training Center in Lakewood, Colo. On-the-job training usually is directed by Field Headquarters Lead Water-Quality Technicians and Water-Quality specialists in the Hydrologic Investigations Section, with advice from the Water-Quality Specialist.

District seminars or workshops are developed and directed by the Water-Quality Specialist with assistance from the Sediment Specialist and other key water-quality personnel. The seminars or workshops are conducted periodically as the need arises and at the discretion of the District Chief. These training sessions are intended to meet the needs of all personnel involved in water-quality work, as well as selected individuals doing specialized tasks.

The District Chief, with advice from the Training Officer, Water-Quality Specialist, and Field Headquarters supervisors or project chiefs, nominates appropriate personnel for water-quality training at the National Training Center. Nominations are based on specialized needs to fulfill project and program commitments and to foster career development, subject to fiscal and scheduling constraints. All training and training needs are documented in personnel Career-Documentation Profiles.

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SUPPLEMENTAL INFORMATION

Because quality assurance is an important part of every task performed in water-quality work, definition and documentation of all aspects of all tasks are difficult. The publications listed in "References Cited" and the material included in this Supplemental Information section help provide necessary information. Therefore, the use of this quality-assurance plan necessitates that both sections of the report be consulted.

The Water-Quality Specialist maintains a complete file of all supplemental material and loans or provides copies upon request. Each Field Headquarters maintains a file of Montana District Water-Quality Technical Memorandums.

Exhibit A. POLICY--Cross-sectional stream surveys

Cross-sectional stream surveys are conducted during the year at NASQAN and other selected stations according to the guidelines that follow:

1. NASQAN and Benchmark Network sampling instructions indicate the number of times per year that cross-sectional surveys are to be conducted. Several years of surveys have documented channel conditions at most stations and have enabled the number of surveys to decrease compared to previous years. The cross-sectional surveys are made when the variability of chemical or physical properties is thought to be large.

2. The required water-quality measurements for cross-sectional surveys are made at the centroids of increments of equal discharge. A minimum of six increments is used at each site.

3. Graphs of cumulative percentage discharge versus stream width are used to determine the centroids of equal-discharge increments. For streams with unstable channels, discharge may need to be measured prior to sampling to determine centroids of increments. All cross-sectional stationing is from the left bank (looking downstream).

4. The following water-quality measurements are made at the centroid of each increment: water temperature, pH, specific conductance, dissolved oxygen, and suspended-sediment concentration. If measurements are made in place, the mean values for the vertical section are reported. If samples are collected and used for the measurement, they are a composite of the vertical section. Sediment samples are sent to the laboratory for analysis and the values are recorded on the field form by personnel in the Environmental Sciences Unit.

5. A stream discharge, which is required for each increment, is recorded on the field form with the other values for the particular increment.

6. Cross-sectional survey information from the field form is entered into the computer program WATSTORE/NWIS86 water-quality file by the Water-Quality Data Manager, Hydrologic Surveillance and Analysis Section.

At stations where continuous temperature or specific-conductance monitors are operated, cross-sectional surveys of temperature (or specific conductance) are made at least twice during the year. One survey is made during spring runoff and the other during mid- to late summer. Results of all cross-sectional surveys are summarized in the station analysis.

EXHIBIT B. FORM--Surface-Water-Quality Field Notes

U.S. GEOLOGICAL SURVEY, WRD MONTANA DISTRICT SURFACE-WATER-QUALITY FIELD NOTES REVISED 890601

BACTERIOLOGY

Time Collected ______

Time Filtered ______

Sampling Points	Fec Coli Vol	Fec Coli Cnt	Fec Strp Vol	Fec Strp Cnt	Tot Coli Vol	Tot Coli Cnt
Col/100ml Remarks						
Ideal cnt	20-60		20-100		20-80	
Incub. T.	44.5°C		35°C		35°C	
Time (hrs)	20-24		46-50		22-24	

Col/100ml = 100 x Col. Counted / ml of sample filt.

QW MONITOR

Temp	SC	pH	DO
(Stream)			
(Monitor - Before Calib.)			
(Monitor - After Calib.)			

