Quality-Assurance Plan for Water-Quality Activities in the USGS Ohio Water Science Center

By Donna S. Francy and Kimberly H. Shaffer

Open-File Report 2008–1250

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

U.S. Department of the Interior
DIRK KEMPTHORNE, Secretary

U.S. Geological Survey
Mark D. Myers, Director

U.S. Geological Survey, Reston, Virginia 2008

For product and ordering information:
World Wide Web: http://www.usgs.gov/pubprod
Telephone: 1-888-ASK-USGS

For more information on the USGS—the Federal source for science about the Earth,
its natural and living resources, natural hazards, and the environment:
World Wide Web: http://www.usgs.gov
Telephone: 1-888-ASK-USGS

Suggested citation:
Francy, D.S., and Shaffer, K.H., 2008, Quality-assurance plan for water-quality activities in the USGS Ohio Water Science Center: U.S. Geological Survey Open-File Report 2008–1250, 73 p.

Contents

Figures

Tables

Conversion Factors

Multiply	By	To obtain
millimeter (mm)	0.03937	inch (in.)
liter (L)	0.2642	gallon (gal)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

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

$$°F=(1.8\times°C)+32$$

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L), micrograms per liter (µg/L), or parts per billion (ppb).

Quality-Assurance Plan for Water-Quality Activities in the USGS Ohio Water Science Center

By Donna S. Francy and Kimberly H. Shaffer

Abstract

In accordance with guidelines set forth by the Office of Water Quality in the Water Resources Discipline of the U.S. Geological Survey, a quality-assurance plan has been written for use by the Ohio Water Science Center in conducting water-quality activities. This quality-assurance plan documents the standards, policies, and procedures used by the Ohio Water Science Center for activities related to the collection, processing, storage, analysis, and publication of water-quality data. The policies and procedures documented in this quality-assurance plan for water-quality activities are meant to complement the Ohio Water Science Center quality-assurance plans for water-quality monitors, the microbiology laboratory, and surface-water and ground-water activities.

1.0 Introduction

The U.S. Geological Survey (USGS) was established by an act of Congress on March 3, 1879, to provide a permanent Federal agency to perform the systematic and scientific "classification of the public lands, and examination of the geologic structure, mineral resources, and products of the national domain." The Water Resources Discipline (WRD) of the USGS is the Nation's principal water-resources information agency. The overall mission of the WRD is to collect and provide unbiased, scientifically based information that describes the quantity and quality of waters in the Nation's streams, lakes, reservoirs, and aquifers. Water-quality activities in the Ohio Water Science Center (OWSC) are part of the WRD's overall mission of appraising the Nation's water resources.

To address quality-assurance and quality-control issues that are related to water-quality activities, the WRD has implemented policies and procedures designed to ensure that all scientific work conducted by or for the WRD is consistent and of documented quality. The Office of Water Quality (OWQ) is responsible for the policies, procedures, and protocols that apply to the water-quality activities in each Water Science Center (WSC) in the WRD.

This quality-assurance plan describes the management policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation procedures for ensuring quality in the OWSC water-quality program. Quality assurance, quality control, and quality assessment are all components of a quality assurance plan. The terms are defined as follows:

Quality assurance (QA)—The systematic management of data-collection systems by using prescribed guidelines and criteria for implementing technically approved methods and policies. Quality assurance incorporates a comprehensive plan that outlines the overall process for providing a product or service that will satisfy the given requirements for quality.

Quality control (QC)—The specific operational techniques and activities used to obtain the required quality of data. Quality control consists of the application of technical procedures to achieve prescribed standards of performance and to document the quality of collected data. Quality-control data that do not meet required standards are used to evaluate and implement corrective actions necessary to improve performance to acceptable levels.

Quality assessment—The overall process of assessing the quality of environmental data by reviewing (1) the appropriate implementation of QA policies and procedures and (2) analyzing the QC data. Quality assessment encompasses both the measurable and unmeasurable factors that affect the quality of environmental data. Assessment of these factors may indicate limitations that (1) require modifications to protocols or standard operating procedures for sample collection and analysis, or (2) affect the desired interpretation and use of the environmental data.

Quality-assurance, quality-control, and quality-assessment systems complement each other to provide a comprehensive QA program that ensures that quality objectives are identified and integrated into all levels of water-quality activities. By integrating these components into a disciplinewide QA guidance document, the OWQ is enhancing water-quality data collected by the USGS by providing the following:

- **consistency** in data quality across all levels of the WRD;
- **accountability** to clients, the scientific community, regulatory agencies, and the general public;
- **comparability** of results among samples, sites, and laboratories;
- **traceability** from the end product back to its origins, and to all supplementary information, through written records;
- **application** of appropriate and documented techniques that lead to similar results time and again;
- **representativeness** of the data in describing the actual chemical composition of the biological or physical conditions at a sampling site for a given point or period in time; and
- **adequacy** of the amount of data obtained to meet data objectives.

1.1 Purpose and Scope

The purpose of this QA plan for water-quality activities is to document the standards, policies, and procedures used by the OWSC for activities related to the collection, processing, storage, analysis, and publication of water-quality data. This plan identifies responsibilities for ensuring that stated policies and procedures are carried out. The plan also serves as a guide for all OWSC personnel who are involved in water-quality activities and as a resource for identifying memorandums, publications, and other literature that describe associated techniques and requirements in more detail. This QA plan supersedes Francy and others (1998).

The scope of this QA plan includes discussions of the policies and procedures in the OWSC followed by procedures for the collection, processing, analysis, storage, and publication of water-quality data. Although procedures and products of data-collection and interpretive investigations are subject to the criteria discussed in this plan, most water-quality projects are required to have separate and complete QA plans or workplans. The policies and procedures documented in this QA plan for water-quality activities are intended to complement QA plans for water-quality monitors and the microbiology laboratory and for surface-water and ground-water activities.

2.0 Organization and Responsibilities

Quality assurance is an active process of achieving and maintaining high-quality standards for water-quality data. Consistent quality requires specific actions that are carried out systematically in accordance with established policies and procedures. Errors and deficiencies can result when individuals fail to carry out their responsibilities. Clear and specific statements of responsibilities promote an understanding of each person's duties in the overall process of ensuring the quality of water-quality data.

2.1 Organizational Chart

The OWSC's organizational structure is shown in the organizational chart (fig. 2.1). Discipline specialists (ground water, surface water, and water quality), the National Water Quality Assessment Program (NAWQA) Transport of Anthropogenic and Natural Contaminants to Supply Wells (TANC) coordinator, special support (library and building services), and the Supervisor for Administrative Services report directly to the Center Director. There are four investigation units, each with a Investigation Supervisor reporting to the Center Director and team members—Ecological Investigations, Geohydrological Investigations, Hydrologic and Hydraulic Investigations, and Hydrologic Networks and Data Investigations (Columbus and New Philadelphia offices).

2.2 Responsibilities

The final responsibility for the preparation and implementation of and adherence to the QA policies that are described in this QA plan lies with the OWSC Director (Schroder and Shampine, 1992, p. 7; Brunett and others, 1997). The following is a list of responsibilities for selected OWSC personnel who are involved in the oversight, collection, processing, storage, analysis, and publication of water-quality data.

<u>The Center Director</u> and designated management personnel are responsible for ensuring the technical quality of all OWSC programs and products. Specific duties include the following:

1. Managing and directing the OWSC program, including designation of personnel responsible for managing all water-quality activities.
2. Ensuring that water-quality activities in the WSC meet the needs of the Federal government, the OWSC, cooperating State and local agencies, and the general public.
3. Ensuring that all aspects of this QA plan are understood and followed by OWSC personnel. This is accomplished by direct involvement of the OWSC Director or through clearly stated delegation of this responsibility to other personnel in the OWSC.
4. Providing final resolution, in consultation with the OWSC Water-Quality Specialist, of any conflicts or disputes related to water-quality activities within the OWSC.
5. Ensuring the completion of technical reviews of all water-quality programs.
6. Ensuring that all publications and other technical communications released by OWSC personnel are accurate and comply with USGS policy.

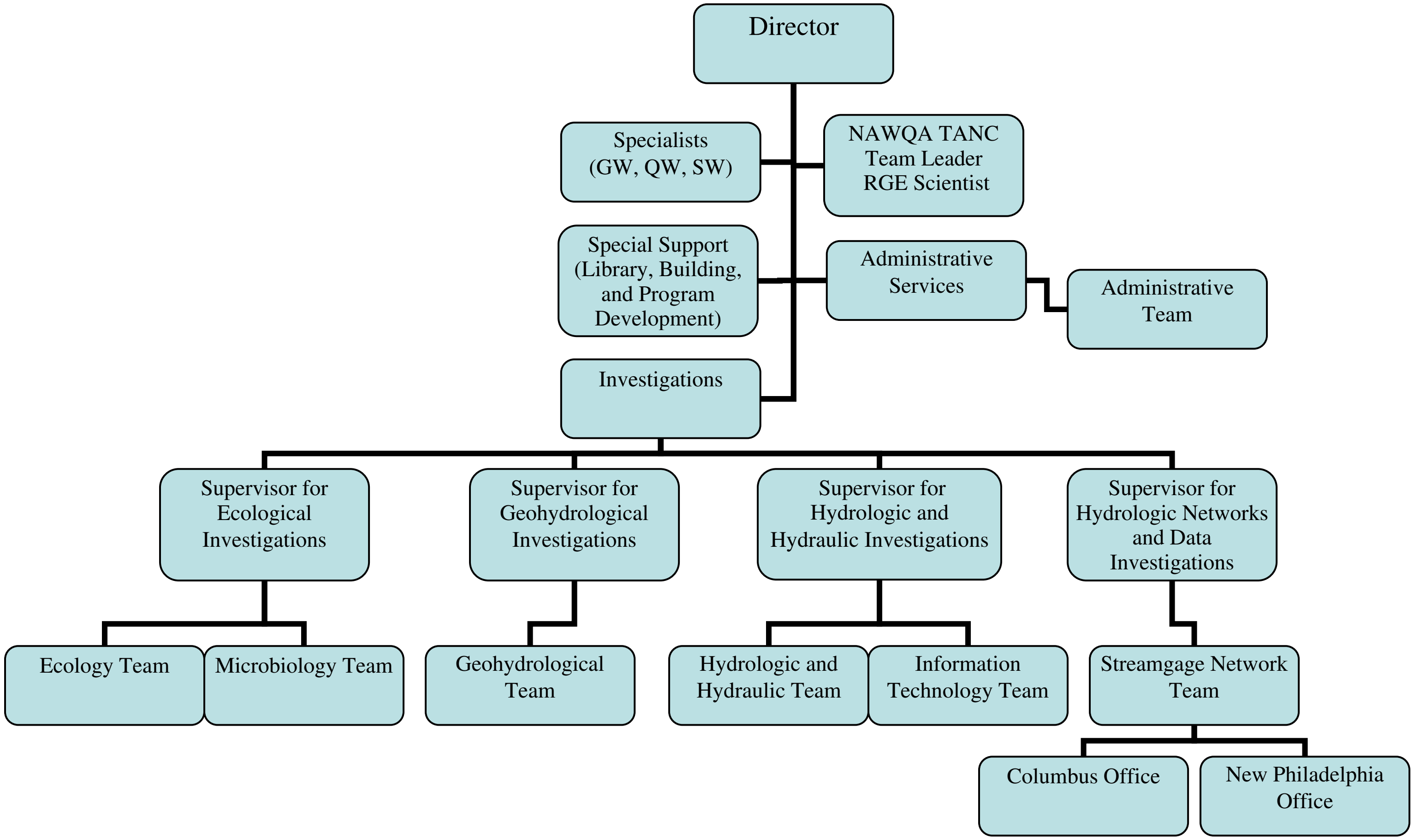

Figure 2.1 Ohio Water Science Center organizational chart (February 2008).

The OWSC Water-Quality Specialist (QW Specialist) is responsible for writing QA/QC polices and providing oversight and assistance on project QA/QC activities. Specific duties include the following:

1. Providing consultation, reviews, and assistance on water-quality issues to project leaders, when needed.
2. Ensuring that all aspects of this QA plan are understood by OWSC personnel involved in water-quality studies.
3. Keeping OWSC personnel briefed on procedural and technical communications from regional and Headquarters offices, including OWQ, Branch of Quality Assurance (BQS), and NWQL.
4. Preparing and implementing the OWSC water-quality QA plan and ensuring that it is reviewed and revised every 3–5 years to document current responsibilities, methods, and ongoing procedural improvements.
5. Assisting the OWSC Director, project chiefs, and team leaders to ensure that water-quality activities in the OWSC meet the needs of the Federal government, the OWSC, cooperating State and local agencies, and the general public.
6. Participating in technical reviews of all OWSC water-quality programs.
7. Assisting the OWSC Director to ensure that all publications and other technical communications released by the OWSC that relate to and include water-quality information are accurate and comply with USGS policy.
8. Overseeing and organizing water-quality reviews by Headquarters and the Region.
9. Assisting project personnel in the approval of analytical laboratories (except the NWQL) used for OWSC projects and in reviewing semiannual Standard Reference Sample program samples operated by BQS.
10. Assisting project personnel to ensure the quality and accuracy of all project water-quality data.
11. Overseeing the OWSC staff participation in the National Field Quality Assurance (NFQA) program.
12. Providing training on water-quality issues, as needed.
13. Maintaining copies of the references included in the QA Plan, updating the references, and providing them to OWSC managers and staff.

The Water-Quality Database Manager (QW Database Manager) provides support to the QW Specialist in maintaining the water-quality database. Specific duties include the following:

1. Oversight and maintenance of the OWSC water-quality database, including data entry and printing of weekly Watlists (see Appendix A for the routine QW management process), and entry of batch files from the QW data transfer system (QWDX; see *http://qwdx.cr.usgs.gov*).
2. Keeping OWSC personnel updated on procedural and technical communications on database issues and providing training, as needed.
3. Maintaining updated parameter-code lists and other database lists for use by project personnel.
4. Assisting project personnel and the QW Specialist to ensure quality and accuracy of all data in the database.

The Field Service Unit Coordinator provides support to the QW Specialist in maintaining supplies and equipment. Specific duties include the following:

1. Maintaining a supply of reagents, bottles, and other supplies needed for routine water-quality sampling, and ensuring that such supplies are in compliance with USGS protocols.
2. Assisting the QW Specialist in implementation of the NFQA program.
3. Assisting project personnel in the purchase of water-quality equipment, as needed.

The Project Chief is responsible for ensuring that QA/QC procedures are implemented by the project team. Specific duties include the following:

1. Managing and directing the project's field and laboratory (if applicable) water-quality activities.
2. Writing and implementing a project workplan or QA/QC plan.
3. Ensuring that the project's water-quality activities meet the needs of the Federal government, the OWSC, cooperating State and local agencies, and the general public.
4. Ensuring that all aspects of this QA plan that pertain to the project's field and laboratory water-quality activities are understood and followed by project personnel.
5. Obtaining guidance, as appropriate, for project QA/ QC activities from the QW Specialist.
6. Ensuring that QA/QC activities are properly carried out by the project staff.
7. Ensuring the quality and accuracy of all project water-quality data.

2.3 References Used for the Organization and Responsibilities Section

The following table lists reports referred to in this section. For a complete citation, refer to Section 13.0 of the report. Copies of these references are available by contacting the QW Specialist.

Table 2.3. Summary of references for organization and responsibilities related to quality assurance.

Reference	Subject
Brunett and others, 1997	QA/QC procedures for district ground-water activities
Schroder and Shampine, 1992	Guidelines for preparing a quality-assurance plan.

3.0 Program and Project Planning

The OWSC Director has primary responsibility for overall OWSC program planning and is responsible for ensuring that OWSC projects are supportive of OWSC and national priorities. The OWSC Director receives aid and advice from the Regional office, the OWSC technical specialists, and project chiefs about the technical accuracy of water-quality data collection and analyses and conformance with OWSC, Regional, and national policies. All water-quality projects require review and approval prior to the commencement of work. Quality-assurance requirements should be integrated into the project proposal. Whether or not a separate QA plan will be required for a water-quality project will depend on the complexity of the work, the needs of the OWSC or the cooperator, or other criteria as described in Shampine and others (1992).

3.1 Project Proposals

Project proposals are developed at the local level in response to requests by cooperating agencies, needs recognized by the WRD in working closely with other agencies, or national programs. OWSC proposals conform to standard USGS format as described in Northeastern Region Policy Memorandums 2006−01 and 2004−01 (accessed June 2008 at *http://water.usgs.gov/usgs/orh/nrwww/prog-dev/proposals.html*), both titled, "Requirements for Submittal and Approval of Project Proposals."

Each proposal must (l) state the problem or need for the study, (2) define objectives—what will be done to help solve the problem, (3) describe the relevance and benefits—why should USGS conduct the study and how will the work support the goals of WRD, and (4) define the approach—how work will be done to accomplish the objectives. For relevance and benefits, refer to USGS goals as expressed in the USGS Science Strategy (accessed June 2008, at *http://www.usgs.gov/science_strategy/*), USGS Federal-State Cooperative Program Priorities (accessed June 2008 at *http://water.usgs.gov/admin/memo/policy/wrdpolicy99.30.html*), or WRD Policy on avoiding competition within the private sector (accessed June 2008 at *http://water.usgs.gov/admin/memo/policy/wrdpolicy04.01.html*). The approach consists of a detailed outline of data-collection activities to be carried out (if new data are needed), the QA plan, the QC information needed, and the analytical techniques to be used. Project report plans, cost estimates, time schedules, and personnel requirements also are addressed. Consultation with regional and discipline specialists is encouraged in the preparation of proposals and in the execution of projects.

The number and types of QC samples are established during the proposal- development phase in consultation with the QW Specialist. Careful examination of the following questions will help evaluate QC sample needs:

1. Why are the data being collected and how will the data be used?
2. What level of potential contamination from sampling and analytical procedures will be assessed by use of blanks?
3. How will the data on replicate samples be used to establish acceptable limits of variability?
4. How will the data from standard reference samples and spike samples be used to assess acceptable levels of bias for each analyte?
5. How will the types of QC samples be distributed during phases of the project?
6. What other variables in the project (such as flow, season, etc.) will affect the distribution of QC samples?

Review of project proposals is given high priority. In particular, the design of the data-collection approach is reviewed to ensure that it is neither overdesigned nor underdesigned and that it is adequate to fulfill the objectives of the project. Project proposals are reviewed by the appropriate OWSC personnel (discipline specialists, supervisor, technical experts) and, at the discretion of the OWSC Chief, may be sent to other WSCs for review. The Northeast Regional office is the level of final review and approval of all project proposals.

3.2 Project QA/QC Plans and Workplans

Project workplans are developed from approved project proposals. The OWSC requirements for the content, review, and revision of workplans are outlined below.

For small or routine projects, the project chief prepares, at the minimum, a project QA/QC plan. The project QA/QC plan contains the project description, objectives, purpose and scope, approach, reports, technical review dates, data collected, a listing of QC objectives and number of samples, and corrective action procedures. (See Appendix B for an example of a project QA/QC plan.)

For large or complicated projects, the project chief prepares a workplan that identifies all project work elements and the related technical methods and approaches that are necessary to satisfy project objectives. Descriptions of the methods and approaches to be used to complete the technical elements of the project are required in the workplan. References for standard field and analytical procedures are provided. Any new or unapproved field and laboratory methods that will be used must be described in detail. The workplan should list the following information about the study:

1. Introduction, objectives, and purpose and scope of the project.
2. Approach for the study:
    - Sampling locations and frequency.
    - Description of the sample types and sample-collection procedures (or references).
    - Names of laboratories, approval status, and descriptions of laboratory tests.
    - Anticipated methods for data analysis and presentation.
3. QA/QC activities:
    - Types and frequency of QC data collection, including sampling and analysis of blanks, spikes, and reference samples to estimate bias and replicates to estimate variability and establish data quality objectives (Mueller and others, 1997).
    - Responsibilities for QC data collection and maintenance of the database, and description of how the project uses QC data.
    - Procedures to verify field-analysis data, such as pH, temperature, and dissolved oxygen (that is, participation in NFQA, bench-test meters against standards and ASTM meters, etc.).
4. The project timeline listing major project elements and planned completion dates.
5. The project report plan, including technical-review dates.

3.3 Project Review

Project and field reviews are conducted periodically by OWSC management, technical advisors, or discipline specialists to ensure compliance with the QA/QC plan or project workplan. Project reviews are also used to ensure that data collection, analysis, and reporting are being done in accordance with broader OWSC policies and requirements. Quality-assurance activities with respect to project reviews are outlined in the next section.

3.3.1 Review Schedules

Regularly planned reviews ensure that water-quality programs or projects are conducted efficiently to produce quality products on time. Informal reviews are part of ongoing quality assurance, whereby problems and related issues are addressed as they arise. Quarterly project reviews are held by the OWSC; however, these reviews address budget and cooperator issues and only briefly address technical aspects of the project.

Technical reviews are needed for most projects. The type and frequency of technical reviews depend on the size and duration of the project and project objectives. For most water-quality projects, the OWSC implements a review schedule for evaluating the technical development and progress of project activities at 10-, 40-, 70-percent (10/40/70) project-completion milestones. For small or routine projects or projects of short duration, 10/40/70 technical reviews may be impractical or unnecessary; instead, reviews are done as requested by the project chief or required by the supervisor. For projects in which the cooperator is heavily involved in project activities, such as analytical microbiology projects, quarterly conference calls or meetings with the cooperator may serve as a technical review.

The supervisor and QW Specialist will require a list of review dates and completed reviews during quarterly project reviews. For new projects, the project chief will need to complete a project start-up checklist and submit to the QW Specialist during or before quarterly project reviews (Appendix C).

Field reviews are done by the QW Specialist, a designated experienced technician, or the Regional Water-Quality Specialist to ensure that sample collection and processing protocols and field documentation procedures are complete and accurate. For long-term projects (3 or more years), field reviews are generally done every 3 years. For short-term projects, field reviews may be done once during the data-collection period, especially for new field personnel or on projects that involve nonstandard protocols. Field reviews on short-term projects that use standard protocols are generally done only if requested by the supervisor or QW Specialist. Field reviews are documented with a memorandum to the appropriate project chief and the OWSC supervisor.

3.3.2 Review Documentation

The following information should be included in technical project review documentation:

- Date of review
- Type of review (10/40/70 or discipline, etc.)
- Names of reviewers and(or) attendees
- Responses to recommended action items from the last review
- Status, plans, and problems with data collection, data analysis, and report writing
- Major findings
- QA/QC activities and results
- Cooperator/customer contacts
- Recommended followup or action items
- Date for next review

Documentation from the review is maintained in the project files. The project chief is responsible for documenting comments and action items from the review, a copy of which is provided to the supervisor and each reviewer. Documentation must include a description of all actions or recommendations for fixing deficiencies, or written explanation as to why a fix cannot be made.

3.4 References Used in the Program and Project Planning Section

The following table lists reports and memorandums referred to in this section. For complete citations, refer to Sections 13.0 and 13.1 of the report, respectively. Copies of these references are available by contacting the QW Specialist.

Table 3.4. Summary of references for program and project planning.

Reference	Subject
NR Guidance Memorandum 2006-01 and 2004-01	Requirements for submittal and approval of project proposals
USGS Strategic Plan for 2000–2005	Help with writing relevance and benefits section of proposal
WRD Policy Memorandum 99.30	Priority issues for the Federal-State Cooperative Program
WRD Policy Memorandum 04.01	Avoiding competition with the private sector
Mueller and others, 1997	Example of QC sample design used by NAWQA for surface-water sampling.
Shampine and others, 1992	Integrating quality assurance into project workplans.

4.0 Water-Quality Laboratories

The comparability and consistency of water-quality data depend to a large extent on the reliability of the analytical work done in the laboratory. Because of the inherent variability among laboratories, one of the best ways to provide comparability and consistency is to use a single laboratory as much as is practical. A large proportion of the analytical water-quality work for the OWSC is done by the USGS National Water Quality Laboratory (NWQL), laboratories approved by the NWQL, and the Ohio Water Microbiology Laboratory (OWML).

4.1 Selection and Use of an Analytical Laboratory

The National Water Quality Laboratory (NWQL) was established as the laboratory to meet the needs of the WRD, and it is the required laboratory for use in all WRD national water-quality programs (WRD Memorandum 92.036). There are conditions for selecting a laboratory other than the NWQL.

4.1.1 Selection

Contract or cooperator laboratories can be used when the cooperative agreement designates a laboratory other than the NWQL or when analytical services are required that cannot be provided by the NWQL. Laboratories can be used for developing analytical techniques or to provide data for research purposes, and these laboratories are generally exempt from approval requirements that other laboratories must meet (OWQ Technical Memorandum 07.01). Contract or cooperator laboratories can also be used when analyses must be done within a few hours of sample collection and cannot be done conveniently in the field.

4.1.2 Requirements for Use

All laboratories that provide analytical services to WRD must meet the requirements described in OWQ Memorandum 07.01 before any analytical data can be stored in the WRD National Water Information System (NWIS) database (discussed in Section 10) or published by the WRD. Laboratories affected by this policy include those that provide chemical, biological, radiochemical, stable-isotope, or sediment analytical services. The project chief is responsible for ensuring that all laboratories providing analytical services to the OWSC have met the requirements for approval. The laboratory approval process is project based, and assistance will be provided by the USGS Branch of Quality Systems (BQS) when requested. The project staff is responsible for obtaining the following data and information from a laboratory and entering it into the BQS database:

1. Document the project data-quality requirements and laboratory information.
2. Obtain QC data that provide an initial demonstration of capability for the laboratory.
3. Evaluate the lab capabilities in relation to project objectives.
4. Prepare a Laboratory Selection Package and submit it for review and approval. The package should be reviewed by at least two people who are independent of the project; for example, the QW Specialist, a Regional QW Specialist, an analyst from a different laboratory, or other knowledgeable peer reviewer.
5. Obtain QC data to assess the laboratory performance during the life of the project.
6. Review the laboratory performance at least annually.

The LEP does not require approval for projects using the NWQL because abundant QA information is available. Accreditation by the National Environmental Laboratory Accreditation Program (NELAP) is not a substitute for the LEP because NELAP does not incorporate project-specific data requirements. Although initial implementation of the LEP focused on water-chemistry analytical services, other analytical work (for example, microbiology) in the Ohio WSC should be included in the LEP because such additional services are scheduled for implementation in late 2008.

For laboratories analyzing samples for inorganic constituents, the laboratory must participate in the BQS Standard Reference Sample (SRS) program (*http://bqs.usgs.gov/srs/*), a semiannual program to evaluate the performance of USGS cooperator and contract laboratories.

4.2 Laboratories Used by the OWSC

In addition to the NWQL and those approved by the NWQL, the laboratories used for analytical services by OWSC projects are listed and described below.

The USGS Ohio Water Microbiology Laboratory (OWML) is located within the OWSC and is a full-service microbiology laboratory. The OWML provides data on microorganisms of public-health significance in surface waters, ground waters, and sediments for a variety of study objectives. A laboratory information management system (LIMS) is being used by the OWML to store sample login information, sample results, associated QC results, and laboratory equipment maintenance and QA checks. General information about the OWML is available at *http://oh.water.usgs.gov/micro_index.htm.*

Heidelberg College Water-Quality Laboratory is located in Tiffin, Ohio, on the college campus. The lab participates in the SRS program and analyzes a small number of samples for inorganic constituents as part of a small, ongoing project.

State and local cooperator laboratories are used by the OWSC for analytical work on cooperative projects. In most cases, the laboratories analyze samples for *E. coli* and turbidity. These data are generally used by the USGS for research purposes and are not entered into NWIS. The only laboratory results from a cooperator laboratory that are entered into NWIS are those samples analyzed by an USGS summer intern or contract employee; these employees are hired and trained by the USGS to meet specific project objectives and QA requirements. Cooperator laboratories are periodically reviewed by OWML personnel for specific projects, and reference samples for turbidity and *E. coli* are provided for QC checks.

4.3 Documentation for Laboratories Used by the OWSC

4.3.1 National Water Quality Laboratory

1. *Methods used*—The NWQL uses approved methods for determination of organic, inorganic, and radioactive substances in water, sediments, and biological tissues. The methods used include methods approved by the USGS, U.S. Environmental Protection Agency (USEPA), the American Public Health Association (APHA), the American Water Works Association, the Water Environmental Federation, and the American Society for Testing and Materials (ASTM). The references for analytical methods currently used at the NWQL can be found in the LIMS catalog at *http://nwql.cr.usgs.gov/usgs/catalog/index.cfm*. Other analytical methods from the USEPA that are currently used at the NWQL can be found on at *http://www.epa.gov./epahome/publications.htm*. Analytical methods from the ASTM that are currently used at the NWQL can be found at *http://www.astm.org*.
2. *Laboratory QA plan*—The NWQL QA plan is contained in Pritt and Raese (1995). A copy of this report can be obtained by sending an email request to *nwqlqc@usgs.gov*.
3. *QC program*—Quality control at the NWQL is monitored by three programs: (1) the internal blind sample program, (2) the external blind sample program, and (3) bench-level QC samples. Information about the internal blind sample program and bench-level QC samples can be obtained by sending an email request to *nwqlqc@usgs.gov*. Information about the external blind sample program can be found at *http://bqs.usgs.gov/bsp/mainpage.html*.
4. *Performance-evaluation studies and certification programs*—The NWQL participates in performance-evaluation studies and laboratory certification programs. A list of the current programs and a description of each can be found by sending an email request to *nwqlqc@usgs.gov*.
5. *Laboratory reviews*—External agencies and customer organizations audit the NWQL to assess analytical methods and QA/QC programs. A table of audits that shows the year reviewed, reviewing agency, and purpose of the review can be obtained by sending an email request to *nwqlqc@usgs.gov*.
6. *Miscellaneous services*—Information about and access to other services offered by the NWQL can be found by USGS employees on the Web at *http://wwwnwql.cr.usgs.gov/USGS/profile.html*. The services offered include but are not limited to the following:
   - Biological unit
   - Chain-of-custody procedures
   - Contract services
   - External performance evaluations
   - Laboratory services catalog
   - Methods Research and Development Program
   - Organic spike kits
   - Publications
   - Quality assurance of selected field supplies
   - SPiN (schedules, parameters, and network record)
   - Technical memorandums

4.3.2 Ohio Water Microbiology Laboratory

1. *Methods used*—The methods used by the OWML can be categorized as compliance, official, provisional, or experimental. Compliance methods are those published by USEPA and were developed to determine compliance with standards for the protection of public health. These include methods for fecal-indicator bacteria, coliphage, and *Cryptosporidium*/*Giardia*. Official methods are noncompliance methods published by water-analysis authorities such as the APHA, USEPA, or USGS. Provisional methods are published methods that are still being validated by the method developer, usually USEPA. Experimental methods are methods that are currently being tested to establish QA/QC practices and determine use and applicability; research methods are considered experimental. Results from compliance and official methods are entered into NWIS, but not results from provisional or experimental methods. Descriptions and references for the analytical methods routinely used by the OWML can be obtained at *http://oh.water.usgs.gov/micro_methods.htm*
2. *QA plan*—The QA Plan for the OWML is contained in a document entitled "Quality Assurance/Quality Control Manual, Ohio Water Microbiology Laboratory," available at *http://oh.water.usgs.gov/micro_qaqc.htm*. The QA/QC Manual for the OWML is routinely updated to include current methods and procedures.
3. *QC program*—The OWML analyzes QC samples including matrix spikes, blanks, replicates, and positive and negative control cultures. The types of QC samples analyzed depend on the analytical method and are described in the OWML QA/QC Manual. Results from QC samples are recorded on bench sheets and (or) in the LIMS, and they can be obtained by contacting the laboratory.
4. *Certification programs*—The OWML does not participate in any certification programs.
5. *Laboratory reviews*—The OWML is reviewed periodically by USEPA for participation in USEPA-sponsored research and monitoring programs. For example, review and approval was done by qualified representatives from the National USEPA Homeland Security Research Center (located in Cincinnati, Ohio) onsite on January 3−4, 2007. The OWML was also reviewed during the Ground-Water/Water-Quality Review on June 14, 2007, by Joe Duris (Michigan WSC). Before the LEP was initiated, the OWML was last reviewed and approved by BQS on December 31, 2001. In addition to external reviews, the OWML Laboratory Manager reviews laboratory and documentation procedures quarterly.

4.3.3 Heidelberg College Water Quality Laboratory (WQL)

1. Methods used—The WQL analyzes water samples for the OWSC for dissolved silica, sulfate, and chloride, suspended solids, and total and dissolved nutrients. The standard operating procedures for each method were provided by the WQL in July 2007 and are kept on file by the QW Specialist.
2. Laboratory QA plan—The QA Plan for the WQL is contained in a document entitled, "Heidelberg College Water Quality Laboratory Research Methods and Quality Control-Quality Assurance Procedures for Tributary Monitoring Studies." A copy is kept by the Ohio WSC project chief of the Hellbranch Water Quality Project; it was last updated January 2002.
3. QC program—The WQL incorporates calibration standards, calibration blanks, matrix spikes, duplicates, and reference samples.

4. Certification/evaluation/round-robin programs—The WQL is in the process of obtaining certification as a drinking-water laboratory by Ohio Environmental Protection Agency. The WQL participates in the USGS SRS Program.
5. Dates and participants of laboratory reviews—The WQL was last reviewed by the BQS in 2002; however, this review was not completed because of anticipated revisions to the USGS laboratory review process.

4.4 References Used for the Water-Quality Laboratories Section

The following table lists reports and memorandums referred to in this section. For a complete citation, refer to Section 13.0 of this report. Copies of these references are available by contacting the QW Specialist.

Table 4.4. Summary of references for selecting and using water-quality laboratories.

Reference	Subject
WRD Memorandum 92.036 (USGS)	Policy of the WRD on the use of laboratories by national water-quality programs.
OWQ Technical Memorandum 07.01	Policy for the evaluation and approval of analytical methods.
Pritt and Raese, 1995	Quality assurance/quality control manualNWQL.

5.0 Field Service Units and Laboratories, Mobile Labs, and Field Vehicles

The OWSC maintains facilities such as the Field Service Unit (OWSC Warehouse and OWML), mobile labs, and field vehicles for use in preparing equipment for field activities, processing samples, performing sample analysis, and preparing samples for shipment to analytical laboratories. This section documents the OWSC's criteria for maintaining and operating these facilities. Facilities are maintained in accordance with standards set forth in the OWSC Chemical Hygiene Plan (CHP), written and maintained by the Chemical Hygiene Officer (last updated April 2007), as required by Branch of Operations Technical Memorandum 91.01. As per the CHP, the Environmental Compliance Coordinator oversees the OWSC waste-disposal practices to ensure that procedures are in compliance with State and Federal regulations.

5.1 OWSC Warehouse and Ohio Water Microbiology Laboratory

The OWSC warehouse serves as Field Service Unit (FSU) for all personnel and projects. The FSU is supplied with buffers and standards needed for instrument calibrations; supplies and space for cleaning of instruments, samplers, and other items; and supplies, forms, containers, and coolers for shipping samples. The FSU also maintains a limited amount of expendable supplies, such as sample bottles and acid cartridges for titrations. The FSU Coordinator is responsible for maintaining this inventory of supplies; all users are responsible for general upkeep, organization, safety and cleanliness of the warehouse. Except for those items provided by the FSU, project personnel are responsible for ordering supplies and equipment needed for project water-quality operations.

Equipment and appliances in the FSU are available for use by all personnel and projects. These include three autoclaves for sterilizing sampling equipment and supplies, two refrigerators for storing samples and supplies, and a system that provides deionized water. The equipment and appliances in the FSU are maintained and checked by OWML personnel as described in the OWML QA/QC Manual (see *http://oh.water.usgs.gov/micro_qaqc.htm*). Minimum requirements for the quality of distilled or deionized water for use in USGS water-quality operations are described in OWQ Technician Memorandum 92.01.

The main laboratory of the OWML is equipped with a fume hood, chemical storage cabinets, and additional benchtop areas for preparing for water-quality field work. The fume hood is used to prepare dilute acid solutions and handle other hazardous materials used for water-quality work. Although daily access to the OWML is limited to those employees with duties in the laboratory, other OWSC personnel can request access to the OWML main laboratory for water-quality work when needed. The equipment and accessories in the OWML main laboratory are maintained and checked by OWML personnel as described in the OWML QA/QC Manual (see *http://oh.water.usgs.gov/micro_qaqc.htm*).

5.2 Mobile Labs and Water-Quality Field Vehicles

Mobile labs and field vehicles refer to all vehicles that are designed, designated, and outfitted for use during water-quality sample-collection and processing activities at or near sample-collection sites. The OWSC maintains vehicles designated for water- quality sample collection and processing. If an undesignated vehicle must be used for water-quality work, portable processing and preservation chambers are used for sample processing, and extra QC samples are collected to document that the data have not been compromised.

A field vehicle is designated as a water-quality field vehicle when it meets criteria to maintain a noncontaminating environment for the constituents being sampled for. The work area must be maintained to eliminate sources of sample contamination. Specifications for vehicles used when sampling for water-quality constituents are discussed by Horowitz and others (1994) and in the "National Field Manual for the Collection of Water-Quality Data" (NFM) (Wilde and others, eds., 2003, TWRI book 9, chap. A2.3)—a TWRI that describes in greater detail the recommended and required policies and procedures for collecting and processing water-quality samples in the WRD. The specifications include the following requirements:

- Materials used for cabinets, storage, and work surfaces must be easy to maintain, made of or covered with noncontaminating materials, and must be such that they can be cleaned with water or solvents as appropriate. Cargo must be restricted to equipment and supplies related to water-quality sample collection unless stored in a separate compartment. No potentially contaminating equipment or supplies, such as sounding weights, solvents, fuel, etc., may be transported in the interior compartment of the vehicle.
- If project objectives require a dust barrier, it should be installed between the cab and work area of the vehicle.

The users of the vehicle are responsible for maintaining the vehicle, for maintaining the suitability of the vehicle for water-quality sample collection, and for keeping the vehicle supplied for field work.

5.3 References Used for the Field Service Units and Laboratories, Mobile Labs, and Field Vehicles Section

The following table lists reports and memorandums referred to in this section. For a complete citation, refer to Section 13.0 of the report. Copies of these references are available by contacting the QW Specialist.

Table 5.3. Summary of references for Field Service Units and laboratories, mobile labs, and field vehicles.

Reference	Subject
Branch of Operations Technical (OP) Memorandum 91.01 (USGS)	Safety Chemical-Hygiene Plan.
Horowitz and others, 1994	Protocol for collecting and processing samples for inorganic analysis.
Office of Water Quality Technical Memorandum 92.01	Requirements for distilled or deionized water.
Wilde and others, eds., 2003 (National Field Manual, TWRI book 9, chap. A2.3)	Guidelines for field vehicles.

6.0 Water-Quality Instruments

The OWSC complies with the WRD policy of providing personnel with high-quality field instruments and equipment that are safe, precise, accurate, durable, reliable, and capable of performing required tasks (WRD Memorandum 95.35). Accordingly, selection of appropriate instruments for use in water-quality projects in the OWSC should be based on the specifications described in the USGS NFM (TWRI book 9, chaps. A1-A9) and the requirements of the project. The Hydrologic Instrumentation Facility (HIF), which analyses precision and bias of water-quality instruments, also should be consulted for recommendations when appropriate. The FSU Coordinator should be consulted if project personnel need assistance with the selection or use of equipment.

All instruments used by OWSC personnel for water-quality measurements are to be properly operated, maintained, and calibrated. Details of methods for field measurements are provided in the NFM (Wilde, F.D., 2005−present, chap. A6). All personnel should read the pertinent sections of this chapter before making their first field measurements and should use the manual as a reference thereafter. Also, for correct operation of any field or laboratory equipment, the manufacturer’s operating guidelines should be carefully followed. Most instruments will be calibrated in the field before sample measurements are made.

Instrument maintenance and QC activities (meter calibrations and equipment maintenance) are the responsibility of individual field and project personnel. Before leaving on a field trip, the person or crew cleans water-quality instruments, adjusts them if necessary, and checks them for serviceability. Instruments that are malfunctioning or in poor condition are reported to the project chief and (or) Field Services Unit Coordinator. Batteries are changed on a regular schedule. A spare pH probe and dissolved-oxygen membrane and water-quality standards should be carried in the field.

Single or multiparameter water-quality continuous monitors are maintained, calibrated, and operated as described in the QA/QC Plan for Project 00304 (Appendix B). These guidelines were based on requirements listed in Wagner and others (2006).

6.1 Calibration of Water-Quality Instruments

Table 6.1 is a summary of information regarding calibration methods, acceptance criteria, calibration frequency and location, responsible persons, and references for instructions for the calibration and use of water-quality instruments to measure routine parameters in the OWSC. Field personnel or project chiefs are responsible for meter calibrations of water-quality instruments. For nonroutine measurements, the project chief is responsible for establishing calibration methods and acceptance criteria. Consult Wilde (2005–present, chap. A6.5) for reduction-oxidation potential or the manufacturer's instructions for other nonroutine measurements, such as field screenings for chemical constituents. To facilitate annual water-quality equipment checks for all OWSC employees, supplies will be set up by the FSU Coordinator during January training weeks.