Tape Removed

INSTRUMENT CALIBRATION

Parm	Mtr W#	Std/Mtr	Std/Mtr	Std/Mtr
pH				
SC				
DO			air ☐	Wnk. ☐

DISSOLVED OXYGEN

Bar P = ______ Temp = ______

Sp Cond K = ______ DO Sat = ______

METER: water DO ______ mg/l

MODIFIED WINKLER	1	2
PAO Normality		
Final Buret ml		
Initial Buret ml		
Titrant used (A)		
Sample Vol (B)		
DO mg/L = A x 200/B		

% Sat = (DO) ______ / (DO Sat) x 100 = ______

ALKALINITY

Titrant Normality (N)	
Sample Volume (ml)	
Initial pH (pH units)	
Carbonate e.p. (pH units)	
Titrant used (ml)	
Bicarbonate e.p. (pH units)	
Titrant used (ml)	
Carbonate (mg/L) (00452)	
Bicarbonate (mg/L) (00453)	
Alkalinity, Carbonate (mg/L) (39086)	
Alkalinity, Fixed Endpt. Titrnt. (mg/L) (39036)	

REMARKS: ______

(over)

Station Name ______

Station No. ______ Date ______ Time ______

Collector(s) ______ Project No. ______

FIELD MEASURMENTS

Gage HT	(00065)	______ ft.
Q, Inst	(00061)	______ CFS { Meas. / Rate / other }
Temp, Water	(00010)	______ °C
Temp, Air	(00020)	______ °C
Sp Cond	(00095)	______ µS/cm 25°C
pH	(00400)	______ units
Dis Oxy	(00300)	______ mg/L
Carbonate	(00452)	______ mg/L
Bicarbonate	(00453)	______ mg/L
Alk, Carb	(39086)	______ mg/L
Alk, FET	(39036)	______ mg/L
Fecal Coli	(31625)	______ Col/100 ml
Fecal Strep	(31673)	______ Col/100 ml
Baro Press	(00025)	______ mm Hg

SAMPLES COLLECTED

(Circle) Monthly, Quarterly, Other
High, Medium, Low Flow

Schedules ______, ______
______, ______

Nutrients---------------N ☐ P ☐

Major Ions---------------------- ☐

Trace Elements--Raw ☐ Filt ☐

TOC-- ☐ DOC-- ☐ SOC-- ☐

Pesticide -------- Bed ☐ Water ☐

Other Organic ---- Bed ☐ Water ☐

Radiochemical -------------------- ☐

Sediment - X-Sec ☐ DS ☐ Bed ☐

Bacteria ------------------------ ☐

Other Biologic ------------------ ☐

X-Section Survey (Reverse) ------- ☐

SAMPLING CONDITIONS

SAMPLE LOCATION: (Circle) Wading, Cable, Ice, Boat, Bridge, ______ Feet, Mile, Above, Below, Gage and ______ Pool, Riffle, Open Channel, Braided, Backwater, Sand, Rock, Mud Bottom

SAMPLE METHOD: (Circle) EDI, EWI, Single Vertical, Point, Surface

COLLECTION POINTS: ______, ______, ______, ______,
______, ______, ______, ______,
______, ______, LB= ______, RB= ______,

Width ______

STREAMFLOW (01351): (Circle) Dry, Low, Normal, Above Normal, Flood, Ice Cover ______ %