Thorough documentation of all calibration activities associated with water-quality data collection is a critical element of the OWSC QA program. A record of the calibration is maintained in an equipment log book, and this information is copied onto the site field sheet or entered into the Personal Computer Field Form (PCFF). **Project personnel are to keep calibration and maintenance records in bound equipment log books, written in ink, and stored with the instrument**; documentation includes the manufacturer, make, model, and serial or property number. Completed notebooks are kept by project personnel while the project is still active and transferred to the OWSC Archive Coordinator when inactive. Similar records for OWML laboratory equipment are to be kept in laboratory drawers near the equipment. Information that is required to be included with the calibration and maintenance records includes

- date
- initials and last name of the individual performing the activity
- results of calibration or equipment check
- any actions taken

Calibration and maintenance records are checked for completeness and accuracy annually by the QW Specialist.

Table 6.1. Summary of calibration information for water-quality instruments used to measure selected parameters in the OWSC.

[NIST, National Institute of Standards and Technology; NFM, National Field Manual; FSU, Field Service Unit]

Parameter	Calibration method	Acceptance criteria and response if unacceptable[1]	Calibration frequency and location	References for calibration and use
Temperature	Three-point check with NIST-certified thermometer	± 0.5°C for liquid filled or ± 0.2°C for thermistor; replacement	Annually, FSU	Wilde, 2006 (NFM, chap. A6.1); manufacturer's instructions
Dissolved oxygen	One-point calibration in air	± 0.2 mg/L; change or clean membrane or replace probe	Daily in field or FSU, before taking measurements	Wilde, 2006 (NFM, chap. A6.2); manufacturer's instructions
	Two-point calibration with zero-DO check	Reads ± 0.2 mg/L Reads ≤ 0.2 mg/L	Quarterly or annually[2]	
Specific electrical conductance	At least two standards, bracketing expected values	± 5 percent; clean or replace probe	Daily in field or FSU, before taking measurements	Wilde, 2005 (NFM, chap. A6.3); manufacturer's instructions
pH	Two-point calibration, bracketing expected values	± 0.1 unit; clean or replace probe	Daily in field or FSU, before taking measurements	Wilde, 2006 (NFM, chap. A6.4); manufacturer's instructions
Turbidity (using a ratiometric, white light turbidimeter, such as the Hach Model 2100P)	Reference turbidity calibration with formazin	Within manufacturer's range; repair or replace	Annually	Wilde, 2005 (NFM, chap. A6.7); manufacturer's instructions
	Calibrations with secondary standards (0-10, 0-100, and 0-1000)	Within 5 percent of the reference turbidity values; recalibrate with reference turbidity	Daily in field or FSU, before taking measurements	
Barometric pressure	Check against NIST certified barometer	± 2 millimeters Hg; replacement	Annually, or more if needed	Wilde, 2006 (NFM, chap. A6.2); manufacturer's instructions

[1] If a parameter is outside the acceptance criterion, the parameter should be recalibrated, if possible. Additional information, obtained from manufacturer's instructions, can assist field personnel in determining whether the probe needs to be replaced. Information includes expected lifespan of a probe (all probes), cell constant and reading in air (specific conductance), dissolved oxygen gain and dissolved oxygen charge, and millivolts (pH).

[2] Dissolved oxygen instruments used throughout the year need a two-point calibration quarterly; equipment used seasonally or for synoptic studies need a two-point calibration annually.

6.2 References Used for the Water-Quality Instruments Section

Table 6.2 is a list of reports and memorandums referred to in this section on water-quality instruments. For a complete citation, refer to Section 13.0 of the report. Copies of these references are available by contacting the QW Specialist.

Table 6.2. Summary of references for water-quality instruments.

Reference	Subject
U.S. Geological Survey, 1997-present (TWRI Book 9, chaps. A1-A9)	National Field Manual for the Collection of Water-Quality Data.
Wilde, ed., 2005-present (TWRI book 9, chap. A6)	Field measurements.
WRD Memorandum 95.35 (USGS)	Instrumentation plan for the WRD and the hydrologic field instrumentation. and equipment policy and guidelines.
Wagner and others, 2006	Guidelines and standard procedures for continuous water-quality monitors

7.0 Site Selection and Documentation

Deciding where to sample is an important initial step toward achieving project objectives and meeting OWSC QA/QC requirements. Once a site is selected, thorough documentation is required.

7.1 Site Selection

Site selection for sampling is important to the validity of water-quality data. Selection of a suitable site can be made only after considering the study objectives and types of data needed, the suitability of a site for sampling, the physical characteristics of the area, and the site's accessibility and safety. Specific guidelines for site selection are contained in Wilde (2005, chap. A1). The project chief is responsible for the selection of sampling sites, after consultation with the QW Specialist and the Surface-Water or Ground-Water Specialist, as appropriate.

7.1.1 Surface Water

If possible, flowing-water sites are located at or near streamgages. If this is not possible, the water-quality station should be located where the streamflow can be measured and water samples can be collected at all stages of flow to be monitored. If the water-quality station is too close downstream from either the confluence of two or more streams or a point source of pollution, the collection of a representative sample may be difficult because of incomplete mixing. Under such conditions, the criteria for the minimum number of vertical transects sampled may need to be increased, and lateral mixing should be documented with cross-sectional surveys at various stages of flow. Other considerations for surface-water site selection are described in Averett and Schroder (1994).

The selection of still-water sampling sites depends on whether project objectives can be satisfied by random and (or) stratified sampling strategies. Detailed information on selection of lake monitoring sites is available in Nevers and Whitman (2005) and Averett and Schroder (1994). Special considerations should be made when establishing beach-monitoring sites. For routine monitoring, collect samples in the area used for swimming at 0.7 to 1-meter water depths. At some beaches, multiple samples may be needed to adequately represent overall water-quality conditions (Myers and others, 2007).

7.1.2 Ground Water

The selection of wells for ground-water sampling is dependent on many variables, including location, accessibility of the well, depth, and type of well completion, availability of geologic and water-use information, and sampling purpose(s). If suitable existing wells cannot be found, new wells will need to be installed. The minimum well-selection criteria for any ground-water project done in the OWSC include sufficient documentation to (1) determine the hydrogeologic zone from which the ground water is being withdrawn and (2) ensure that materials and techniques used to construct the well are suitable for sampling the constituents of concern. Guidelines for ground-water site selection are presented in Lapham and others (1997).

7.2 Site Documentation

All site data, whether for surface-water or ground-water sites, are entered into the NWIS database through the USGS Ground-Water Site Inventory (GWSI). The procedures for establishing the station identification number (station ID) and site name and for entering data into GWSI are described below. The project chief is responsible for establishing the site, with assistance from the GWSI Administrator.

1. Establish an 8-digit or 15-digit station ID and a site name. Eight-digit numbers are used for establishing the downstream order of surface-water and lake sites that are to be streamflow and stage measuring stations (Martin and Cohen, 1994). The assignment of 8-digit station ID's is a process that requires the gathering of detailed information. Several time-consuming tasks must be completed to determine the station ID for 8-digit station ID's; this process is overseen by the OWSC Surface-Water Specialist. Fifteen-digit numbers are used for all other sites and are composed of the latitude, longitude, and a 2-digit sequence number.
    - Determine the latitude and longitude using a topographic map, as described in Martin and Cohen (1994), or by use of a Global Positioning System (GPS).
    - To ensure that sites are not duplicated, retrieve a list of existing sites from GWSI that are within a 1-mile radius of the proposed new site.
    - Follow correct site-naming procedures, described more fully in Martin and Cohen (1994). For stream-water sites, use the stream name; at, near, above, or below, as applicable; the closest town or city; and OH for Ohio. For ground-water sites, use the county abbreviation and the next available sequential number in the ground water site catalog (located in the OWSC Ground-Water Specialist's office).

- GWSI site-header records must exist in the NWIS site file before the return of analytical data from the NWQL. The pertinent information that makes up the header must be entered no later than 10 days after sample collection; preferably, the information is entered before sample collection.

2. Fill out a GWSI paper form and enter data electronically into GWSI. Make sure that all required fields are complete and accurate. Have another project team member check the entry.
3. Edit the file, if necessary, and transfer the information to the GWSI Administrator who will check, edit, and enter the site into the GWSI database.

After the site is established, the project chief constructs a QW site file containing descriptive information on location, conditions, purpose, and ancillary information for all new water-quality data-collection sites (Schroder and Shampine, 1995). Descriptive site information, including latitude, longitude, hydrologic units, and other site information, is stored electronically in GWSI. The project chief is responsible for ensuring that the site file is maintained for each data-collection site. Archiving of this information is discussed in Section 10.4.

If data are to be reported in the Annual Data Report, site information is also entered in the Site Information Management System (SIMS). The SIMS is an internal system that houses station descriptions, station analyses, and other site information (see *http://tx.cr.usgs.gov/field/sqlsims/StationsRpt.asp?office_id=45*).

To standardize and facilitate the processing of water-quality data in the OWSC and to ensure that water-quality data are entered into the proper database in a timely manner, the following procedures will be used:

- For each sample that will be sent to the NWQL for analysis, an Analytical Services Request (ASR) form will be completed by the Project Team with a copy retained in a project file as part of the sample tracking system. For USGS employees, ASR forms can be downloaded from the NWQL (*http://wwwnwql.cr.usgs.gov/USGS/USGS_srv.html*) and filled out.
- An alternative to manually completing an ASR form is to enter sample and field data into a Personal Computer Field Form (PCFF). PCFF allows users to enter field-derived sample-collection data into electronic USGS field forms automatically, thereby eliminating any transcription errors in the transferring of data. PCFF software can be downloaded at *http://water.usgs.gov/usgs/owq/pcff.html*. The use of a PCFF is highly recommended because it automates the documentation process and eliminates transcription errors.
- The project chief is responsible for tracking all pending samples submitted for analysis. Sample status at the NWQL can be tracked from login to completion of analysis (see section 9.0).

7.2.1 Surface Water

A station description is prepared for each water-quality station that is sampled on a regular or periodic basis. Sites established at existing streamgages commonly will need only supplemental information to complete the description. Other surface-water sites, such as sites where there is no preexisting gage, and lakes, estuaries, and coastal waters, may require varying amounts of supplemental information to complete the station descriptions. The minimum information required for establishing electronic files in NWIS for surface water is listed in table 1–1 in Wilde (2005, chap. A1). For continuous water-quality-monitoring sites, station-description requirements are presented by Wagner and others (2006).

Information about the station, including the station description and safety information, are kept in a site field folder. A site field-folder checklist for surface-water quality sites is shown in figure 1–2 in Wilde (2005, chap. A1).

7.2.2 Ground Water

A well file (analogous to a surface-water station description) is prepared for each well that is sampled on a regular or periodic basis. The minimum information required for establishing electronic files in NWIS for ground water is listed in table 1-4 in Wilde (2005, chap. A1). Wells selected as potential sampling sites may need to be visited before completion of the GWSI site file to verify that information obtained from driller's log or other sources is correct. Copies of well logs obtained from the Ohio Department of Natural Resources are filed with the original GWSI form and in the site field folder. For continuous water-quality monitoring sites, station-description requirements are presented by Wagner and others (2006).

Information about the well, including the station description, safety information, and water-level records, are kept in a site field folder. Before sampling, obtain permission to sample the well and arrange for site access; keep these documents in the site field folder. It is also recommended that photographs of the well site be taken to document well characteristics and local land-use practices near the well. A site field-folder checklist for ground-water quality sites is shown in figure 1–4 in Wilde (2005, chap. A1).

7.3 References Used for the Site-Selection and Documentation Section

The following table lists reports referred to in this section. For a complete citation, refer to Section 13.0 of the report. Copies of these references are available by contacting the QW Specialist.

Table 7.3. Summary of references for site selection and documentation for water-quality programs.

Reference	Subject
Averett and Schroder, 1994	Guide to the design of surface-water quality studies.
Lapham and others, 1997	Guidelines and standard procedures for studies of ground-water quality.
Martin and Cohen, 1994	Documentation procedures.
Myers and others, 2007	NFM, Fecal indicator bacteria, Surface water sample collection.
Nevers and Whitman, 2005	Lake Monitoring Field Manual.
Schroder and Shampine, 1995	Guidelines for documenting new water-quality data-collection sites.
Wagner and others, 2006	Guidelines and standard procedures for continuous water-quality monitors.
Wilde 2005 (TWRI book 9, chap. A1)	Preparations for water sampling.

8.0 Sample Collection and Processing

Water-quality data collected by the USGS are used by agencies throughout the Federal, State, and local levels to guide their decisions concerning the appropriate and efficient management of water resources for the Nation. These data are a vital component of water-resources activities performed by the USGS and the OWSC. Water-quality data are collected as part of such Federal programs as the National Stream-Quality Accounting Network (NASQAN) and the National Water-Quality Assessment (NAWQA) Program, as well as cooperative projects jointly funded by local or State agencies.

The primary objective in collecting a water-quality sample is to obtain environmental data that are representative of the system that is being studied. Sampling and processing techniques for specific constituents vary according to the general class of compound, such as inorganic or organic chemicals. If incorrect sampling procedures produce a nonrepresentative sample, or if the sample is contaminated or degraded before analysis can be completed, the value of the sample is limited and the data are questionable. It is the responsibility of each employee involved in water-quality sampling to avoid sample contamination and degradation during all phases of sample collection and processing. Compliance with documented and technically approved sample-collection and processing protocols, in particular NFM Chapters A4 and A5 (Wilde, 2006, 2004a), is critical to ensuring the quality of water-quality data.

It is the policy of this OWSC that all personnel involved in collecting and processing water-quality data will be adequately informed and trained regarding water-quality data-collection and processing procedures established by the WRD. Rapid changes in technology and improved methods for sample collection and processing are continually being developed; this necessitates that all OWSC personnel who are involved in water-quality sampling be aware of changing requirements and recommendations. The QW Specialist is responsible for providing information to OWSC personnel on the correct and current protocols to follow in collecting and processing water-quality samples. It is OWSC policy to provide water-quality personnel with ample opportunities to attend training courses, including those at the USGS National Training Center. Project personnel are responsible for informing OWSC Managers and the QW Specialist of sampling plans and any need for current information and (or) training.

The project chief is responsible for seeing that field personnel take the following steps to ensure the quality and integrity of the OWSC's water-quality data:

Instantaneous Water-Quality Data

- Samples must be collected and processed according to prescribed WRD protocols, as described and referenced below. For projects that are using non-WRD protocols, samples must be collected and processed as outlined in the project workplan.
- All samples must be shipped to the laboratory in an expedient manner (from the field, if necessary), within the required holding time for each analysis.
- All samples should be logged into NWIS (usually within 7 days of sample collection) before completion of analysis and transmittal of the results back to the OWSC.
- All analytical data must be reviewed in a timely manner and within the required holding times for each analysis (to allow time for reanalysis), and fully documented in the station analysis file.

Continuous Water-Quality Data

- The site should be vertically and horizontally well-mixed in the cross section.
- Location of the sensors must be fully documented.
- All pertinent information regarding the site, cross-sectional variability, equipment maintenance, and data shifts must be fully documented and included in the station analysis file.
- Monitors must be inspected and calibrated as frequently as required to obtain as complete a record as possible.
- Sites should be operated as described by Wagner and others (2006).

8.1 Physical Measurements and Chemical Constituents in Water

Many studies that are designed to evaluate the water quality of an aquatic system are based upon analyses of physical and chemical parameters associated with the water. Physical parameters generally are measured in the field, whereas most chemical parameters require laboratory analysis. This section of the QA plan includes an overview of relevant OWSC and WRD policies, as well as references for specific procedures pertaining to the measurement of field parameters and the collection and processing of samples for water-quality analysis. Information in this section is drawn primarily from the NFM. Additional sources of information include manuals published by the NAWQA Program (Shelton, 1994; Koterba and others, 1995; Shelton, 1997) with updates on the NAWQA intranet site at *http://water.usgs.gov/nawqa-only/ftsup/* . The project proposal and workplan also should be consulted for specific guidelines by project personnel for details of sample collection and processing.

8.1.1 Field Measurements

Routine field measurements include temperature, dissolved-oxygen (DO) concentration, specific electrical conductance (conductivity), pH, turbidity, and alkalinity or acid neutralizing capacity. Other types of measurements that also may be necessary for specific projects include reduction-oxidation potential (E_h) and total iron. OWSC procedures for collecting field measurements in surface- and ground-water systems are provided in chapter A6 of the NFM (Wilde, 2005–present). Field measurements should represent, as closely as possible, the natural conditions of the system at the time of sampling. To ensure quality of the measurements, calibration within the range of expected field conditions at each site is required for most instruments.

Field-measurement data must be recorded while in the field, including methods, equipment, and calibration information. Field-measurement data can be stored on paper field forms, which may be national forms available at *http://water.usgs.gov/usgs/owq/Forms.html* or national forms customized for a particular project. The preferred way to store field-measurement data is on a Personal Computer Field Form (PCFF), available at *http://water.usgs.gov/usgs/owq/pcff.html* . For alkalinity, OWSC personnel are encouraged to use alkalinity calculators available at *http://or.water.usgs.gov/alk/*.

Project personnel are responsible for accuracy and completeness of field data, with final oversight and review by the project chief. To avoid the loss of data because of possible instrument malfunction, backup instruments and sensors in good working condition should be taken on field trips. To avoid random recording and calculation errors, all measurements should be double-checked.

To document the quality and proficiency of taking field measurements, all OWSC personnel involved in the collection of water-quality data are required to participate in the National Field Quality Assurance (NFQA) Program (Stanley and others, 1998). All personnel who use instruments to measure pH, specific conductance, and (or) alkalinity receive Standard Reference Samples (SRS) annually from the NFQA Coordinator at the Branch of Quality Systems in Lakewood, Colo. (see *http://nfqa.cr.usgs.gov/*). Each participant receives two samples for each parameter and performs the measurements with the same techniques and instruments that are routinely used in the field or laboratory. Personnel who expect to perform these measurements or who are expected to maintain proficiency are also encouraged to participate. The NFQA program is implemented in the OWSC by the FSU Coordinator, with oversight by the QW Specialist.

Results of the NFQA Program are reviewed by the Regional Hydrologist, the QW Specialist, and the FSU Coordinator; results are also sent to the Director of the OWSC. Staff receiving an unsatisfactory rating will analyze a second set of samples. The QW Specialist, FSU Coordinator, or an experienced technician will work with the employee to identify the cause of the unsatisfactory result. If it is caused by a malfunctioning meter, the meter will be repaired or replaced.

8.1.2 Cleaning of Sampling and Processing Equipment

Considerable care must be taken to avoid contamination during sampling and processing. The two biggest sources of aqueous sample contamination are improperly cleaned equipment and atmospheric inputs, such as dirt and dust (Horowitz and others, 1994).

Procedures for cleaning equipment used for water-quality sampling and processing are described in chapter A3 of the NFM (Wilde, 2004b) and by Koterba and others (1995). All new equipment acquired for water-quality sampling, as well as equipment that has been in long-term storage, must be cleaned in the office before being used in the field. Similarly, equipment must be cleaned as soon as possible after sample collection and before being used again to avoid cross-contamination between sampling sites. Cleaning procedures vary with the intended use of the equipment; that is, whether samples are collected for organic compounds, major constituents, trace metals, or nutrients. For example, nonphosphate detergent, several deionized-water rinses, and hydrochloric acid are used to remove trace inorganics during the cleaning procedure for nonmetal equipment; for organics, a methanol rinse is used instead of acid. Methanol is not used, however, to clean equipment used in sampling for dissolved and suspended organic carbon (Wilde, 2004b).

Implementation and continued compliance with the “parts-per-billion” protocol, originally described by Horowitz and others (1994), requires careful attention to equipment cleaning protocols (Wilde, 2004b).

Equipment blanks are a particular type of blank sample that is used to verify that cleaning procedures used by the field personnel are adequate for removing contamination. These blanks ensure that individual pieces of sampling equipment are not sources of detectable concentrations of constituents to be analyzed for in environmental samples. An annual equipment blank, collected in the office laboratory, is required for each set of equipment used to collect water-quality samples (Horowitz and others, 1994; Wilde 2004b, chap. A3). Annual equipment blanks that indicate detectable levels of constituents require submission of blanks for individual components of the equipment to isolate the source of contamination. When the source of contamination has been determined, the necessary maintenance must be performed to eliminate contamination, or the equipment must be replaced. The project chief monitors the results of annual equipment blanks and ensures compliance with OWSC standards.