WEATHER DATA: Weather Code (0041) ______, Cloud Cover (00032) ______ %

Wind Speed MPH (00035) ______

SAMPLER TYPE: Chemical ______ Sediment ______ DO ______ Bed ______

Bacteria ______ (Sterilized ☐) Other ______

EXHIBIT B. FORM--Surface-Water-Quality Field Notes--Continued

WEATHER CODES

0 - CLOUDLESS
1 - PARTLY CLOUDY
2 - CLOUDY
3 - OVERCAST
10 - PRECIPITATION WITHIN SIGHT
13 - UGLY, THREATENING SKY
40 - FOG
50 - DRIZZLE
51 - SLIGHT DRIZZLE, INTERMITTENT
52 - SLIGHT DRIZZLE, CONTINUOUS
53 - MODERATE DRIZZLE, INTERMITTENT
54 - MODERATE DRIZZLE, CONTINUOUS
55 - THICK DRIZZLE, INTERMITTENT
56 - THICK DRIZZLE, CONTINUOUS
57 - DRIZZLE AND FOG
58 - SLIGHT OR MODERATE DRIZZLE AND RAIN
59 - THICK DRIZZLE AND RAIN
60 - RAIN
61 - SLIGHT RAIN, INTERMITTENT
62 - SLIGHT RAIN, CONTINUOUS
63 - MODERATE RAIN, INTERMITTENT
64 - MODERATE RAIN, CONTINUOUS
65 - HEAVY RAIN, INTERMITTENT
66 - HEAVY RAIN, CONTINUOUS
67 - RAIN AND FOG
68 - SLIGHT OR MODERATE MIXED RAIN AND SNOW
69 - HEAVY MIXED RAIN AND SNOW
70 - SNOW OR SLEET
71 - SLIGHT SNOW IN FLAKES, INTERMITTENT
72 - SLIGHT SNOW IN FLAKES, CONTINUOUS
73 - MODERATE SNOW IN FLAKES, INTERMITTENT
74 - MODERATE SNOW IN FLAKES, CONTINUOUS
75 - HEAVY SNOW IN FLAKES, INTERMITTENT
76 - HEAVY SNOW IN FLAKES, CONTINUOUS
77 - SNOW AND FOG
78 - GRANULAR SNOW (FROZEN DRIZZLE)
79 - ICE CRYSTALS
80 - SHOWERS(S)
81 - SLIGHT OR MODERATE RAIN SHOWER(S)
82 - HEAVY RAIN SHOWER(S)
83 - SLIGHT OR MODERATE SNOW SHOWER(S)
84 - HEAVY SNOW SHOWER(S)
85 - SLIGHT OR MODERATE RAIN AND SNOW SHOWER(S)
86 - HEAVY RAIN AND SNOW SHOWER(S)
87 - GRANULAR SNOW SHOWER(S)
88 - SLIGHT OR MODERATE HAIL OR RAIN AND HAIL SHOWER(S)
89 - HEAVY HAIL OR RAIN AND HAIL SHOWER(S)
90 - THUNDERSTORM
93 - SLIGHT THUNDERSTORM WITH RAIN OR SNOW
94 - SLIGHT THUNDERSTORM WITH HAIL
95 - MODERATE THUNDERSTORM WITH RAIN OR SNOW
96 - MODERATE THUNDERSTORM WITH HAIL
97 - HEAVY THUNDERSTORM WITH RAIN OR SNOW
99 - HEAVY THUNDERSTORM WITH HAIL

SAMPLING METHOD

EWI	10
EDI	20
Single Vertical	30
Multiple Verticles	40
Point Sample	50
Grab Sample (dip)	70

Additional remarks:____________________

ALKALINITY

INCREMENTAL TITRATION

pH		TITRANT(ml)	pH		TITRANT(ml)
	/			/	
	/			/	
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X-SECTION

Station									
ft fr LB									
Q, inst.									
Temp.									
Cond.									
DO									
pH									
Sed. Conc.									

Exhibit C. POLICY--Analytical services provided by District laboratories

The following policy is established to clearly define the relations that exist between analytical services provided by the National Water Quality Laboratory (NWQL) and analytical services performed by District operations. The policy is guided by the assumption that each District maintains one or more mobile laboratories and has trained personnel capable of making determinations that cannot be provided in an adequate time frame by the NWQL.

Water-quality determinations performed by the District are restricted to the following:

1. Determinations of time-critical water-quality characteristics for which expected changes in concentration or level with time are significant in terms of the precision required by project objectives. These determinations might include:

   a. Characteristics affected by loss or gain of carbon dioxide, such as pH, alkalinity, and bicarbonate.

   b. Constituents affected by changes in temperature or in oxidation-reduction potential, such as dissolved oxygen, carbon dioxide, and other gases; the ferrous/ferric iron ratio; and sulfide.

   c. Bacteriological analyses and determinations of biochemical oxygen demand.

   Determinations for the first two classes of characteristics usually are made onsite using portable field instruments or kits.

2. Analytical determinations needed for decisions concerning the immediate course of field work. These determinations generally provide less accuracy and precision than the regular laboratory methods and thus are not usually suitable for publication in data reports. A conservative approach is used in deciding which types of determinations fall in this category. In many instances, central laboratories can provide priority processing when large numbers of analytical tests are required. Therefore, the most efficient utilization of human resources, time, and money for performance of such work is used as the basis for deciding whether to use the services of central laboratories or District laboratories.