8.1.3 Surface-Water Sampling

Surface-water samples are collected to determine the concentrations of inorganic (trace elements, nutrients, and major ions), organic, and radiochemical constituents. Processes that control concentrations of surface-water constituents are discussed in Hem (1989).

Collecting surface-water samples that accurately represent the physical and chemical characteristics of the aquatic system requires the appropriate use of sampling equipment and methods in order to describe environmental variability and to prevent contamination or bias in the sampling process. All OWSC personnel who are involved in water-quality studies must be well informed of the various factors that must be considered to ensure the collection of representative samples. The choice of sampling equipment and method of sample collection are based on established protocols and guidelines, depending upon the characteristics of the target constituents, study objectives, hydrologic conditions, and sampling logistics.

8.1.3.1 Equipment Selection

Guidelines for selecting equipment for sampling surface water are provided in Horowitz and others (1994), Davis and the Federal Interagency Sedimentation Project (2005), and in chapter A2 of the NFM (Wilde and others, eds., 2003). Review of equipment selection by OWSC technical specialists occurs during proposal and workplan review and during periodic project and field reviews.

8.1.3.2 Sample Collection

Guidelines for the collection of surface-water samples are provided in chapter A4 of the NFM (Wilde, 2006). Field personnel are responsible for examining the sampling site carefully and choosing the most appropriate sampling method to generate the best sample possible under the conditions at the time of sampling. In a comparison of grab samples and cross-sectionally-integrated sampling methods, investigators found that concentrations of dissolved constituents were not consistently different (Martin and others, 1992). However, concentrations of some sediment-associated constituents were significantly lower in the grab samples than in the cross-sectionally-integrated samples.

At flowing-water sites (with velocities greater than 1.5 cubic feet per second), collection of an isokinetic, depth-integrated, discharge-weighted sample is standard procedure. In this manner, the sample is collected through the entire depth of the water column at multiple vertical transects by either the equal-discharge (EDI) or equal-width increment (EWI) method. The EDI method requires some knowledge of the distribution of streamflow in the cross section; samples are obtained from the centroids of segments having equal discharge increments. The transit rate at each centroid need not be constant, but equal samples volumes are collected at each vertical. The EWI method requires that samples be taken at verticals equally spaced across the stream. The volume collected is proportional to stream discharge and is not the same at each vertical; however, the transit rate of the sampler at all verticals must be equal. The sampler also needs to be filled isokinetically; that is, water approaching the sampler must not change in velocity or direction as it enters the intake (Ward and Harr, 1990). To collect an isokinetic sample, it is important that the correct sampler be used for the conditions at the sampling site and that the sampler be used correctly. Refer to Wilde (2006) or Edwards and Glysson (1988) for details on how to collect an isokinetic sample. These procedures generate a representative cross-sectional sample that is both flow-weighted and depth- and width-integrated (Edwards and Glysson, 1988; Ward and Harr, 1990).

Occasionally, the use of nonintegrated or non-flow-weighted methods may be appropriate at flowing-water sites because of hydrologic, climatic, or safety conditions, or specific project objectives. For example, a single-vertical at the centroid-of-flow (VCF), dip sample, or pump sample are acceptable when high velocities, shallow channel depths, or excessive debris in the stream preclude the use of EDI or EWI methods. Study objectives may also dictate the use of nonisokinetic sampling methods (Wilde, 2006). In the VCF, the sampler is lowered and raised through the water column at a uniform transit rate at one location. In the dip-sampling method, a sample is collected below the surface of the water to minimize collection of surface film and avoid contact with the streambed.

Still-water samples are generally collected at multiple locations in the water body and at multiple depths. The probability that a single sample of a lake or reservoir is representative of the whole body of water is slight; therefore, a still-water sampling program must be carefully designed (Ward and Harr, 1990). Thief-type samplers usually are used to collect still-water samples; however, pumping samplers also can be used. Refer to Wilde (2006), Ward and Harr (1990), and Nevers and Whitman (2005) for complete discussions of still-water sampling.

Specific procedures employing two-person sampling teams (clean hands/dirty hands) with specific, designated roles in sample collection and handling are required when sampling for trace inorganic constituents with ambient concentrations at or near 1 microgram per liter (µg/L), or when aluminum, iron, and manganese ambient concentrations are below 200 µg/ L. These procedures are described by Wilde (2006), with specific instructions in table 4–3.

Thorough documentation of sampling equipment and methods that are used is required in field records associated with water-quality samples. The project chief is responsible for timely review of field records.

8.1.4 Ground-Water Sampling

OWSC ground-water sampling procedures are designed to ensure that (1) the samples collected are representative of water in the aquifer and are not contaminated by well-construction material or sampling equipment and (2) the composition of the samples is not altered by physical or chemical processes during sampling. It is critical that field personnel be aware of all factors that can compromise the integrity of ground-water samples and implement consistent strategies to protect sample integrity.

8.1.4.1 Equipment Selection

Guidelines for selecting appropriate equipment for ground-water sampling are provided in the NFM (Wilde and others, eds., 2003, chap. A2). All project personnel involved in ground-water sampling for water-quality studies must understand the advantages and disadvantages of available equipment with respect to study objectives. Because of the wide range of factors involved, the ideal equipment for sample collection under some circumstances may not exist. When compromise decisions are required, the field team must thoroughly document with field notes the compromises that are made. Review of equipment selection occurs during proposal and workplan review and during periodic project reviews by OWSC technical specialists.

8.1.4.2 Sample Collection

Guidelines for collecting representative water-quality samples from ground water are provided in chapter A4 of the NFM (Wilde, 2006). These guidelines help prevent or minimize loss of sample integrity. The standard procedure for ground-water sampling is to purge the well to remove at least three well volumes of standing water while monitoring field measurements for stabilization. Routine field measurements include pH, temperature, specific electrical conductance, dissolved oxygen, alkalinity, and turbidity. This procedure may be modified, depending on project objectives, site characteristics, or factors such as depth of pump and water availability. Optimum well-purging procedures remove all stagnant water while minimizing turbulence and aeration of ground water in the well, tubing, and pump.

Two-person sampling teams are required to implement coordinated clean-handling techniques when collecting samples for trace elements with ambient concentrations at or near 1 µg/L or when aluminum, iron, or manganese ambient concentrations are below 200 µg/L (Wilde, 2006).

Thorough documentation of sampling equipment and methods that are used is required in field records associated with water-quality samples. The project chief is responsible for timely review of field records.

8.1.5 Precipitation Sampling

Specific procedures in the OWSC for collecting precipitation samples are based primarily on the study objectives. Bulk collectors are constructed to accept dryfall in addition to wetfall, whereas wet-only collectors are designed to open up only during periods of precipitation. Bulk sampling is appropriate if the project goal is determination of total atmospheric input of constituents. Wet-only sampling is appropriate if the goal is to determine concentrations of dissolved constituents in the precipitation itself. Major factors that must be considered in sampling for precipitation quality include the location of the sampling station relative to human influences, the choice of sampling equipment, and special sample-handling procedures that may be necessary.

Guidelines regarding the collection and analysis of precipitation samples are provided in Dossett and Bowersox (1999) and in a case study (Willoughby, 2000). The USEPA's recommended QA/QC procedures and requirements for precipitation samples are given in Peden and others (1986).

The project proposal and workplan should be consulted for specific guidelines regarding the factors that must be considered in choosing the sample location, the sampling equipment and frequency, and the special sample-handling procedures that may be necessary based upon the study objectives.

8.1.5.1 Site Selection and Installation

For sites of regional or background precipitation quality, locate sites so that they are reasonably distant from traffic and other human activity that would disturb land or water surfaces. Avoid overhead obstructions; a general guidelines is that the line-of-sight angle from the top of the collector to the nearest overhead obstruction should be 30° or less.

For bulk and wet-only samplers, ensure that sample containers, funnels, liners, and tubing consist of inert, nonabsorbing materials that will not affect the typically low concentrations of ions in solution. Polyethylene or Teflon are suitable materials for subsequent determinations of major ions. Glass is acceptable if mercury is to be determined, but Teflon is recommended if other trace elements are of interest (Willoughby, 2000).

8.1.5.2 Sample Collection

Weekly, daily, event, and within-event frequencies are all common, depending on project objectives. Periods of greater than 2 weeks between retrievals of wet-deposition samples are not recommended because of the possibility of evaporation and sample degradation. For dry-deposition samples, monthly retrievals are recommended. Remove wet-deposition samples carefully and cap them until they are split and field measurements are made. Do not touch collection surfaces when removing or installing the collection vessel. Remove dry-deposition material from the collector by sequential rinsing with deionized water from a wash bottle of known volume and alternate scrubbing with a spatula of inert plastic.

8.1.6 Automatic Samplers

Automatic water-quality sampling stations are an important part of some water-quality projects. The types of supporting equipment will depend on the objectives of the project and the target analytes. Typical supporting equipment used in the OWSC include the following:

- a datalogger to serve as station controller and to trigger sample collection
- modem and telephone for external communications
- relays for triggering the automatic sampler to collect a sample
- a refrigerator or nonrefrigerated automatic water-quality sampler
- sample bottles of the size and composition to suit sample-analysis criteria
- peristaltic pump
- pump tubing
- flowthrough chambers or valves, if needed, to facilitate flushing of the sample line with native water before sample collection.

8.1.6.1 Site Selection and Installation

Automatic water-quality sampling stations are typically installed on streams but also can function at still-water sites. At flowing-water sites, the automatic sampler is usually collocated with a streamgage; if this is not possible, the automatic water-quality sampling station should be located where the stream discharge can be measured. The sample intake must be in an area where there is adequate mixing to ensure that the resulting point samples closely represent water from the stream cross section. At still-water sites, the sample intake should be as close as possible to the area of interest.

8.1.6.2 Sample Collection

Samples are collected based on time, water level, flow, or rainfall and are triggered by the station datalogger. When a sample is triggered, the sample line is first purged, rinsed with native water, and then deposited in the sample bottle(s). Alternatively, the sampler can be equipped with a valve system to flush the line rather than purge and rinse. After the sampling event, samples are retrieved from the sampler and transported to the office or laboratory for processing. Sample processing procedures include compositing separate bottles into one sample, splitting the composited sample, filtration, and sample preservation.

8.1.7 Sample Processing

All samples collected for water-quality analysis must be processed according to procedures in the NFM (Wilde, 2004a, chap. A5) as soon as possible following collection. The constituents of interest and study objectives determine the specific processing procedures that are necessary, which must be described in the project workplan. As a rule, field personnel are required to follow a NFM Field Manual (Wilde, 2004a, Section 5.0.2 and table 5.1) to help ensure the quality of the data collected.

All OWSC water-quality studies that include the analysis of trace elements in concentrations less than 10 ppb must use the protocols for sample processing as described in Wilde, section 5.6 (2004a). These techniques require the use of processing and preservation chambers to reduce the potential for contamination from the surrounding environment during sample splitting, filtration, and preservation.

8.1.7.1 Sample Compositing and Splitting

Guidelines for using sample compositors and splitters are in the NFM (Wilde and others, 2003, chap. A2). Two types of sample splitters presently in use in the WRD are the churn splitter, which also serves as a compositing device, and the cone splitter, which requires a separate compositing vessel. Each splitter has specific advantages and disadvantages (OWQ Technical Memorandum 97.06 and Horowitz and others, 2001). Either splitting method can be applied to inorganic and organic constituents within the technical design limits of the device and as long as the equipment is constructed of appropriate materials. Technical design limits are based on suspended-sediment concentrations and the construction material of the splitter.

8.1.7.2 Sample Filtration

Filtration is required for many water-quality samples in order to separate particulates from the water and constituents in solution. Selection of the appropriate filter unit and filter characteristics to be used depends on the constituent class of interest and is based on guidance provided in the National Field Manual (Wilde and others, 2003, chap. A2). Guidelines for filtration procedures for specific constituent groups are provided in the National Field Manual (Wilde, 2004a, chap. A5). The choice of filter type and filtration equipment and the lot number are to be documented on field forms and in field notes.

For surface water, the most common filtration system consists of a reversible, variable-speed battery-operated peristaltic pump and 0.45-micrometer-pore-size disposable capsule filter. For ground water, the sample is generally pumped directly from the well through a 0.45-micrometer-pore-size disposable capsule filter. Filtration of samples for analysis of trace elements in concentrations less than 10 ppb must be done in a processing chamber that encloses the filtering unit and sample bottles in a protected environment (Wilde, 2004a, chap. A5). Filtration of water samples for determination of organic compounds involves the use of a glass-fiber plate filter with a stainless steel or aluminum assembly for most organics or a nylon capsule filter for organonitrogen herbicides (Wilde, 2004a, chap. A5, section 5.2.2; Sandstrom, 1995). Filtering of samples for carbon requires the use of a 25-millimeter glass-microfiber filter; the procedure used is based on the type of carbon analyte (Wilde, 2004a, chap. A5, section 5.2.2.C).

8.1.7.3 Sample Preservation

Sample preservation techniques are required for some constituent groups to prevent reduction or loss of target analytes and to stabilize analyte concentrations for a limited time. Guidelines for sample preservation are provided in the NFM (Wilde, 2004a, chap. A5), and the NWQL Services Catalog at *http://nwql.cr.usgs.gov/usgs/catalog/index.cfm* . Because some samples have a very limited holding time even when preserved, field personnel must ensure that all water-quality samples are shipped to the laboratory as quickly as possible and that time-sensitive samples are received in good condition within the appropriate holding time. For details on sample shipping requirements, refer to Section 9.0 of this QA plan.

For chilled samples, the NWQL records cooler temperature upon receipt and sends the temperature reading to the person who prepared the shipment and the project chief in a log-in report.

8.2 Biological sampling

Many water-quality studies in the WRD are beginning to employ a multidisciplinary approach that relies on data from a range of sampling media. A variety of different types of biological samples may be incorporated into a water-quality project in order to provide multiple lines of evidence with which to evaluate a particular aquatic system. Different collection and processing methods for biological assessments have been developed to fit a variety of sampling locations and objectives.

8.2.1 Aquatic Biota and Habitat

Design of studies of aquatic biota and habitat requires careful thought and planning because the sampling error can often exceed the natural variability in populations. A variety of biological sample types may be collected, including samples of algae, aquatic macroinvertebrates, and fish, plus habitat evaluations. For a discussion of environmental and biological considerations in the sampling of aquatic organisms, refer to Averett (1973).

8.2.1.1 Algae

Algae are present in a variety of stream and lake habitats and microhabitats. Algae grow in waters as periphyton (attached to a substrate) or as phytoplankton (suspended in water). The choice of the type of habitat to sample in streams (riffles, pools, runs) and lakes (littoral, or nearshore; limnetic, or open water; epilimnetic, or upper, warm, lighted, layer of open water; and hypolimnetic, or lower, cool, dark layer of open water) is related to project objectives. The purpose, scope, and objectives of a study will also determine whether samples are collected from natural and (or) artificial substrates and whether the sampling methods used are to yield quantitative or qualitative results.

Algal samples are collected for determination of algal biomass and (or) for taxonomic identification. Guidelines for identifying sampling sites and collecting samples for algal biomass are described in the NFM (Berkman and Canova, 2007, chap. A7.4). Protocols for collecting samples and identifying the algal community for the NAWQA Program (biomass and taxonomic identification) are described in Moulton and others (2002).

Measurement of algal biomass is done in many river and lake studies and may be especially important in studies that address nutrient enrichment or toxicity. Algal biomass in a water body can be estimated in three ways: (1) by quantifying chlorophyll a (CHL a), (2) by measuring carbon biomass as ash-free dry mass (AFDM), or (3) by measuring particulate organic carbon (POC) (Berkman and Canova, 2007). Quantitative phytoplankton samples are typically collected in the same manner as water-chemistry samples, with special attention to the depth of light penetration (or euphotic zone) for collecting a representative sample of the algal community (Berkman and Canova, 2007, chap. A7.4.3.B). The sampling procedures for periphyton vary by the substrate to be sampled. For example, to characterize biomass from a macroalgae such as *Cladophora*, sampling from a large area is recommended. Phytoplankton biomass samples are very susceptible to degradation and cannot be held for more than 24 hours before significant changes begin to occur. Periphyton biomass samples have been found to have longer holding times (Biggs, 1987). For a detailed discussion on holding times for algal samples, refer to Berkman and Canova (2007, chap. A7.4.5.C) Sample filtration and freezing is the best protection from degradation. Algal biomass samples are analyzed by the USGS NWQL.

Samples for taxonomic analysis are generally preserved with buffered formaldehyde diluted to 5-percent formalin (refer to Moulton and others, 2002, p. 8). Algal taxonomy samples are analyzed as part of a cooperative agreement between a contract laboratory and the USGS (Charles and others, eds., 2002).

8.2.1.2 Macroinvertebrates

Macroinvertebrates are aquatic organisms that include larval and adult insects, worms, mussels, clams, and snails that inhabit surface water for all or part of their life cycle. Collecting and processing macroinvertebrate samples for species identification and enumeration can be time consuming and complex. Like other aquatic organisms, macroinvertebrate species prefer specific habitats and are associated with those habitats when sampled. In lakes, these habitats include limnetic, profundal (bottom), and littoral areas. In streams, these habitats include riffles, pools, runs, streambanks, island or bar edges, tree roots, and other woody debris. Macroinvertebrates that are benthic (live in or on bed materials) are generally insect larvae, crayfish, and freshwater clams and mussels. Zooplantkton, such as microcrustaceans, represent the larges biomass of invertebrates in lakes. Consider what component of the invertebrate community is most important for meeting project objectives.

Sampling and identification methods must be closely matched to project objectives to obtain adequate assessment of macroinvertebrate communities. Methods such as fixed net or kick-net sampling can result in quantitative or qualitative data, respectively. Identification to the family or genus and species level will yield a significant difference in results. Protocols for collecting samples and identifying the macroinvertebrate community for the NAWQA Program are described in Moulton and others (2002). The advantages and disadvantages of collecting samples of benthic invertebrates by use of artificial substrates are described in Rosenberg and Resh (1993). Methods for designing sampling plans and collecting mollusks and aquatic insects for subsequent tissue analysis for chemical contaminants are described in Crawford and Luoma (1993). Personnel working on projects that include macroinvertebrate sampling are advised to consult with the OWSC macroinvertebrate expert for assistance with the latest protocols and other pertinent information.

Qualitative and quantitative methods to process benthic macroinvertebrate samples have been developed and tested by the USGS NWQL (Moulton and others, 2002). These samples are processed, cleaned, and preserved with 10 percent formalin before being sent to the laboratory (Moulton and others, 2002).

8.2.1.3 Fish

Fish are the most common vertebrates found in streams and lakes. Sampling programs must be designed to collected fish in the specific habitats they prefer. These habitats include open water and littoral areas of lakes; stream riffles, pools, runs, streambanks, and island or bar edges; and tree roots and other wood debris (Meador and others, 1993a). Sampling fish is a labor-intensive endeavor, and most identification and other measurements must be carried out in the field rather than the laboratory. It is essential that an ichthyologist be part of the sampling team. Before fish sampling is conducted, careful consideration must be given to collecting permits; protecting endangered, threatened, and special-concern species; and coordinating sampling efforts with other fish ecologists (Meador and others, 1993a).

Protocols for collecting a representative sample of fish community for the NAWQA Program are described in Meador and others (1993a), which has been superseded by Moulton and others (2002). Two complementary methods are used for collecting fish: electrofishing and seining. For electrofishing, a high-voltage potential is applied between two or more electrodes that are placed in the water to capture fish. It is required that someone certified in electrofishing be part of the sampling team. Seines are sampling devices that trap fish by enclosing or encircling them. After processing and data collection, most fish are released live back to the water body. Fish specimens that are not positively identified in the field are preserved, labeled, and returned to the laboratory for later identification.

Methods for designing sampling plans and collecting fish for subsequent tissue analysis for chemical contaminants are described in Crawford and Luoma (1993). When collecting samples for tissue analysis, proper precautions must be taken to protect samples from extraneous contaminants in the environment. Tissue samples are processed, carefully packaged, and preserved on dry ice by field crews; they must be analyzed by the USGS NWQL for chemical contaminants within 6 months of the time a sample was collected.

8.2.1.4 Habitat

Evaluation of aquatic habitat in streams and lakes is an important component of biological-water-quality investigations. Habitat assessment of streams based on a spatially hierarchical framework that incorporates habitat data at basin, segment, and reach levels and in microhabitats within the channel and flood plain. At basin and segment levels, most habitat assessments are done from maps or digital coverages. At the reach, channel, and flood-plain levels, most habitat assessments are done onsite.

Protocols for characterizing stream habitat for the NAWQA Program are described in Meador and others (1993b), which has been superseded by Fitzpatrick and others (1998). The goal of stream habitat characterization in NAWQA is to relate habitat to other physical, chemical, and biological factors that describe water-quality conditions. Procedures for collecting habitat data at basin and segment scales include the use of geographic information system databases, topographic maps, and aerial photographs. Data collected at the reach scale include measurements and observations of substrate, channel geomorphology, streamflow, and stream bank, plus riparian characteristics.

8.2.2 Microorganisms

Many water-quality studies in the WRD, and especially in the OWSC, involve the collection and analysis of samples for microorganisms of public-health significance. Three major groups of microorganisms affect water quality in the United States—bacteria, viruses, and protozoa. Different collection and processing methods for microbiological assessments have been developed to fit a variety of sampling locations and project objectives. All collection, processing, and analysis of microbiological samples must be done by use of sterile techniques.

8.2.2.1 Fecal-indicator and Pathogenic Bacteria

Samples for bacteria collected by the OWSC include those for fecal-indicator bacteria and for pathogenic (disease-causing) bacteria.

Samples for fecal-indicator bacteria are collected in streams, lakes, and ground water to assess the public health acceptability of water. Fecal-indicator bacteria are used to monitor ambient water quality for recreational, industrial, agricultural, and water supply purposes. They do not necessarily cause disease but are associated with the presence of intestinal pathogens in water; some fecal-indicator bacteria are found in the environment.

Protocols for collecting and processing samples for fecal-indicator bacteria are described in the NFM (Myers and others, 2007). Collection methods vary depending on whether samples are obtained from lakes, streams, or wells. OWSC processing protocols are described on the OWML Web site at *http://oh.water.usgs.gov/micro_index.htm*; the type of processing protocol used depends on the water source, target organism, and project objectives. Most processing methods are standard methods established by USEPA or APHA. The OWSC routinely tests waters for identification and enumeration of four types of fecal-indicator bacteria: total coliforms, *Escherichia coli* (*E. coli*), enterococci, and *Clostridium perfringens (C. perfringens)*. Except for *C. perfringens*, samples for fecal-indicator bacteria in the OWSC are generally processed in the field or in a local laboratory within 6 hours of collection using membrane-filtration or enzyme-substrate, liquid-broth methods. Samples for *C. perfringens* are processed in the OWML within 48 hours of sample collection using a membrane-filtration method.

Protocols for collecting and processing samples for pathogenic bacteria are expensive and time consuming. Because standard protocols are not available, project-specific protocols must be established and documented by the project chief.

8.2.2.2 Viruses and Coliphage

Samples for viruses collected by the OWSC include those for fecal-indicator viruses and for human enteric viruses. Coliphage are fecal-indicator viruses that infect and replicate in coliform bacteria, primarily *E. coli*. Coliphage are found in high numbers in sewage and represent the survival and transport of viruses in the environment. Human enteric viruses are pathogenic to humans and transmitted through the oral-fecal route. More than 100 types of human enteric viruses may be present in fecal-contaminated waters (Havelaar and others, 1993).

Protocols for collecting and processing samples for coliphage are described in the NFM (Bushon, 2003). Two main groups of coliphage are used by the WRD and OWSC as viral indicators: somatic and F-specific coliphage. The sampling techniques and equipment used to sample for coliphage are the same as those used for fecal-indicator bacteria, although larger sample volumes may be needed, depending on the analytical method. Analytical methods for somatic and F-specific coliphage include the single-agar layer quantitative method and the two-step enrichment presence/absence method. Both are standard methods developed by USEPA and described on the OWML Web site at *http://oh.water.usgs.gov/micro_index.htm*. Samples for coliphage are analyzed in the OWML laboratory within 48 hours of sample collection.

Protocols for collecting and processing samples for human enteric viruses are expensive and time consuming. Sampling for viruses generally involves passing large quantities of water (for example, 1,000 L of ground water or 200 L of surface water) through a positively-charged filter or ultrafilter that concentrates the viruses (Francy and others, 2004). The filter is then sent to the OWML for processing and detection of viruses. Because standard sampling and analytical protocols are not available for enteric viruses, project-specific protocols must be established and documented by the project chief. For example, collection of samples for enteric viruses by a molecular method, quantitative polymerase chain reaction (qPCR), is described for some current OWSC projects at *http://oh.water.usgs.gov/micro_projects.htm* .

8.2.2.3 Protozoa

Samples for protozoa collected in the OWSC include those for *Cryptosporidium* and *Giardia*, the principal protozoan pathogens that affect the public health acceptability of waters in the United States. Both are widely distributed in the aquatic environment and produce environmentally resistant forms (oocysts and cysts) that allow for their extended survival in water.

Protocols for collecting and processing samples for protozoan pathogens are described in the NFM (Bushon and Francy, 2007). Sampling for *Cryptosporidium* and *Giardia* involves collection of 10 L of water by the same techniques used to sample for fecal-indicator bacteria. The 10-L sample is then sent to the OWML for processing within 72 hours of sample collection. Immunomagnetic separation/fluorescent antibody (IMS/FA) is the method of choice for ambient waters. IMS/FA was established and tested by USEPA and described on the OWML Web site at *http://oh.water.usgs.gov/micro_index.htm*.

8.3 Suspended-Sediment and Bottom-Material Samples

OWSC water-quality activities occasionally include the collection of suspended-sediment and bottom-material samples.

In the OWSC, the Surface-Water Specialist is the primary technical contact for laboratory and QA/QC-related questions for suspended-sediment data. Guidelines for the collection of suspended-sediment samples are described in the surface-water quality-assurance plan for OWSC (Greg Koltun, written commun., 2007, available at *http://130.11.184.104/ohioinfo/ohio_swqap.pdf*). This publication includes pertinent WRD publications and WRD Office of Surface Water (OSW) memorandums. Suspended-sediment samples typically are analyzed by the Heidelberg College Water Quality Laboratory for concentration and by the Kentucky WSC for particle-size distribution.

Bottom-material samples may be analyzed for chemical constituents, including trace elements or hydrophobic organic compounds. Protocols for collecting and processing bottom-material samples for chemical constituents are described in the NFM (Radtke, 2005) and in Shelton and Capel (1994). Because the study sites will affect the quality of data collected, they must be carefully selected to meet project objectives. Statistical or deterministic methods can be used to select the number of sampling sites. Field personnel must be familiar with the factors involved in the selection of sediment-sampling equipment that are based on the type of analyses to be performed and hydraulic conditions, as well as special cleaning procedures that may be required when sampling for each constituent. Other considerations are methods for compositing and subsampling, holding times, and storage of samples. The project workplan should be consulted for specific guidelines for sediment sampling, depending on project objectives.

Bottom-material samples are also analyzed for microbiological constituents, mainly bacterial indicators, in the OWSC. Protocols for collecting and analyzing bottom-material samples for bacterial indicators are described in the NFM (Myers and others, 2007). Because of the spatial heterogeneity of bacteria in sediments, it is recommended that three bottom-material samples be composited from each site for microbiological analysis.

Individuals who have questions regarding the collection and handling of suspended-sediment samples should contact the Ohio WSC Surface-Water Specialist. For particular questions concerning sediment chemistry or microbiological samples, contact the QW Specialist.

8.4 Quality-Control Samples

Quality-control samples are mandated components of all OWSC water-quality studies to identify, quantify, and document bias and variability in data that result from collecting, processing, handling, and analyzing samples. Bias is the systematic, directional error measured by the use of blank, spike, or reference-material samples. Variability is random error measured by the use of environmental or QC sample replicates. The collection of chemical and microbiological data can include blanks, spikes, reference materials, and replicates. Biological and sediment QC data are generally limited to the collection of replicates.

Guidelines for the collection of specific types of QC samples and the use of QC data are provided in the NFM (Wilde, 2006, chap. A4.3). Specific guidelines for the collection and processing of QC samples must be included in the project workplan, discussed in section 3.2 of this plan. The types of QC samples to be collected and their frequency depend on study objectives, data-quality requirements, site conditions, and management or regulatory policies. **Don't just add QC samples to satisfy a general requirement; instead, add QC samples by first understanding the purpose for each QC sample and planning how you will interpret the results.** The project chief is responsible for reviewing QC data in a timely manner and implementing necessary modifications, when appropriate, to sampling and processing techniques. The QW Specialist has the responsibility for advising OWSC personnel regarding the collection and interpretation of QC samples.

8.4.1 Blank samples

The purpose of a blank is to measure the magnitude of a contaminant concentration that might be introduced into the sample through any stage in collecting, handling, or analyzing a sample. Obtain the appropriate blank water from One-Stop Shopping of the NWQL for the type of chemical analysis to be performed on the sample. See NWQL Rapi-Note 06.022 for information on blank water for chemical constituents (*http://wwwnwql.cr.usgs.gov/USGS/rapi-note/06-022.html*). Obtain buffered blank water for microbiology from a commercial supplier (see Office of Water Quality WaQI Note at *http://water.usgs.gov/usgs/owq/WaQI/WaQI05.03.pdf*) or from the OWML. Obtain sterile water for microbiological blank samples from the OWML or prepare it in-house.

- Inorganic blank water is used for inorganic constituents and suspended sediments. Don't substitute deionized water for inorganic blank water.
- Organic blank water, pesticide grade, is used for pesticide compounds and organic carbon.

- Organic blank water, N_2-purged, VOC/pesticide grade is used for volatile organic compounds, pesticides, organic carbon, and suspended sediments.
- Sterile buffered water (PO_4-$MgCl_2$) or sterile water is used for fecal-indicator bacteria and coliphage samples, respectively.

Different types of blank samples for chemical sampling include field, equipment, sampler, filter, ambient, and source-solution blanks. A field blank is most commonly collected and represents the entire sampling system. Definitions, procedures, and purposes of blank samples are described in the NFM (Wilde, 2006, chap. A4.3.1). Some blank samples for microbiological sampling are the same as those for chemical sampling (field and equipment blanks). Others are specific for a microbiological processing procedure (filter and procedure blanks for membrane filtration). Definitions and purposes for microbiological blanks are described for NAWQA microbiology but can be applied to any program within the USGS (see *http://130.11.184.104/internal/pdf/gw_qc_samples1.pdf*).

8.4.2 Replicate samples

The purpose of a replicate is identify and (or) quantify the variability in all or part of the sampling and analysis system. Replicates are considered identical or nearly identical in composition and are collected in duplicate, triplicate, or greater. Common types include concurrent, sequential, lab-replicate split, and field-replicate split replicates. Definitions, procedures, and purposes of replicate samples are described in the NFM (Wilde, 2006, chap. A4.3.2); this information can be used for chemical, microbiological, biological, and sediment samples. Replicates can be used to measure sampling, analytical, or both sampling and analytical variability. For example, a lab-replicate split is a sample collected in a single bottle that is split into replicates after having been processed and preserved to determine analytical variability.

8.4.3 Spike samples

The purpose of a spike is to identify the loss or gain of target analytes that occurred because of degradation, water-matrix characteristics, or laboratory method performance. Bias determined from spikes is termed “recovery” and reflects the amount of analyte measured as a percentage of the amount spiked. Spikes are either field or laboratory spikes. Information on spike samples can be obtained in the NFM (Wilde, 2006, chap. A4.3.3). For chemical sampling, spike solutions, spike kits, and instructions are available through the NWQL One-Stop Shopping system. For microbiological sampling, contact the OWML for information on laboratory/matrix spikes. For example, matrix spikes are recommended for coliphage samples collected as part of NAWQA microbiological sampling (see *http://130.11.184.104/internal/pdf/gw_qc_samples1.pdf*).

8.4.4 Reference samples

Reference samples are samples of known composition and are used to determine bias and variability associated with field-handling, shipping, and laboratory procedures. Information on reference samples can be obtained in the NFM (Wilde, 2006, chap. A4.3.4). Reference samples for inorganic analytes (nutrients, trace elements, major ions, precipitation, and mercury) in a natural-water matrix are available to USGS personnel from the USGS BQS (see *http://bqs.usgs.gov/srs/*). Reference samples for fecal-indicator bacteria are available from the OWML (see *http://130.11.184.104/internal/pdf/Pricelist12152006.pdf*) or a commercial supplier (see *http://130.11.184.104/internal/pdf/control_cultures_list_updated_Feb_2007.pdf*).

8.4.5 QC Samples for Biological, Bottom-Sediment, and Specialized Samples

The bias of biological and bottom-sediment data cannot be easily determined because blanks, spikes, and reference samples are not feasible or available. The variability of these data, however, can be determined by the use of replicate samples.

For algal samples, estimates of variability are based on replicate counts of algal cells, filaments, or colonies from a sample that has been split into subsamples. Bias is determined by repeatable and correct taxonomic identifications and counts among replicate or split samples. For QC purposes, one in every 10 to 20 samples are collected, split into two or more equal parts, enumerated, and taxonomically identified. Replicates for species identifications and enumerations should agree with 10–15 percent to ensure data quality. A sufficient number of samples also need to be collected to determine spatial variability. Information describing QC samples for algal data can be obtained in Moulton and others (2002).

For macroinvertebrate samples, estimates of bias and variability are made by splitting a single sample into different fractions for identification and enumeration. A similarity index value is computed on the basis of the differences between counts and identifications obtained from the various fractions (Cuffney and others, 1993). Questionable taxonomic identifications should be verified with an independent expert.

Quality-control samples for bottom-sediment chemistry and microbiology are generally limited to replicate sampling. It is possible, however, to obtain solid-phase reference materials from chemical supply companies or the National Bureau of Standards. These reference materials contain known concentrations of certain inorganic and organic constituents.

Some special needs projects may incorporate additional QC samples, such as those using specialized sampling equipment or targeting constituents not routinely sampled by the Ohio WSC. The project chief is responsible for ensuring that adequate QC data are collected and should consult the QW Specialist or Regional Specialist for advice.

8.5 Safety Issues

Because the collection of water-quality data in the field can be hazardous at times, the safety of field personnel is a primary concern. Field teams often work in areas of high traffic, remote locations, and under extreme environmental conditions. Field work involves the transportation and use of equipment and chemicals and commonly requires working with heavy machinery. Additionally, field personnel may come in contact with waterborne and airborne chemicals and pathogens while sampling or processing samples. Beyond the obvious concerns regarding unsafe conditions for field personnel, such as accidents and personal injuries, the quality of the data also may be compromised when sampling teams are exposed to dangerous conditions. Guidelines pertaining to safety in field activities are provided in the NFM (Lane and Fay, 1997, chap. A9) and in Yobbi and others, (1996); all field personnel and project chiefs are encouraged to read these documents before any field activities.

An individual has been designated as Collateral-Duty Safety Officer by the OWSC Director. The primary duty of the Safety Officer is to ensure a safe working environment for all OWSC employees. The Safety Officer provides information about safety policies and procedures applicable to field, laboratory, and office activities of OWSC personnel. Much of this information is transmitted from the Regional Safety Officer. The OWSC Safety Officer purchases safety equipment and supplies, such as gas-cartridge personal floatation devices, and monitors the safe use of equipment and vehicles. He/she also coordinates training sessions to ensure that all personnel are familiar with proper use of equipment and understand safety procedures. The Safety Officer must approve Job Hazard Analysis (JHA) for all project proposals. Personnel who have questions or concerns pertaining to safety, or who have suggestions for improving some aspects of safety, should direct those questions, concerns, and (or) suggestions to the Safety Officer or to their supervisor.

So that personnel are aware of and follow established procedures and protocols that promote all aspects of safety, the OWSC communicates information and directives related to safety to all personnel. This is done through memorandums, email, videotapes, and in-house training sessions.

All chemicals stored or used in the laboratory or in field vehicles are included a OWSC chemical inventory, updated annually by the OWSC Chemical Hygiene Officer. A complete collection of Material Safety Data Sheets (MSDS) for chemicals used in the OWSC is stored in the laboratory and by the front door. A Chemical Hygiene Plan (CHP) is updated periodically by the OWSC Chemical Hygiene Officer. Personnel are to refer to the CHP for information on the safe handling and storage of chemicals, personal protective equipment, emergency procedures, waste-disposal practices, and chemical-procurement procedures. Project personnel are required to consult the Chemical Hygiene Officer for permission to order any chemical or hazardous substance. The CHP is stored outside the laboratory so that it is available to all personnel.

8.6 References Used for the Sample Collection and Processing Section

The following table lists reports and memorandums referred to in this section. For a complete citation, refer to Section 13.0 of the report.

Table 8.6.1 Summary of references used for physical measurements and chemical constituents in water.

Reference	Subject
Davis and the Federal Interagency Sedimentation Project, 2005	Acceptable sediment and water-quality samplers.
Dossett and Bowersox, 1999	Collection and analysis of precipitation samples.
Edwards and Glysson, 1988	Representative sampling techniques for surface water.
Hem, 1989	Processes that control chemical characteristics of water.
Horowitz and others, 1994	Protocol for collecting and processing inorganic constituents at ppb concentrations.
Horowitz and others, 2001	Evaluation of a 14-L Teflon churn splitter.
Koterba and others, 1995	Collecting and processing ground-water samples (NAWQA).
Martin and others, 1992	Compare grab sampling with cross sectionally integrated sampling.
Nevers and Whitman, 2005	Lake monitoring and sampling manual.
OWQ Memorandum 97.06 (USGS)	Comparison of splitting capabilities of the churn and cone splitters.
Peden and others, 1986	QA/QC for precipitation samples.
Sandstrom, 1995	Filtration of water-sediment samples for organic compounds.
Shelton, 1994	Collecting and processing stream-water samples (NAWQA).
Shelton, 1997	Collecting samples for volatile organic compounds (NAWQA).
Stanley and others, 1998	National field quality-assurance program.
Wagner and others, 2006	Continuous water-quality monitors.
Ward and Harr, 1990	Representative sampling techniques for surface water.
Wilde, ed., 2004a (TWRI book 9, chap. A5)	Processing of water samples.
Wilde, ed., 2004b (TWRI book 9, chap. A3)	Cleaning equipment used to collect water-quality samples.
Wilde, 2005-present (TWRI book 9, chap. A6)	Field measurements.
Wilde, 2006 (TWRI book 9, chap. A4)	Collection of water samples.
Wilde and others, 2003 (TWRI book 9, chap. A2)	Selection of equipment used to collect and process water-quality samples.
Willoughby, 2000	Case study discussing methods of precipitation sampling and analysis.

Table 8.6.2. Summary of references for collecting and processing biological samples.

Reference	Sample type
Averett, 1973	Considerations for biological sampling.
Biggs, 1987	Holding times for periphyton samples.
Bushon, 2003	Fecal indicator viruses.
Bushon and Francy, 2007	Protozoan pathogens.
Charles and others, eds., 2002	Protocols for analysis of algal taxonomic samples.
Crawford and Luoma, 1993	Contaminants in tissues.
Fitzpatrick and others, 1998	Protocols for habitat assessment.
Francy and others, 2004	Sampling methods for enteric viruses.
Berkman and Canova, 2007	Algal biomass indicators.
Havelaar and others, 1993	Coliphage and viruses.
Meador and others, 1993a	Fish.
Meador and others, 1993b	Habitat.
Moulton and others, 2002	Protocols for sampling algal, invertebrate, and fish communities as part of the NAWQA Program.
Myers and others, 2007	Fecal indicator bacteria.
Rosenberg and Resh, 1993	The use of artificial substrates for benthic macroinvertebrates.

Table 8.6.3. Summary of references for collecting suspended-sediment and bottom-material samples, quality control, and safety.

Reference	Subject
Cuffney and others, 1993	Bias and variability for macroinvertebrate samples.
Lane and Fay, 1997 (TWRI book 9, chap. A9)	Safe field operations.
Moulton and others, 2002	Protocols for sampling algal, invertebrate, and fish communities as part of the NAWQA program.
Myers and others, 2007, (TWRI book 9, Chap. A7, section 7.1.2C)	Field and laboratory methods for fecal-indicator bacteria in bed materials.
Radtke, 2005 (TWRI book 9, chap. A8)	Collecting and processing bottom-sediment samples.
Shelton and Capel, 1994	Collecting and processing streambed-sediment samples.
Wilde, 2006 (TWRI book 9, chap. A4.3)	Quality-control samples.
Yobbi and others, 1996	Safe field operations.

9.0 Water-Quality Sample Handling and Tracking

All water-quality samples must be uniquely identified, documented, handled, shipped, and tracked appropriately. Following proper protocols for sample handling, shipping, and tracking ensures that samples will be processed correctly and expeditiously to preserve sample integrity between the time of collection and the time of analysis. This section describes the procedures used by the OWSC for handling, shipping, and tracking samples from collection through transfer of the samples to an analytical facility. Procedures for handling and shipping of samples are described in the NFM (Wilde, 2004a, chap. A5.5) and in Office of Water Quality Technical Memorandum 92.06. Receipt of analytical data from laboratories is covered in Section 10.0 (Water-Quality Data Management).