3. Physical measurements of suspended sediment and bottom materials, primarily concentration and particle-size determinations.

4. Simple determinations, such as specific conductance or chloride, needed in large numbers for use as a basis for selecting samples for further analysis of other constituents.

The NWQL has the capability to determine sediment concentration and size analyses when required in connection with the chemical analysis of sediment samples. Sediment samples are not chemically analyzed in the District.

Typically, a District has the following capabilities and supplies to meet the requirements for water-quality work:

1. A supply of calibrated field instruments with the necessary spare parts for measuring specific conductance, pH, temperature, and dissolved oxygen.

2. Capability for isolation, incubation, and counting of bacterial cultures.

3. Testing kits for rapid, on-the-spot chemical analyses needed to guide the course of onsite work.

4. An appropriate supply of samplers, sample filters, sample containers, sample shipping containers, and chemicals approved for sample preservation or analysis. In many instances, these are supplied by the NWQL to assist in quality control and to provide economies through bulk-lot purchasing.

5. Equipment such as simple colorimeters, ovens, sterilizers, refrigerators, incubators, hot plates, micro and macro laboratory balances, binocular microscopes, filtering apparatuses, demineralizers, vacuum pumps or aspirators, appropriate glassware, and benches and tables. Minimum utilities include hot and cold water, drains, and electricity.

Mobile laboratories operated by Districts are considered to be essential in conducting water-quality work, and usually conform to the limitations described above. The use of sophisticated analytical equipment by a District is permitted only with the approval of the Assistant Chief Hydrologist for Research and Technical Coordination at National Headquarters through the appropriate Regional office.

EXHIBIT D. FORM--Ground-Water-Quality Field Notes

U.S GEOLOGICAL SURVEY WATER-QUALITY WORKSHEET

Sample number____________ Date__________ Time__________

Local Number__________________ Site I.D.____________

Collected by______________________ Acid Lot #________

Analyzing Laboratory: /__/ MBMG /__/ NWQL /__/ __________

****

PARAMETERS

CODE	DESCRIPTION	VALUE
00020	Air Temperature................................	________ °C
00010	Water Temperature..............................	________ °C
00095	Specific Conductance...........................	________ usiemens/cm at 25°C
00400	pH...	________ units
00300	Dissolved Oxygen...............................	________ mg/L
	Sulfide..	________ mg/L S^{2-}
	Iron (ferrous).................................	________ mg/L Fe^{2+}
	Iron (total)...................................	________ mg/L Fe
99900	Nitrate .... Enter into C185 misc. remarks (C196=99900 Hach field NO_3 (0-30) CD reductn)	________ mg/L
00447	Carbonate Concentration........................	________ mg/L $CO_3{}^{2-}$
00450	Bicarbonate Concentration......................	________ mg/L $HCO_3{}^-$
00419	Carbonate Alkalinity...........................	________ mg/L $CaCO_3$
00410	Fixed End Point (pH=4.5) alkalinity............	________ mg/L $CaCO_3$
	Carbonate End Point............................	pH=________
	Bicarbonate End Point..........................	pH=________

PUMPING DATA

Total Well Depth......__________BLSD hold:

Pump Set At...........__________BLSD cut: ________

Pump On...............__________

Pump Off..............__________ M.P. ________

Pumping Period........__________Minutes

Discharge.............__________GPM SWL ________

Static Water Level....__________BLSD

Pumping Water Level...__________BLSD

Drawdown..............__________Feet

COMMENTS

/__/ Field parameters measured through sampling chamber and stable.

/__/ Sample collected through sampling chamber.

/__/ No bubbles /__/ No odor

/__/ Bubbles __________________

/__/ Odor__________________

/__/ Filter Condition__________________

/__/ Water Color__________________

INCREMENTAL TITRATION DATA

Sample Size: /__/ 25 ml, /__/ 50 ml, /__/ 100 ml, /__/ _______ ml

Acid Normality: /__/ 0.1600, /__/ 1.600, /__/ ________

pH	Titrant Divisions		pH	Titrant Divisions

OTHER INFORMATION

Exhibit E. POLICY--Station analyses

Station analyses are required for water-quality stations that are regularly scheduled for measurement and sampling, but not miscellaneous sampling sites. Water-quality activities, with the exception of daily suspended sediment and water-quality monitors, are included on a single, consolidated analysis. Separate station analyses are written for daily suspended sediment and water-quality monitor sites. Station analyses are written by the person(s) assigned to field activities or, for sediment, the person responsible for completion of records. Examples that follow serve as guidelines for completing a station analysis.