9.1 Preparation for Sampling

It is essential that field personnel be properly prepared with the correct equipment and supplies to perform the necessary sampling activities. Proper preparation saves time and labor costs associated with repeated sampling trips that result from inadequate planning. Therefore, before commencing field activities, the project chief or field-trip leader is responsible for ensuring that the following preparations have been completed:

- Review the sampling instructions for each site and the list of sample types required.
- Ensure that the station site file is current.
- Obtain field sheets or notebooks and analytical services request forms (ASRs). Because the PCFF software prepares all necessary forms, the use of the PCFF is preferred.
- Ensure that necessary supplies are available, such as bottles, standards, filters, preservatives, meter batteries, labels, waterproof markers, shipping containers, etc.
- Ensure that all sampling equipment is thoroughly cleaned, decontaminated, and correctly stored for field use.
- Check meters and sensors for proper performance.

A checklist prepared ahead of time that lists equipment and supplies required for the sampling trip is the best way to expedite preparations and avoid oversights that might lead to delays or error.

An ASR must accompany the samples sent to the NWQL for analysis. The ASR is prepared ahead of time in part by the project personnel. ASR forms can be obtained from the NWQL (http://wwwnwql.cr.usgs.gov/USGS/USGS_srv.html); these can be downloaded and filled out or completed electronically online. ASRs can also be generated electronically by use of the Office of Water Quality PCFF software (http://water.usgs.gov/usgs/owq/pcff.html). Using the PCFF whenever possible is preferred; field data and sample information are entered once, reducing the possibility of transcription and typographical errors.

9.2 Onsite Sample Handling and Documentation

During a sampling trip, take clear, concise field notes on standard USGS field forms, available at *http://water.usgs.gov/usgs/owq/Forms.html*. If standard forms are not used, it is the responsibility of the project chief to develop project-specific forms with approval from the QW Specialist. Field notes can also be entered directly into the PCFF, whenever possible. Check field notes for errors and completeness before leaving the site.

Ensure that sample bottles are labeled and handled appropriately for the intended analysis; otherwise, bottle mix-ups or other errors may occur, and the samples may be wasted. For example, nutrients, organics, and microbiological samples must be stored in a refrigerator or cooler at 1 to 4°C. Using the wrong labels or tape may compromise volatile organic carbon results (see NWQL Rapi-Note 05-018). The project team is responsible for ensuring that each sample is properly labeled with a permanent waterproof marker or with preprinted labels that will remain securely attached to bottles, even when they become wet. The label must include

- station identification number
- date and time of sample collection
- sample designation code (Wilde, 2004a, chap. A5, Appendixes A5−A through C)

For shipping samples to a laboratory other than the NWQL, include the station identification number, the date and time of sample collection, and any other information required by the laboratory. The label should be kept as uncluttered as possible, and only essential information for identifying the sample should be included.

9.3 Sample Shipment and Documentation

Upon completion of a sampling trip, samples should be packaged and shipped to the laboratory for analysis as soon as possible. Ship samples after sample collection and the same day whenever possible. Generally, the shorter the time between sample collection and processing and sample analysis, the more reliable the analytical results will be. Be aware of specific holding times for the types of samples being collected; lengthy field trips and short holding times may require that some samples be shipped from the field. A list of holding times for samples sent to the NWQL is available in Maloney (2005, Appendix A). Holding times for microbiological samples are listed in Myers and others (2007, Table 7.1−5) and at the OWML Web site at *http://130.11.184.104/internal/micro_services_instructions.htm*. Before shipping samples to the laboratory, the project team should complete the following tasks:

- Check that sample sets are complete and that sample bottles are labeled correctly, with all required information (see Section 9.2).
- Complete the ASRs for all samples being sent to the NWQL. If samples are being sent to a different, approved laboratory, information similar to that required on the ASRs should be provided to the laboratory.

- Pack samples carefully in shipping containers to avoid bottle breakage, shipping container leakage, and sample degradation. Check that bottle caps are securely sealed. Follow the packing and shipping protocols established by the USGS and the receiving laboratory. For additional information on shipping, refer to the NFM (Wilde, 2004a, chap. A5.5), NWQL Memorandum 02.04, and the following NWQL Rapi-Notes:

  - 01−013, Sample shipping reminder
  - 01−034, Safe shipping reminder
  - 03−032, FedEx tags on coolers
  - 04−016, Shipping potentially hazardous samples to the NWQL
  - 07−016, Sample shipment destinations and NWQL closeout information for radiochemical, stable isotope, and tritium samples not analyzed at the NWQL.

9.4 Sample Tracking Procedures

The project chief is responsible for maintaining a record of all samples collected and shipped to a laboratory for analysis to ensure the complete and timely receipt of analytical results. The record should include station identification number, sample date and time, regular and QC samples collected, QWDATA record number, date sent to the lab, and date data received from the lab. The project chief or designated project-team member is responsible for recording the required information, reviewing the record on a timely basis, and contacting the analytical laboratory for any missing data. For samples sent to the NWQL, sample status can be tracked from login to completion at *http://nwql.cr.usgs.gov/usgs/sampstatus/index.cfm*.

9.5 Chain-of-Custody Procedures for Samples

When chain-of-custody procedures are appropriate or required (for example, when data may be used in legal proceedings or samples sent to multiple laboratories), the project chief should establish, maintain, and document a chain-of-custody system for field samples that is commensurate with the intended use of the data. A sample is in custody if it is in actual physical possession or in a secured area that is restricted to authorized personnel. Every exchange of a sample between people or places that involves a transfer of custody should be recorded on appropriate forms that document the release and acceptance of the sample. The project chief is responsible for obtaining and (or) generating chain-of-custody forms. Each person involved in the release or acceptance of a sample should keep a copy of the transfer paperwork. The project chief, or designee, is responsible for ensuring that custody transfers of samples are performed and documented according to the requirements listed below.

- Containers used for shipment of samples are sealed with custody seals, which are signed and dated by the shipper and covered with tape.

- Before the shipper is released from custody of the samples, laboratory personnel receiving the samples carefully examine the shipping container to ensure that opening or tampering with the container has not occurred.

- The project chief should ensure that the laboratory is correctly following its own internal chain-of-custody procedures for sample tracking.
- A copy of the chain-of-custody documentation is kept in the project site folder and maintained in the OWSC office for 3 years after completion of the project or until all customers are satisfied that there is no longer a need for ready access to it, whichever is later.

9.6 References Used for the Sample Handling and Tracking Section

The following table lists reports and memorandums referred to in this section. For a complete citation, refer to Section 13.0 of the report.

Table 9.6.1. Summary of references for handling and tracking water-quality samples.

Reference	Subject
Maloney, 2005	List of hold times for samples sent to the NWQL.
Myers and others, 2007	Holding times for samples for analysis of fecal indicator bacteria.
NWQL Memorandum 02.04	Requirements for shipping samples to the NWQL.
NWQL Rapi-Notes 05-018,	USGS employees can access Rapi-Notes at http://wwwnwql.cr.usgs.gov/USGS/rapi-note.html.
OWQ Technical Memorandum 92.06	Shipping samples.
Wilde, 2004a (TWRI book 9, chap. A5)	Processing water samples.

10.0 Water-Quality Data Management

Water-quality data that are collected for hydrologic investigations are recorded on paper and stored electronically. Chemical, physical, biological, and ancillary data measured in the field are recorded directly onto standard USGS field forms or entered into the PCFF; field data entered into the PCFF must be printed before leaving the site. Because of the elimination of data transfer errors, the use of the PCFF is recommended; the current electronic version can be downloaded at *http://water.usgs.gov/usgs/owq/pcff.html*. Data typically are stored either in the NWIS QWDATA database (U.S. Geological Survey, 2007a) or in the NWIS-ADAPS database (U.S. Geological Survey, 2007b). NWIS user manuals are available online for the latest NWIS version. The NWIS is the storage and data-dissemination system for water-quality, streamflow, well, and water-use information collected by the USGS. There are two local NWIS databases within the OWSC; database 01 is for ambient environmental data, whereas database 04 is for quality control data. Data that cannot be stored in these national databases may be stored in other databases, such as project databases.

10.1 Processing Data

Sampling information, field determinations, and ancillary information are recorded on water-quality field notes that are considered original record. These data are combined with analytical data from the laboratory in computer data files and paper files. Sample information and field data are entered into QWDATA upon return from the field by a designated member of the project team (sample login). Data from the NWQL are retrieved automatically once a week.

Data analyzed by laboratories other than the NWQL or those in the QWDX system must be entered into NWIS, if possible (Hubbard, 1992), and identified according to the analyzing laboratory. Data entry is the responsibility of the project chief.

10.1.1 Continuous Monitoring Data

Continuous monitoring data are water-quality records (water temperature, conductivity, etc.) that are transmitted at regular hourly or 4-hour intervals, depending on the site. The signal is received by the local readout ground station (LRGS). The Satin (Satellite system) transfers data from the LRGS to the NWIS server. The Sentry system processes the data on the NWIS server, decodes the data to a standard format, and automatically loads the data into NWIS. Once processed, the raw input data are automatically archived. More information about the LRGS can be found at *http://wwwnwis.er.usgs.gov/datarelay/lrgs/lrgs_goes.html*. In general, data are not manipulated by the field instrument or a computer except to convert recorded signals into data in engineering units or to display data in a convenient format. The transfer of data from the electronic storage medium to NWIS requires thorough checking to ensure that the data have transferred successfully or that as much data as possible have been recovered and errors identified (WRD Memorandum 87.085).

In addition to the telemetered data, continuous monitoring data are downloaded from the recorder to a computer or other storage device during routine site visits (backup data). These data are processed in the office as soon as possible and archived in NWIS. More information on WRD policy pertaining to electronically recorded data is contained in WRD Memorandum 87.085.

Continuous monitor site inspections and data are processed as described in Wagner and others (2006) and the OWSC QA/QC plan for continuous monitors (Appendix B). This includes daily review of sensor function and deletion or flagging of spurious data, if necessary, for sites equipped with telemetry.

10.1.2 Analytical Data

Analytical data are results of field and laboratory chemical, physical, or biological determinations. Most water-quality samples are analyzed in the field, at the NWQL, or at the OWML. In some cases, samples may be analyzed by research laboratories or by laboratories outside of the USGS (see Section 4.1).

In order to enter analytical data into the NWIS database, a site identification number must first be assigned and entered into the OWSC site file (see Section 7.2). Field measurements are entered into the NWIS database by the project team as soon as possible after returning from the sampling field trip. A record number is assigned by the system and is recorded on the field form and (or) a project-specific logsheet (see example below). Sample logging is required for data from the NWQL or OWML to successfully transfer the data into the database.

Environmental-sample data are entered into the OWSC NWIS QWDATA database 01; QA/QC data are entered into the OWSC NWIS QWDATA database 04.

Station number	Date/ time	Schedules requested	NWIS record number	Lab ID number	Station number	Date/ time	Schedules requested	NWIS record number	Lab ID number
0208500	Sept. 21, 1993/	1043	993000025						
"	"	542	"						
0209754	Oct. 4, 1993/								

Figure 10.1.2. Example of a project-specific logsheet.

All data from the NWQL are automatically transferred to the appropriate OWSC database with a cron job once a week. The QW Database Manager prints the Watlists and sorts them by project number. Watlists are output files produced by batch input programs that contain (a) a listing of the records that were updated, (b) a cation-anion balance table if the balance can be computed, and (c) a listing of any generated error messages. Watlists for samples and results successfully loaded into QWDATA are given to the QW Specialist, who reviews them for general content and distributes them to project personnel. The QW Database Manager also distributes rejected records and works with project personnel to make corrections. Samples that have not been entered into NWIS or samples with incorrect site header information will be rejected by the local database. For details on processing data from the NWQL, refer to Appendix A.

Data from some laboratories other than the NWQL are generally retrieved through the QW Data Transfer System (QWDX) (*https://qwdx.cr.usgs.gov/*). Local database users can set up automated downloads of data from analytical laboratories (see Office of Water Quality WaQI Note 2007.12 at *http://water.usgs.gov/usgs/owq/WaQI/WaQI07.12.pdf*). Data are entered and stored according to procedures already described for processing NWIS analytical data. Appropriate codes are used to identify the data as originating from non-USGS sources.

10.1.3 Non-National Water Information System Databases

Sometimes data collected by project personnel cannot be entered into the OWSC NWIS QWDATA database because the cooperator required a different system (such as data collected for some military projects) or because NWIS cannot accept the type of data that are generated by the project (for example, taxonomic data or microbiological research data). In these cases, project databases may be established to accommodate the data storage requirements and formats. Project databases that are the sole repository for project data should have a written procedure for data entry, storage, and long-term backup and archival. The project chief has the responsibility for developing and implementing management of project databases.

10.2 Validation (Records Review)

Data validation is the process whereby water-quality and associated data are checked for completeness and accuracy. After validation, data records are finalized in the OWSC database.

10.2.1 Continuous Monitoring Data

Following the entry of continuous monitoring data into NWIS, original data and (or) graphs of original data are reviewed by water-quality-monitor staff or the Surface-water Specialist for anomalous values, dates, and times, and preliminary updating is done. Additional field inspections will be done if original data suggest equipment problems. After each site visit, the following will be completed:

- run backup data into NWIS
- remove or flag (as bad) any anomalous unit values in HYDRA (PR–2 in Adaps)
- update water-quality monitor Excel spreadsheets
- update NWIS with any necessary fouling or drift corrections

Throughout the year, the water-quality-monitor project chief will check the data and corrections and will put the data into "in-review" status. Once the data are compiled for the entire year, the record is checked and reviewed by water-quality-monitor staff and then submitted to the water-quality monitor project chief for final review and approval for the annual water-data report. A detailed discussion on validation (record review) of water-quality monitors is provided in Wagner and others (2006).

10.2.2 Analytical Data

All field notes and field measurements are reviewed for completeness and accuracy by the project chief or designated project team member. If possible, this should be done within 7 days after returning from the field trip.

All data entered into NWIS QWDATA appear in the analytical output file (Watlist) that includes sample header information, analytical results, method information, and any data qualifiers (U.S. Geological Survey, 2007a, Appendix C, 3.8). Quality-control checks are done by the NWIS software and QC failure flags are also listed on the Watlists. Among the most common QC failure flags are the following:

- Cation/anion balance that is not within the allowable range.
- Sizeable differences between field and laboratory values for pH, specific conductance, and alkalinity.
- A ratio of dissolved solids to specific conductance that is below 0.55 or above 0.86.
- Sizeable differences between determined and calculated values for dissolved solids.
- A dissolved concentration of a particular metal species or organic carbon that is greater than the total concentration.
- A concentration of a constituent that exceeds Federal or State drinking-water standards.

A detailed discussion of these QC failures and appropriate remedies are provided in NWQL Technical Memorandum 93-02 and Brown and others (2003).

Field and laboratory analyses, such as pH, specific conductance, and alkalinity, are compared to confirm agreement of independent measurements. If data from more than one sample are available for a site, the analysis also is compared with previous analyses within a hydrologic context to identify obvious errors, such as decimal errors, and possible sample mix-ups or anomalies warranting analytical reanalysis. These reports and comparisons are reviewed and noted on the Watlist. It is the responsibility of the project chief to ensure that the Watlists are carefully reviewed in a timely manner for failure flags, errors, and omissions and to take appropriate corrective action. Errors and omissions in the database may be changed by the QW Specialist, the QW Database Manager, or other employees designated by the QW Specialist.

An excellent way for the project team to review project data is to tabulate or graph environmental and QA data. The types of tables that can be generated through QWDATA are described in the NWIS users manual (U.S. Geological Survey 2007a, Section 3.4). Results from environmental samples are reviewed for completeness, and questionable values are noted. The QA data are evaluated in conjunction with the environmental samples to assess the quality of data resulting from field and laboratory activities. For example, results from field blanks are examined for sampling bias, and results from replicate samples are examined for sampling and laboratory variability. If an error is detected, the affected data are corrected or qualified, as appropriate; contact the QW Specialist for assistance. If the cause of the error can be determined, action is taken to remedy the problem.

Quality-control data on analytical results from the NWQL may also be used by OWSC personnel to validate data. The BQS operates the Inorganic Blind Sample Program (IBSP) through the QADATA application (*http://bqs.usgs.gov/bsp/mainpage.html*) and the Organic Blind Sample Program (OBSP) (*http://bqs.usgs.gov/OBSP/index.html*). The monthly report generated by the QADATA application includes statistical tables, control charts, and precision plots. Statistical data tables, box plots, time series charts, and summary reports are available through the OBSP.

Prompt review is necessary to allow analytical reanalysis to be performed before sample holding times have been exceeded for accuracy and precision. Because sample holding times vary for different constituents, it is OWSC policy for the project chief to review analytical results immediately upon receipt.

Requests to the NWQL for reanalysis are made by USGS employees through the NWQL sample status page (*http://nwql.cr.usgs.gov/usgs/sampstatus/index.cfm*). Requests to the OWML are made by contacting laboratory personnel through an email request. Reanalysis requests are logged and tracked by the project chief by recording the request on the primary printout and project-specific logsheet.

Once the analysis has been rerun and the results are received, the project chief does one of the following: (a) accepts the original value, (2) updates the original value to the rerun value, or (3) deletes both original and rerun values. The decision is noted on the primary printout and project-specific logsheet. Corrections to NWIS resulting from reruns by the NWQL must be made to the laboratory database as well as to the OWSC database (through the QW Database Manager) and are made by the project chief or his/her designee by email request to LABHELP (email address is GS-W-COden NWQL LabHelp).

The data quality indicator (DQI) is a result-level field in NWIS that is used to indicate the quality and ultimate distribution of the data (see OWQ Technical Memorandum 02.15 for additional information). The default setting is "S" for "presumed satisfactory." Beginning in 2008, the DQI will be changed through the use of batch files by the QW Database Manager to

"R" for "reviewed and accepted" each year after the annual data report is published. The use of other DQIs or the changing of individual results (usually to "Q" for "reviewed and rejected") requires approval and assistance from the QW Specialist.

10.2.3 Annual Data Report

Although data checks are made by the project chief and the project team throughout the year, the final check is done after the water year while preparing the annual data report to ensure that data are accurate in both NWIS and local files. The project chief (or project team member) uploads the data into the SIMS, where a table is created. The project chief (or project-team member) checks the table for completeness and accuracy. The table is then forwarded to an independent reviewer (who is not on the project team), who will complete the annual-data-report checklist (Appendix D). The table is subject to final review by the QW Specialist. Following approval by the QW specialist, the QW Database Manager is notified to change the DQI codes of the data in NWIS. A description of the types of data that are required to be listed in the annual data report is in Appendix E. Research methods are generally not included in the annual data report; these are methods that do not meet the criteria of approved methods as outlined in Office of Water Quality Technical Memorandum 98.05.

10.3 Data Storage

In accordance with WRD policy, all water data collected as part of routine data collection are stored in the NWIS computer database. Data collected by others, such as cooperators, universities, or consultants, which are used to support published USGS documents and are not published or archived elsewhere, also should be entered into NWIS; however, these data must be flagged with the appropriate DQI code and identified according to analytical laboratory and collection organization. Other outside data may be entered into the database at the discretion of the QW Specialist if data-collection methods and quality have been reviewed and found to be acceptable. Quality-assurance data are stored in a separate database (database 04) in NWIS and are identified by special medium codes and sample types. Electronically stored data that cannot be entered into NWIS are stored in project databases online or offline. The NWIS QWDATA database receives daily incremental backup and weekly full backup. The project chief has responsibility for maintaining backups of data not stored in NWIS.

In addition to electronically stored data, other project data and information, including field notes, ASRs, Watlists, and site information, are retained in station folders and maintained in the project office by the project chief while the project is active.

10.4 Records Archival

According to WRD policy, all original data that are published or support published scientific analyses shall be placed in archives (WRD Memorandum 92.059; Hubbard, 1992). Original data—from automated data-collection sites, laboratories, outside sources, and non-automated field observations—are unmodified data as collected or received and in human-readable, conventional units (engineering units, generally with a decimal). Original data should be preserved in this form, no matter how they may be modified later (Hubbard, 1992).