WATER-QUALITY MONITOR
(Water Temperature)

Station Analysis, 1988 Water Year

Flathead River at Flathead, B.C.

Station No. 12355000
Record comp. (office): Kalispell

Supervising Office: Helena, Mont.
Cooperator: Mont. Department of Fish, Wildlife and Parks

Equipment.--An Enviro-Labs servo unit IS-102 mounted on a 12-volt digital recorder with a solid-state timer set to punch at 1-hour intervals.

Evaluation of site.--Temperature checks are taken at the probe during low flows and from the shore near the sloping outside gage during high flows. The probe is housed in black plastic pipe from the gage house streamward; the last 20 ft are enclosed in 1-in. galvanized pipe that is attached to the upstream side of the outside gage in fast-moving water. The streambed is clean and consists of large gravel and rock. Excellent mixing at all stages.

Method of record computation.--Daily maximum, minimum, and mean temperatures to the nearest 0.1 °C were obtained using the digital record processed by computer. No corrections were applied during the water year. All values were scanned for accuracy using engineer notes, climatological data, comparison with other stations, and knowledge of the drainage area. A year-end daily values manipulation was used to round 0.1 values to 0.5 values; the rounding was checked and updated prior to publishing.

Evaluation of record.--Record good except for period of no record March 2-8 when the temperature probe was frozen in ice.

Remarks.--Turbulent flow in this section of the river creates excellent mixing. A temperature cross-sectional survey on August 3 showed temperatures to be uniform (11.0 °C) across the channel.

Yearly maximum: 19.0 °C on July 26
Yearly minimum: 0.0 °C on many days November to March.

Prepared by: R.L. Clements
October 25, 1988
Checked by: R.J. Weinberg
November 8, 1988

WATER QUALITY

1987 Water Year

Station I.D.: 06089000
Station Name: Sun River near Vaughn, Mont.
Cooperator: USGS-MRB, NASQAN
Observer: Donna Dahl, R.R. 1146, Great Falls, MT 59401 through July 1987; Janette Palmer, R.R. 1145, Great Falls, MT 59401 from August 1987.
Laboratories: Arvada, Colo. (chemical); Helena, Mont. (specific conductance)

QW Supervising Office: Helena Field Headquarters
Water discharge by: Helena Field Headquarters

Sampling.--USGS technicians collected six NASQAN and three additional chemical-quality samples over a discharge range of 130 to 1,370 ft^3/s. One sample was obtained with a bucket sampler at estimated quarter points from county bridge 1.8 mi downstream from the gaging station. Seven samples were collected using the EWI method and a DH-48 sampler. One sample was collected at estimated quarter points through ice cover 150 ft upstream from the gage using a DH-48 sampler.

The observer collects daily specific-conductance samples with a small bucket sampler from near midpoint from the county bridge. Air and water temperature readings are also made by the observer.

Two cross-sectional surveys were performed this year in which values of specific conductance, pH, water temperature, dissolved oxygen, and suspended-sediment concentration were determined for each EDI quarter point. Both surveys showed only slight differences in all measured parameters for each point, except one survey showed sediment concentrations tended to be larger on the left side of the channel than on the right; sediment concentrations were not determined for individual points of the other survey.

Evaluation of sampling site and conditions.--USGS personnel collect samples in the vicinity of the gage using the EWI or the EDI method and a DH-48 sampler for wading or ice conditions or a D-74 sampler for collecting from the cableway. The observer collects samples for conductivity analysis from the bridge 1.8 mi downstream from the gage.

Muddy Creek enters the Sun River on the left bank 3.7 mi upstream from the station and at times mixing of waters may not be complete. All sampling at the station should be done by either the EWI or EDI method. Water mixing is much more complete downstream at the Manchester Bridge, and samples collected by the observer at a single vertical from the bridge are representative of the cross section.

Remarks.--Daily specific-conductance samples are collected at the bridge rather than at the gage 1.8 mi upstream for two reasons:

1. The observer resides near the bridge site and can easily collect daily specific-conductance samples at the stream's midpoint.

2. Inflow from Muddy Creek, 5.5 mi upstream, is well-mixed with Sun River water at the bridge site, whereas it may not be as well mixed at the gage.

Prepared by: P.L. Karper 12-22-87
Checked by: M.M. Hiner 12-28-87

SEDIMENT

Station Analysis, 1988 Water Year

12334550 Clark Fork at Turah Bridge, near Bonner, Mont.

Record comp. by: Helena
Program: MT-00408

Supervising office: Helena
Cooperators: U.S. Environmental Protection Agency, Montana Power Co. (Jun-Sep)

SAMPLING

Procedure:

Observers--Sampled every other day from October through mid-February, then daily through September. Duplicate pint bottle samples are obtained at a single vertical from the bridge using the depth-integration method. Water temperature and gage height are recorded at each sampling visit.

Starting on June 20, the Montana Power Company (MPC) began sediment monitoring for Phase 2 of the Milltown Dam reconstruction. At that time, the observers became employees of Northern Testing and Engineering (an MPC consultant) for the purpose of collecting chemical samples in addition to sediment. Although still under USGS supervision for sediment operations, salaries were assumed by MPC.

USGS personnel--Sample at a frequency of about every 6 weeks plus during high flows when possible. Samples are depth-integrated and consist of two cross-sectional sample sets bracketed by two sets of duplicate samples from the daily station. At medium and high flows, the EDI method is used from the bridge at centroids of equal discharge increments (not less than four). During low flows, two multi-bottle cross-sectional sample sets are obtained by the EWI method. EDI samples are collected from the upstream side of the bridge. EWI samples are collected by wading about 500 ft upstream of the bridge.

Location of Daily Station: Sampling is done from the bridge at Turah, Mont. The daily station is located on the upstream side of the bridge about 53 ft from the left edge of the water.

Equipment: The observer uses a D-49 sampler suspended by a cable and reel housed inside a small shelter attached to the upstream bridge railing. During cold weather, the observer uses a tubular-insert sampler lowered by hand to the river. USGS personnel use a D-74 or DH-48 sampler. Three sizes of sample nozzles (1/8, 1/4, or 3/8 in.) can be interchanged depending on flow conditions. A wire-weight gage is mounted on the downstream handrail over the main channel of flow near the left bank. A digital and an A-35 analog stage recorder provide a continuous record of streamflow.

Sample Analyses: Observer's and USGS samples were weighed, dewatered, and analyzed for concentration in the District sediment laboratory in Helena. Sand/silt size determinations were made for all USGS cross-sectional samples.

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EVALUATION OF SAMPLING SITE AND SAMPLING CONDITIONS

Moderate quantities of sediment are available from bed and bank materials, agricultural runoff, and tailings deposited along the channel and flood plain. During intense rainstorms, large quantities of sediment can be transported from upstream tailing sources. Rock Creek, which enters the Clark Fork several miles upstream from Turah, generally dilutes the sediment concentration. The Clark Fork at Turah is typically clear to slightly turbid during low flow, although suspended algae and irrigation return flow may cause an increase in turbidity at times. Algal growth along the streambed is minimal at Turah, whereas just upstream from the mouth of Rock Creek, dense mats of algae blanket the streambed in the summer.

Streambed materials consist primarily of sand, gravel, and cobbles. Banks along Interstate Highway 90 have been riprapped and some channelization occurred during highway construction. The stream is primarily riffle, with some scattered shallow to moderately deep pools. Stream widths range from about 100 ft during low flow to about 300 ft at high flow. The Clark Fork bends slightly upstream and downstream from the bridge, but the channel is fairly straight for several hundred feet upstream. A fairly large island lies just upstream from the bridge near the right bank and is inundated only during high flows. Flow distribution at the bridge cross section is very irregular in depth, velocity, and angle of flow. The bridge is skewed to the river, so that flow is not perpendicular over most of the width. Both banks upstream from the bridge are high and probably are not subject to overflow. Downstream from the bridge, both banks are low and may periodically overflow.