Original time-series data (such as specific conductance and temperature values) received from automated data-collection sites should be preserved at the first point where they are readily accessible to USGS personnel for inspection and verification and before any editing or application of corrections and adjustments are performed. This is usually after the original data have been translated or converted (by DECODES, for example) to a human-readable format (WRD Policy Memorandum No. 99.33). Such original time-series data are automatically preserved once they are entered into ADAPS/NWIS. The original data (as downloaded) should be saved until 1 year after the translated, original data have been inspected, verified, and published in case any errors are found; then the original data can be discarded. Similarly, primary computations (printouts of unit values for a water-quality parameter) may be destroyed 1 year after the data have been verified and published (U.S. Geological Survey, 2006a, b) because unit values (data entered into NWIS after about 1984) may now be reproduced on demand from NWIS or from archived files on the Sun server.

Other original data in electronic format may include data from outside sources or laboratories or data that cannot be stored in NWIS such as taxonomic data or microbial research data. These data should be archived in a nonproprietary format, if possible, so that they can be available in the future. Tab- or comma-delimited files are preferred. Include a readme.txt file that will allow others to use and understand the file. For example, the readme.txt file should include the analytical laboratory (and a contact name and phone number) and should define what is in each column of the table, units of measurement, and naming conventions. Lab sample identification numbers should be included with local database record numbers. For a digital database, the readme.txt documentation also should include information about the database table or file structure, copies of customized program code, and information about any algorithms used by the database to calculate results (U.S. Geological Survey, 2006b). Electronic data and readme.txt files should be copied to stable long-term media, such as CD-R, after inspection by the OWSC archive coordinator.

Original data on paper may include field notes, field measurements, continuous-recorder site-inspection records, supplemental QA field sheets, chain-of-custody forms, ancillary data, alkalinity calculations, Analytical Services Request (ASR) forms, rerun request forms, sample-preservation test results, records on sample acceptance or rejection, and calibration notes. These data are archived within 1 year of project completion or termination or if basic data are more than 10 years old. It is the responsibility of the project chief to ensure that project files and documentation entered into the OWSC archive are organized and complete. It is important that USGS site identification numbers be written on all paper forms. The OWSC archive is maintained by the OWSC archive coordinator, who will check the archived project material for completeness and will forward materials to the Federal Records Center (long-term archives). Contact the OWSC archive coordinator for complete instructions on archiving project materials.

Advances in database storage capabilities have eliminated the need to retain some paper records that were archived in the past, including Watlist printouts. Measurement data generated by the NWQL are stored in NWIS, and the associated intralaboratory quality-control (QC) data are stored in Laboratory Information Management System (LIMS). The laboratory QC data can be retrieved from the NWQL LIMS by the station identification number or by date and time of sample collection, as needed. Therefore, Watlist printouts can be destroyed 1 year after the project is completed or the water-quality data have been inspected, verified, and published (U.S. Geological Survey, 2006a). To facilitate retrieval of data from LIMS, some projects create tables linking the station identification number to record numbers (an NWIS reference to a given sample at that site) to the laboratory identification number for a sample. These tables should become part of the project case file and should be retained either electronically on CD-R or archived with the project paper files.

Finally, note that meter-calibration records are maintained and filed by meter, not by sample station or project. Therefore, meter-calibration notebooks will cover multiple samples and may span the life of several projects. Such notebooks should not be archived with project files.

10.5 References Used for the Water-Quality Data Management Section

The following table lists reports and memorandums referred to in this section. For a complete citation, refer to Section 13.0 of the report.

Table 10.5. Summary of references for managing water-quality data and records.

Reference	Subject
Brown and others, 2003	Methods for quality-assurance review of water-quality data (New Jersey).
Hubbard, 1992	Policy recommendations for managing and storing hydrologic data.
NWQL Technical Memorandum 93-02	Review process for samples analyzed at the NWQL.
OWQ Technical Memorandum 98-05	Policy for approved methods and the Annual Data Report.
OWQ Technical Memorandum 02.15	Use of data-quality indicators.
U.S. Geological Survey, 2006a	Records deposition schedule, USGS Manual.
U.S. Geological Survey, 2006b	Records deposition schedule, prepared by WRD Scientific Records Committee.
U.S. Geological Survey, 2007a	NWIS QWDATA user's guide.
U.S. Geological Survey, 2007b	ADAPS user's guide.
WRD Memorandum 87.085 (USGS)	Policy for collecting and archiving electronically recorded data.
WRD Memorandum 92.059 (USGS)	Policy for the management and retention of hydrologic data.
WRD Memorandum 99.33 (USGS)	Preservation of Original Digital Field Data.
Wagner and others, 2006	Guidelines and standard procedures for continuous water-quality monitors.

11.0 Publication of Water-Quality Data

The U.S. Geological Survey Manual (Section 1100.3, available at http://www.usgs.gov/usgs-manual/1100/1100-3.html) defines an information product as the compilation of scientific communication or knowledge such as facts, data, or interpretations in any medium (for example, print, digital, Web) or form, including textual, numerical, graphical, cartographic, or audiovisual, to be disseminated to a defined audience or customer, scientific or nonscientific, internal or external. The term "data" refers to uninterpreted observations or measurements, usually quantitative measurements resulting from field observations and laboratory analyses of water, sediment, or biota.

Water-quality data are published through a USGS publication series, by cooperating agencies and organizations, by scientific and technical societies, or by other publishing organizations. The selection of the appropriate publication outlet for water-quality data will be the responsibility of project chief, with approval from his/her supervisor; a report expert may need to be consulted. A summary of USGS policies on the publication of scientific data is contained in the U.S. Geological Survey Manual (Section 1100.3, available at http://www.usgs.gov/usgs-manual/1100/1100-3.html). Other references that should be consulted when writing reports include "Suggestions to Authors ..." (Hansen, 1991) and the U.S. Government Printing Office Style Manual (U.S. Government Printing Office, 2000).

Report approvals are done per USGS Fundamental Science Practices polices (http://internal.cr.usgs.gov/fsp/), described in the U.S. Geological Survey Manual (Section 502.4, available at http://www.usgs.gov/usgs-manual/500/502-4.html). All USGS information products containing new interpretive information and (or) that are policy sensitive are required to undergo Bureau approval prior to release. Water Science Center Directors have delegated authority for Bureau approval of information products that do not contain new interpretive information.

11.1 Hydrologic Data Reports

All nonproprietary water-quality data collected during the water year are published in the WRD annual data report, "Water Resources Data for the United States, Water Year ___," or in individual project data reports. Hydrologic data reports make water-quality data available to users, but without interpretations or conclusions.

11.2 Interpretive Reports

Interpretive results or conclusions require colleague review and Bureau approval at the regional level for publication. Release of preliminary interpretations prior to final approval is prohibited to avoid disseminating incomplete and (or) incorrect conclusions, which are subject to change as a result of subsequent technical and policy reviews.

Interpretive reports include such USGS outlets as Circulars, Professional Papers, Fact Sheets, Scientific Investigation Reports, and Open-File Reports, as well as non-USGS outlets, such as scientific journals, books, and proceedings of technical conferences. The QW Specialist, project supervisor, and outside technical specialists will provide guidance in ensuring that each water-quality report meets the highest technical standards.

11.3 Other Data Outlets

Water-quality data are released to the public through NWISWeb (*http://waterdata.usgs.gov/nwis/*). Before 2007, the data were aggregated annually for NWISWeb through a manual process. These annual aggregations occurred after the USGS annual water data reports were published and included only data from previous years. As of 2007, water-quality data have been aggregated automatically and more frequently (see Office of Water Quality Technical Memorandum 2007.03 and 2007.04). Therefore, it is important to follow these guidelines:

- Be careful to use the correct qualifiers during sample login, especially for proprietary and internal-use-only samples.
- More timely review of analytical results may be needed, because provisional data will be supplied to Internet users.
- Use DQI codes to document the review and Web transfer status of results.

Constituents in water samples collected by or for the USGS that exceed USEPA Maximum Contaminant Levels (MCLs) for drinking water, as specified in the National Primary Drinking Water Regulations, are promptly reported by the project chief to appropriate agencies that have a need to know (WRD Memorandum 90.038).

11.4 References Used for the Publication Section

The following table lists reports and memorandums referred to in this section. For a complete citation, refer to Section 13.0 of the report.

Table 11.4. Summary of references for publishing data.

Reference	Subject
Hansen, 1991	Suggestions to authors of USGS reports.
OWQ Technical Memorandum 2007.03	Changes to NWISWeb aggregation
OWQ Technical Memorandum 2007.04	Controlling flow of water-quality data to NWISWeb
U.S. Geological Survey Manual	Guidance on release of information and reports policy
U.S. Government Printing Office, 2000	Style manual for printed government documents.
WRD Memorandum 90.038 (USGS)	Policy for reporting Maximum Contaminant Level exceedances.

12.0 Water-Quality Training and Reviews

Periodic reviews of data-collection procedures are used to evaluate the effectiveness of training programs and to determine whether technical work is being conducted correctly and efficiently. Such reviews also are used to identify and resolve problems before they become widespread and potentially compromise the quality of the data.

12.1 Training

Employee training is an integral part of water-quality activities, allowing current employees to maintain and enhance their technical knowledge and new employees to gain the specific skills needed to adequately perform their job. A well-documented training program not only ensures that samples are collected correctly by technically competent personnel but also lends legal credibility to data and interpretations.

Individual training plans are developed by the supervisor and employee at least annually as part of the performance-review process. The OWSC Training Officer is responsible for informing OWSC staff about the availability of training—in-house, USGS, U.S. Government, and other sources of training. The QW Specialist provides recommendations and advice to supervisors and their staff as needed. The OWSC Director has authority and responsibility for approving training opportunities. In addition, staff are responsible for taking full advantage of the training provided. Training documents are maintained in OWSC personnel files by the OWSC Training Officer and Personnel Officer.

Primary sources of water-quality training are USGS courses, usually taught at the National Training Center at the Denver Federal Center; regional training; cyberseminars, and OWSC seminars or in-house training courses. These training courses fill most of the formal water-quality training needs of OWSC personnel. The QW Specialist plays an important role in providing in-house training. OWSC in-house training is used to instruct personnel of changes in prescribed practices and procedures and related USGS polices and programs.

Training of new employees in water-quality work varies according to the needs of the project, but it usually consists of a combination of on-the-job training and formal training courses. On-the-job training is conducted by an experienced technician or hydrologist.

12.2 Reviews

The OWSC policy is to do technical reviews of a project at approximately the 10-, 40-, and 70-percent stages of completion. For projects of short duration, technical reviews are held less frequently. It is the responsibility of the project chief to provide management and the QW Specialist with a list of review dates in the project workplan. The project chief is also responsible for ensuring that all review materials are provided to the reviewers in advance of the project-review meeting. The supervisor and QW Specialist will require a list of review dates and completed reviews during quarterly project reviews. For new projects, the project chief will need to complete a project start-up check list and submit to the QW Specialist for review (Appendix C).

Reviews of sample collection and analysis activities and management of water-quality data are conducted in the field or laboratory by the QW Specialist or a designated reviewer. For long-term projects (3 or more years), these reviews are generally done every 3 years. For short-term projects, reviews may be done during the data-collection period as requested by the supervisor or QW Specialist. Reviews are completed in a timely manner, and comments are documented by the reviewer in a memorandum to the project chief and reviewed individual with a copy to his/her immediate supervisor. Reviews address sample collection and processing techniques; compliance with WRD, OWQ, and OWSC policies; data management procedures; and any other activities pertaining to the collection of high-quality data. When deficiencies are noted, the reviewer, in consultation with the QW Specialist, is responsible for identifying corrective actions. The immediate supervisor is responsible for ensuring that, once identified, corrective actions are implemented and completed in a timely manner.

13.0 References

Averett, R.C., 1973, Biological sampling and statistics, *in* Slack, K.V., and others, eds., Methods for collection and analysis of aquatic biological samples: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A4, p. 6–26.

Averett, R.C., and Schroder, L.J., 1994, A guide to the design of surface-water-quality studies: U.S. Geological Survey Open-File Report 93–105, 39 p.

Berkman, J. H., and Canova, M.G., 2007, Algal biomass indicators, *in* National field manual for the collection of water- quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A7.4. [variously paged].

Biggs, B.J.F., 1987, Effects of sample storage and mechanical blending on the quantitative analysis of river periphyton: Freshwater Biology, v. 18, no. 2, p. 197–203.

Brown, G.A., Pustay, E.A., and Gibs, Jacob, 2003, Methods for quality-assurance review of water-quality data in New Jersey: U.S. Geological Survey Open-File Report 02–383 [variously paged].

Brunett, J.O., Barber, N.L., Burns, A.W., Fogelman, R.P., Gillies, D.C., Lidwin, R.A., and Mack, T.J., 1997, A quality-assurance plan for district ground-water activities of the U.S. Geological Survey: U.S. Geological Survey Open-File Report 97–11, 21 p.

Bushon, R.N., 2003, Fecal indicator viruses, *in* National field manual for the collection of water-quality data—Biological indicators: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A7.2, 24 p.

Bushon, R.N., and Francy, D.S., 2003, Protozoan pathogens, *in* National field manual for the collection of water-quality data—Biological indicators: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A7.3, 24 p.

Charles, D.F., Knowles, C., and Davis. R.S., eds., 2002, Protocols for the analysis of algal samples collected as part of the U.S. Geological Survey National Water-Quality Assessment Program: Philadelphia, Pa., The Academy of Natural Sciences, 124 p.

Crawford, J.K., and Luoma, S.N., 1993, Guidelines for studies of contaminants in biological tissues for the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 92–494, 69 p.

Cuffney, T.F., Gurtz, M.E., and Meador, M.R., 1993, Methods for collecting benthic invertebrate samples as part of the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 93–406, 66 p.

Davis, B.E., and the Federal Interagency Sedimentation Project, 2005, A guide to the proper selection and use of federally approved sediment and water-quality samplers, U.S. Geological Survey Open-File Report 2005–1087, 20 p.

Dossett, S.R., and Bowersox, V.C., 1999, National trends network site operation manual: Champaign, Ill., National Atmospheric Deposition Program Office at the Illinois State Water Survey, NADP Manual 1999–01 [variously paged], accessed August 2007 at *http://nadp.sws.uiuc.edu/lib/manuals/opman.pdf*

Edwards, T.K., and Glysson, G.D., 1988, Field methods for measurement of fluvial sediment: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. C2, 89 p.

Fitzpatrick, F.A., Waite, I.R., D'Arconte, P.J., Meador, M.R., Maupin, M.A., and Gurtz, M.E., 1998, Revised methods for characterizing stream habitat in the National Water-Quality Assessment Program: U.S. Geological Survey Water-Resources Investigations Report 98–4052, 77 p., accessed August 2007 at *http://water.usgs.gov/nawqa/protocols/WRI98-4052/index.html*

Francy, D.S., Jones, A.L., Myers, D.N., Rowe, G.L., Eberle, C.M., and Sarver, K.M., 1998, Quality-assurance/quality-control manual for collection and analysis of water- quality data in the Ohio District, U.S. Geological Survey: U.S. Geological Survey Water-Resources Investigations Report 98–4057, 71 p.

Francy, D.S., Bushon, R.N., Stopar, Julie, Luzano, E.J., and Fout, G.S., 2004, Environmental factors and chemical and microbiological water-quality constituents related to the presence of enteric viruses in ground water from small public water supplies in southeastern Michigan: U.S. Geological Survey Scientific Investigations Report 2004–5219, 60 p.

Hansen W.R., ed., 1991, Suggestions to authors of the reports of the United States Geological Survey (7th ed.): Washington, D.C., U.S. Government Printing Office, accessed October 2007 at *http://www.nwrc.usgs.gov/lib/lib_sta.htm*, 289 p.

Havelaar, A.H., van Olphen, M., and Drost, Y.C., 1993, F-specific bacteriophages are adequate model organisms for enteric viruses in fresh water: Applied and Environmental Microbiology, v. 59, no. 9, p. 2956–2962.

Hem, J.D., 1989, Study and interpretation of the chemical characteristics of natural water (3d ed.): U.S. Geological Survey Water-Supply Paper 2254, 263 p.

Horowitz, A.J., Demas, C.R., Fitzgerald, K.K., Miller, T.L, and Rickert, D.A., 1994, U.S. Geological Survey protocol for the collection and processing of surface-water samples for the subsequent determination of inorganic constituents in filtered water: U.S. Geological Survey Open-File Report 94–539, 57 p.

Horowitz, A.J., Smith, J.J., and Elrick, K.A., 2001, Selected laboratory evaluations of the whole-water sample-splitting capabilities of a prototype fourteen-liter Teflon churn splitter: U.S. Geological Survey, Open-File Report 01–386, 12 p.

Hubbard, E.F., 1992, Policy recommendations for management and retention of hydrologic data of the U.S. Geological Survey: U.S. Geological Survey Open-File Report 92–56, 32 p.

Koterba, M.T., Wilde, F.D., and Lapham, W.W., 1995, Ground-water data-collection protocols and procedures for the National Water-Quality Assessment Program—Collection and documentation of water-quality samples and related data: U.S. Geological Survey Open-File Report 95–399, 113 p.

Lane, S.L., and Fay, R.G., 1997, Safety in field activities, *in* National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water- Resources Investigations, book 9, chap. A9 [variously paged].

Lapham, W.W., Wilde, F.D., and Koterba, M.T., 1997, Guidelines and standard procedures for studies of ground-water quality—Selection and installation of wells, and supporting documentation; U.S. Geological Survey Water-Resources Investigations Report 96–4233, 100 p.

Martin, G.R., Smoot, J.L., and White, K.D., 1992, A comparison of surface-grab and cross sectionally integrated stream-water-quality sampling methods: Water Environment Research, v. 64, no. 7, p. 866–876.

Martin, J.D., and Cohen, D.A., 1994, Policy and procedures for the management and archival storage of data collected for hydrologic investigations of the U.S. Geological Survey, Indiana District: U.S. Geological Survey Open File Report 94–61, 21 p.

Maloney, T.J., ed., 2005, Quality management system—U.S. Geological Survey National Water Quality Laboratory: U.S. Geological Survey Open-File Report 2005–1263 [variously paged].

Meador, M.R., Cuffney, T.F., and Gurtz, M.E., 1993a, Methods for sampling fish communities as part of the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 93–104, 40 p.

Meador, M.R., Hupp, C.R., Cuffney, T.F., and Gurtz, M.E., 1993b, Methods for characterizing stream habitat as part of the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 93–408, 48 p.

Moulton, S.R., Kennen, J.G., Goldstein, R.M., and Hambrook, J.A., 2002, Revised protocols for sampling algal, invertebrate, and fish communities as part of the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 02–150, 75 p.

Mueller, D.K., Martin, J.D., and Lopes, T.J., 1997, Quality-control design for surface- water sampling in the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 97–223, 17 p.

Myers, D.N., Stoeckel, D.M., Bushon, R.N., Francy, D.S., and Brady, A.M.G., 2007, Fecal indicator bacteria, *in* National field manual for the collection of water-quality data—Biological indicators: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A7.1 [variously paged].