RECORD COMPILATION

Stage and Streamflow Record: Continuous stage records were available at this site for the entire year. Daily mean discharges were computed on the basis of Rating No. 2.

Concentration Record and Sediment Load: The observers sampled every second day from Oct. 1 to Feb. 10, then daily from Feb. 11 to Sept. 30. Sediment concentrations for unsampled days were estimated on the basis of adjacent samples, stage pen trace, and weather records. The concentrations are rated poor from Nov. 1 to Jan. 7 when unusually large values were measured during winter low-flow conditions. Part of the problem probably was due to improper use of the winter tubular sampler. Techniques were reviewed with the observer. Thereafter, concentrations decreased to more reasonable values. Concentrations for the rest of the year are rated fair to good, as observer's duplicate-sample results agreed well between each other and with USGS samples when comparison was possible. Owing to a less-than-normal runoff year, no major sediment peaks occurred.

All concentrations (observer's and USGS) were plotted on the A-35 analog stage chart. A continuous concentration curve was drawn on the basis of these plotted points, stage record, notes on river conditions, climatological data, and general knowledge of the Clark Fork's sediment characteristics. Daily mean concentrations were determined graphically from the concentration curve. No concentrations were adjusted by coefficients. No days qualified for subdivision. Daily mean concentrations were listed, verified, and entered into storage using WATSTORE Program 475, which merges the data with streamflow to generate a table of daily suspended-sediment discharges for the year.

Daily mean suspended-sediment concentrations ranged from 3 mg/L on several days from June through September to 93 mg/L on Apr. 18. Daily sediment discharges ranged from 2.0 ton/d on Sept. 9 to 445 ton/d on May 14.

Sediment-Discharge Measurements and Coefficients: Ten cross-sectional suspended-sediment-discharge measurements made this year ranged from 4.8 ton/d on Aug. 3 to 442 ton/d on June 1.

Coefficients computed for cross-sectional samples ranged from 0.94 to 1.06, with the exception of samples having very small concentrations to which coefficients are not considered applicable. Because all comparison samples were within 10 percent of cross-sectional values and no trends were evident, coefficients were not applied.

Size Analysis: Ten sand/silt size breaks were analyzed this year from cross-sectional samples. No samples had sufficient sediment for complete-size analyses. Material finer than 0.062 mm comprised from 43 to 83 percent of the suspended sediment. Surface-water discharges during collection of cross-sectional samples ranged from 296 ft^3/s on Aug. 3 to 2,640 ft^3/s on June 1.

Load Routing: Sediment loads were calculated for the Clark Fork at Deer Lodge, about 90 river miles upstream, and compared with loads at this station. Monthly loads at Deer Lodge compared to loads at Turah and ranged from 6 percent in June to 85 percent in November. Sediment patterns were generally similar for the two sites. During fall and winter base-flow periods, daily sediment loads at Deer Lodge are about 50-80 percent of the load at Turah because contributions from tributaries in the intervening reach are minor. During the spring and early summer runoff periods, the load passing Deer Lodge represents only 10-30 percent of the load at Turah, owing to increased sediment inflow from tributaries downstream of Deer Lodge. Loads at Deer Lodge during late summer base flows are also a small percentage of the load at Turah as a result of irrigation withdrawals in the upper Deer Lodge Valley.

The annual sediment peaks at both sites occurred during different runoff events, with the peaks being very minor and attenuated by distance and tributary inflow. Both peaks were due primarily to snowmelt runoff. The annual sediment discharge peak at Deer Lodge occurred on Apr. 19 (93 ton/d) during a period of rainfall and snowmelt. The sediment-discharge peak at Turah, which was largely composed of discharge from Rock Creek, occurred on May 14 (445 ton/d). The annual instantaneous peak concentration at Deer Lodge occurred on Apr. 19 (158 mg/L) and at Turah occurred on Apr. 18 (98 mg/L).

Remarks: Records are rated good, except for the period Nov. 1-Jan. 7, which is rated poor. Observer's sampling was good throughout the year, except for 2 months during use of a cold-weather sampler. No major hydrologic events occurred during the year. Consequently, magnitudes of instantaneous peaks and daily mean loads are considered to be reasonably accurate.

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