Nevers, M.B., and Whitman, R.L., 2005, Lake monitoring field manual: U.S. Geological Survey report, accessed July 2007 at *http://www.glsc.usgs.gov/_files/research/InlandLakesManual.pdf*

Peden, M., Bachman, C., Brennan, C., Demir, B., and James, K., 1986, Development of standard methods for the collection and analysis of precipitation: Washington, D.C., U.S. Environmental Protection Agency, EPA/600/4-86/024.
Pritt, J.W., and Raese, J.W., eds., 1995, Quality assurance/quality control manual—National Water-Quality Laboratory: U.S. Geological Survey Open-File Report 95– 443, 35 p.
Radtke, D.B., 2005, Bottom-material samples, *in* National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A8, 60 p.
Rosenberg, D.M., and Resh, V.H., 1993, Freshwater biomonitoring and benthic macroinvertebrates: New York, Chapman and Hall, chap. 6, p. 175–233.
Sandstrom, M.W., 1995, Filtration of water-sediment samples for the determination of organic compounds: U.S. Geological Survey Water-Resources Investigations Report 95–4105, 13 p.
Schroder, L.J., and Shampine, W.J., 1992, Guidelines for preparing a quality-assurance plan for the district offices of the U.S. Geological Survey: U.S. Geological Survey Open-File Report 92–136, 14 p.
Schroder, L.J., and Shampine, W.J., 1995, Guidelines for preparing a quality-assurance plan for the district water- quality activities of the U.S. Geological Survey: U.S. Geological Survey Open-File Report 95–108, 12 p.
Shampine, W.J., Pope, L.M., and Koterba, M.T., 1992, Integrating quality assurance in project work plans of the U.S. Geological Survey: U.S. Geological Survey Open-File Report 92–162, 12 p.
Shelton, L.R., 1994, Field guide for collecting and processing stream-water samples for the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 94–455, 42 p.
Shelton, L.R., 1997, Field guide for collecting samples for analysis of volatile organic compounds in stream water for the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 97–401, 14 p.
Shelton, L.R., and Capel, P.D., 1994, Guidelines for collecting and processing samples of streambed sediment for analysis of trace elements and organic contaminants for the National Water-Quality Assessment Program: U.S. Geological Survey Open-File Report 94–458, 20 p.
Stanley, D.L., Shampine, W.J., and Schroder, L.J., 1998, Summary of the U.S. Geological Survey National Field Quality-Assurance Program from 1979 through 1997: U.S. Geological Survey Open-File Report 98–392, 11 p.
U.S. Department of the Interior, 2007, U.S. Geological Survey manual: Accessed November 19, 2007, at *http://www.usgs.gov/usgs-manual/* [variously paged].
U.S. Geological Survey, 1997–present, National field manual for the collection of water- quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chaps. A1–A9 [variously paged]. [Chapters were published from 1997 to 2007; updates and revisions are ongoing and can be viewed at *http://water.usgs.gov/owq/Fieldprocedures.html*]
U.S. Geological Survey, 2006a, U.S. Geological Survey manual, Water Resources Discipline scientific records disposition schedule: Accessed February 2008 at *http://www.usgs.gov/usgs-manual/schedule/432-1-s2/index.html#gw*
U.S. Geological Survey, 2006b, Guidance for the use of scientific records disposition schedule 1400: Accessed February 2008 at *http://water.usgs.gov/usgs/srm/guidance6_21_09.html*
U.S. Geological Survey, 2007a, User's manual for the National Water Information System of the U.S. Geological Survey, Water-Quality System: U.S. Geological Survey Open-File Report, version 4.7, available online at *http://wwwnwis.er.usgs.gov/nwisdocs4_7/qw/QW.user.book.html* , 736 p.

U.S. Geological Survey, 2007b, User's manual for the National Water Information System of the U.S. Geological Survey, Automated Data Processing System (ADAPS): U.S. Geological Survey Open-File Report, version 4.7, available online at *http://wwwnwis.er.usgs.gov/nwisdocs4_7/adaps/adapscover.pdf* , 445 p.

U.S. Government Printing Office, 2000, Style manual: Washington, D.C., accessed October 2007 at *http://www.gpoaccess.gov/stylemanual/index.html* , 326 p.

Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., and Smith, B.A., 2006, Guidelines and standard procedures for continuous water-quality monitors—Station operation, record computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51 p. plus 8 attachments, accessed June 2007 at *http://pubs.water.usgs.gov/tm1d3*

Ward, J.R., and Harr, C.A., 1990, Methods for collection and processing of surface-water and bed-material samples for physical and chemical analyses: U.S. Geological Survey Open-File report 90–140, 71 p.

Wilde, F.D., ed., 2004a, Processing of water samples (version 2.2), *in* National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A5 [variously paged].

Wilde, F.D., ed., 2004b, Cleaning of equipment for water sampling, *in* National field manual for the collection of water- quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A3, 83 p.

Wilde, F.D., ed., 2005−present, Field measurements, *in* National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A6 [variously paged]. [Updates and revisions are ongoing and can be viewed at *http://water.usgs.gov/owq/FieldManual/Chapter6/Ch6_contents.html*

Wilde, F.D., ed., 2005, Preparations for water sampling, *in* National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A1 [variously paged].

Wilde, F.D., ed., 2006, Collection of water samples, *in* National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A4 [variously paged].

Wilde, F.D., Radtke, D.B., Gibs, Jacob, and Iwatsubo, R.T., eds., 2003, Selection of equipment for water sampling, *in* National field manual for the collection of water- quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A2, 123 p.

Willoughby, T.C., 2000, Quality of wet deposition in the Grand Calumet River watershed, northwestern Indiana, October 17, 1995, to November 12, 1996: U.S. Geological Survey Water-Resources Investigations Report 99–4253, 47 p.

Yobbi, D.K., Yorke, T.H., and Mycyk, R.T., 1996, A guide to safe field operations: U.S. Geological Survey Open-File Report 95–777, 29 p.

13.1 USGS Memorandums

The following USGS memorandums are available electronically on the Internet at the following site address, unless stated otherwise: *http://water.usgs.gov/admin/memo/*

Branch of Operations Technical Memorandum 91.01, February 5, 1991, Safety—Chemical-hygiene plan, accessed June 2007 at *http://water.usgs.gov/admin/memo/information/op91.01.html*

National Water Quality Laboratory Memorandum 02.04, September 23, 2002, Requirements for the proper shipping of samples to the National Water-Quality Laboratory.

Northeastern Region Policy Memorandum 2004-01, January 13, 2004, Program and Plans—Requirements for submittal and approval of project proposals, accessed June 2007 at *http://water.usgs.gov/usgs/orh/nrwww/prog-dev/proposals.html*

Northeastern Region Policy Memorandum 2006-01, November 18, 2005, Program and Plans—Requirements for submittal and approval of project proposals, accessed June 2007 at *http://water.usgs.gov/usgs/orh/nrwww/prog-dev/proposals.html*

Office of Water Quality Technical Memorandum 92.01, December 20, 1991, Distilled/deionized water for OWSC operations.

Office of Water Quality Technical Memorandum 92.06, March 20, 1992, Report of committee on sample shipping integrity and cost.

Office of Water Quality Technical Memorandum 97.06, May 5, 1997 (corrected May 14, 1997), Comparison of the suspended-sediment splitting capabilities of the churn and cone splitters.

Office of Water Quality Technical Memorandum 98.05, September 14, 1998, Policy for the approval of U.S. Geological Survey (USGS) water-quality analytical methods.

Office of Water Quality Technical Memorandum 02.15, July 9, 2002, Use of the new data-quality-indicator (DQI) field in NWIS 4_1.

Office of Water Quality Technical Memorandum 07.01, November 14, 2006, Policy for the evaluation and approval of analytical laboratories.

Water Resources Division Memorandum 87.085, September 18, 1987, Programs and Plans—Policy for the collection and archiving of electronically recorded data.

Water Resources Division Memorandum 90.38, April 23, 1990, Policy for reporting maximum contaminant level exceedances.

Water Resources Division Memorandum 92.036, April 16, 1992, Policy of the Water Resources Division on the use of laboratories by national water-quality programs.

Water Resources Division Memorandum 92.059, October 20, 1992, Policy for management and retention of hydrologic data of the U.S. Geological Survey.

Water Resources Division Memorandum 95.35, May 15, 1995, Programs and Plans—Transmittal of an instrumentation plan for the Water Resources Division and the hydrologic field instrumentation and equipment policy and guidelines.

Water Resource Division Memorandum 99.30, July 14, 1999, Priority Issues for the Federal-State Cooperative Program, Fiscal year 2000.

Water Resource Division Memorandum 99.33, September 27, 1999, Preservation of original digital field-recorded time-series data.

Water Resource Division Memorandum 04.01, January 7, 2004, Avoiding competition with the private sector.

Appendix A. Routine QWDATA Management Process in the Ohio Water Science Center

1. Printing weekly Watlists:
   a) Every Friday around 1:05 AM, a cron job fetches, concatenates files from the directory /var/ftp/incoming/.wrd_only/nwis.nwql, and loads the QW batch files from NWQL and into the Ohio Water Science Center's (WSC) QWDATA database.
   b) QW batch files, Watlist, and rejected files (created from process described in item a. above) are placed in the directory /usr/opt/nwis/data/auxdata/qwgetlab and given the following names:
      - qwsample.yyyymmdd.hhmmss
      - qwresult.yyyymmdd.hhmmss
      - watlist.yyyymmdd.hhmmss
      - rejected.sample.yyyymmdd.hhmmss
      - rejected.result.yyyymmdd.hhmmss
   c) The water-quality database (QWDB) manager copies QW batch files, Watlist, and rejected files to a directory (for example, /accounts/dlrunkle/qwdb) for further processing.
   d) The Watlist file is printed and organized by project number.
      - TIP: To get the Watlist to print correctly, use the following Unix print command (Note: laser#, represents the printer name or number, e.g., laser5)
        asa watlist.yyyymmdd.hhmmss | lp –ylandscape –dlaser#
      - Error-free Watlists are given to the Ohio WSC Water-Quality Specialist to review and distribute to project chiefs
      - Rejected samples and results:
        - Using an editor, lines of data in rejected files are separated and grouped by project number to create unique files for each project.
        - Files are renamed with the project account, date, and project chief's name and placed in a QWDB manager's directory (for example, /accounts/dlrunkle/qwdb/BADQW). Examples of the file naming convention are listed below
          - bads.projacct.yyyymmdd.name (rejected.sample)
          - badr.projacct.yyyymmdd.name (rejected.result)
          - badwatlist.projacct.yyyymmdd.name (watlist)
        - The QWDB manager writes a note on the rejected Watlist suggesting possible solutions to the problems, copies the Watlist, and puts the Watlist in the project chief's mailbox to correct. The QWDB manager files the copy of the rejected Watlist in a folder.
          - Common problems, solutions, and process:
            - sample has not been logged in or logged into wrong database
              - ✓ database 01 for environmental samples
              - ✓ database 04 for QC samples
            - error/difference in the site id, date/times, or medium code in Ohio

- QWDATA and NWQL (analytical services request form, ARS)
  - ✓ project chief sends email to: GS-W-COden NWQL LabHelp requesting correction. (Optional, requests reload of data.)
  - ✓ project chief makes correction in Ohio QWDATA data base
- when problems corrected, the project chief
  - ✓ notifies QWDB manager of the change/problem and ask to load rejected sample/results (unless NWQL has been asked to reload the data). Data are loaded into the QWDATA using Option 8, Batch file processing menu, Option 2, Enter batch-file data for logged-in samples (qwcardsin)).
  - ✓ Error-free Watlists are given to the Ohio WSC Water-Quality Specialist to review and distribute to project chiefs.
  - ✓ Rejected files go through the same process described in d.) above.

2. Assistance is provided as needed to help QWDATA users:
   a) solve data-entry problems,
   b) format data-entry files,
   c) untangle sample information differences or errors or request reruns with NWQL,
   d) prepare QWDATA field forms (to enter field or lab data interactively for selected parameters),
   e) describe QWDATA tabling and display options,

3. Loading of data from other USGS labs from the QWDX Web page (*https://qwdx.cr.usgs.gov/*):
   a) When notified that data for Ohio WSC samples has been placed on the QWDX Web page, batch files are downloaded and placed in a directory at /usr/opt/nwis/data/auxdata/qwgetlab/qwdx/
   b) Below is an example of a file name of downloaded data from QWDX:
      - download.qwbatch.dlrunkle.20070502.093936.tar
   c) Files from QWDX are archived and can be retrieved with the following command:
      - tar xvf download.qwbatch.dlrunkle.20070502.093936.tar
   d) Below are examples the file names created by when data are unpacked:
      - SAMPLE.OH.lab_data......from_lxs.dlrunkle.20070502.093936.18384.t.a
      - RESULT.OH.lab_data......from_lxs.dlrunkle. 20070502.093936.18384.t.a
   e) Files are copied to conventional batch file names (qwsample, qwresult) to load into the Ohio QWDATA database (from QWDATA Option 8, Batch file processing menu, Option 2, Enter batch-file data for logged-in samples (qwcardsin)).

4. Local training is provided as needed. The last training presentation was given January 12, 2007, by Donna Runkle and Donna Francy. Training PowerPoint Presentation and handout document are stored under the folder X:\QW\Codes-Training and named
   a) Ohio_qwdata_20070112
   b) QWDATAtraining20070112

5. Spreadsheets of Parameter and Method codes and Collection and Analyzing Entity codes are updated quarterly and stored in the folder X:\QW\Codes-Training for the user's convenience.

6. After annual report has been printed, qwbatch files are compressed and stored under the directory /usr/opt/nwis/data/auxdata/qwgetlab/zipped.files under WY directories.

Appendix B. Example of Project QA/QC Plan

QUALITY ASSURANCE/QUALITY CONTROL PLAN—Project 00304
August 30, 2007

PROJECT TITLE: Water-quality monitors

PROJECT CHIEF: Kim Shaffer

PROJECT SUPPORT: Steve Vivian, Kim Shaffer, Al Dillenburg, Kevin Metzker

COOPERATORS: City of Columbus, Army Corp of Engineers, and Miami Conservancy District (MCD)

PROJECT DESCRIPTION (Introduction and problem): Industrial complexes, metropolitan centers, mining, and intensive agricultural practices potentially impact spatial and temporal distributions of pollutants discharged into the streams of Ohio. Assessment of the effectiveness of pollution abatement and control procedures to meet Federal and State stream-water quality standards requires monitoring of physical, chemical, and biological quality.

PROJECT OBJECTIVES: The objectives are to (1) provide information that will define the water quality (pH, specific conductance, dissolved oxygen, temperature) of selected streams; (2) evaluate data to determine water quality in selected river basins; and (3) provide data to federal, state, and county agencies for planning purposes and for pollution control.

PURPOSE, SCOPE, and APPROACH: Maintain a network of five continuously-recorded water-monitor stations located at key sites to study trends and evaluate water-quality variations. These data will be used to determine temporal relations between existing water-quality conditions and the standards specified by Federal and State Agencies. Four sites are serviced by the USGS Columbus office, and one site is serviced by the USGS New Philadelphia office.

REPORTS: Published in District Annual Report. No interpretive reports.

10-, 40-, AND 70-PERCENT REVIEW DATES: Continuous long-term project, no technical review needed although periodic field checks will be done.

DATA COLLECTED AND ANALYZING LABORATORY OR SOURCE:
Five water-quality monitors are currently maintained by the USGS, Ohio District (table 1). Three are seasonal sites and are highlighted in red.

Table 1. Monitors currently in use by the Ohio Water Science Center.

Site	Cooperator	USGS personnel responsible	Parameters	Equipment
03098600 Mahoning River at Youngstown	Corp of Engineers-- Pittburgh District	Steve Frum	pH, spC, temp D.O.	YSI-6820 Handar555
03219500 Scioto River nr. Prospect, OH	City of Columbus	Al Dillenburg	pH, spC, temp D.O.	YSI-6820 Handar555
03220510 Scioto River bl. O'Shaugnessy Dam	City of Columbus	Al Dillenburg	pH, spC, temp D.O.	YSI-6820 Handar555
03228300 Big Walnut Creek nr. Sunbury	City of Columbus	Kim Shaffer	pH, spC, temp D.O.	YSI-6000 Handar555
03271510 Great Miami River at Miamisburg	Miami Conservancy District	Kevin Metzker	pH, spC, temp D.O.	YSI-6820 Handar555

STANDARD PROTOCOLS

1. **Calibrate field instruments.** Calibrate field instruments the day before or the morning of each field trip according to the manufacturer's instructions. For pH and specific conductance, use a two-point calibration that brackets the expected environmental values. For dissolved-oxygen calibration, use the field barometric pressure out in the field but compare it with the barometer in the constant-temperature room monthly or before each field trip and record in the Barometer Calibration Record(The barometer is checked against Don Scott Airport barometric pressures every month by Bill Yost.) Temperature values will be checked twice annually using an NIST thermometer with a 3-point calibration. Record the Field Meter Calibration both in the instrument log and on the Continuous Water-Quality Monitor Field Form, noting the date.

2. **Pull the data.** Using the Handar program, pull the water-quality monitor data at least monthly.

3. **Set up field instruments.** Recalibrate dissolved-oxygen meter. Set up field instruments to allow adequate time for stabilization and equilibration to current conditions; dissolved-oxygen— 20 min., specific conductance and pH—5 minutes.

4. **Fill out the Station Information.** On the Continuous Water-Quality Monitor Field Form, fill out the first section with the station information.

5. **Measure parameters using the continuous monitor.** In the program EcoWatch, take instantaneous readings from the continuous monitor. Allow adequate time for readings to stabilize (usually taking the 16th reading is adequate). Record current data values for the monitor on the Continuous Water-Quality Monitor Field Form along with the time.

6. **Measure parameters using field instruments.** Record field instrument measurements on the Continuous Water-Quality Monitor Field Form and compare them to the continuous monitoring reading.

7. **Get a Dissolved Oxygen Charge Reading.** This should be reading between 25-75 (50 is optimal), otherwise denotes that the membrane or probe has gone bad.

8. **Clean the continuous monitor.** Wipe off the guard with a paint brush. Gently remove the sensors and clean with a paint brush or wet kimwipe. Be careful not to get water into the electrical contacts. Inspect the DO probe membrane to ensure its integrity; examine the DO electrode for discoloration. If the membrane is damaged or significant discoloration has occurred the probe needs to be serviced; however, after replacing the membrane it takes up to 24 hours to equilibrate. Brush out the sides of the tank. For nonchlorinated tanks, run about 1 cup of chlorine through the line and tank, if necessary. By leaving the standpipe in the drain, this allows the chlorine to backup into the pump line. Rinse the tank and line with river water and fill the tank. Record the tank fill time on the field sheet (this should be within 1 minute). If the fill time is greater than 1 minute, the line is probably fouled and needs maintenance. Place the continuous monitor and field instrument in the tank.

9. **Measure parameters using the continuous monitor and field instrument.** Record both instrument measurements on the Continuous Water-Quality Monitor Field Form. This will be used to determine if a Fouling Correction is needed on the record.

10. **Begin Calibration Drift Checks – Specific Conductance.** For Specific Conductance, at least monthly put the monitor in 3 different standards. The high and low specific conductance standards should bracket the data and the medium should be near the current range of data. If the % error is within 5 microsiemens for standards less than 100 or less than 3% for any other standard, record results and do not calibrate. If the % error is greater than 3% for standards (especially the high standard), recalibrate to the high standard. Since the YSI probes are linear, recalibrating to one standard should correct the % error of all the standards. Recheck the monitor in the 3 different standards. This probe is a linear probe and thus if one standard is off, the should all be off similarly. If the percent error is significantly different for each of the standards, there might be problems with the low standard(s) or the probe could be bad. If this is the case, take a calibration/Cell constant reading and record. This should be around 5.0, if it is 6.0 or greater, the probe is bad. Additionally, as another precaution, rinse off the probe with DI water, and get a Reading in air, and record. When discussing these protocols with YSI, they felt that the probe is so linear that if the monitor is checked in a high standard and the cell constant is checked, this should be adequate quality control and quality assurance. Since each site is different and situations arise that make doing all protocols difficult, the necessary protocols can be adjusted on a case by case basis by the person servicing the site.

11. **Calibration Drift Checks – Dissolved Oxygen.** For Dissolved Oxygen, get a DO charge reading (should be between 25 – 75). If it is not between 25 – 75, the membrane might be damaged, the probe might need to be serviced (discoloration is evident), or the probe could be bad. If the DO charge is less than 25 and there is no discoloration, change the membrane (stretching it as it is placed on) and the DO fluid. If the DO charge is less than 25 and there is discoloration, recondition the probe following manufacturer's instructions and replace the membrane and DO fluid. If the DO charge is between 25 -35 or it has been over a month since the membrane has been changed, take a DO reading in air before changing the membrane. This will determine if any drift correction is necessary. If the DO charge is greater than 35, it has been less than a month since the membrane was changed, and there is no visible damage to the membrane, do not change the membrane. Check the DO reading in air, recording the Temperature, Barometric Pressure, DO Table Reading and the actual monitor reading in air. Recalibrate if greater than .3 mg/L difference. If the DO is recalibrated, check the DO reading in air again and record. If the probe is suspect, get a DO Gain Reading (should be 1.0, but can vary from .7 to 1.5). If Salinity is a factor, get a reading (most sites the salinity is a negligible influence on DO). Quarterly, get a reading in zero DO solution and record. This should read close to 0.0 mg/L, but can vary to .3 mg/L.

12. **Calibration Drift Checks – pH.** For pH, check at least monthly in standards. Use Standards that bracket the data, either 4 and 7, 7 and 10, or 7, 4, and 10. Put the monitor in each necessary standard and record the Theoretical pH, the Buffer Lot No., Buffer Exp., temperature, and the pH reading. Take a second reading in each standard if necessary and record. Make sure to rinse properly between standards and when finished. If the monitor is reading within .2 units in the 7 standard and the other standard(s) are reasonable, do not recalibrate. If the monitor is reading greater than .2 units in 7 standard or the other standards seem unreasonable, recalibrate the monitor in bracketing standards. Get Post Calibration readings in the standards after calibration as a check. Record slope and millivolts if the monitor is suspect.

13. **Calibration Drift Checks – Turbidity.** For Turbidity, check at each inspection in 3 standards that bracket the turbidity. Make sure to rinse well between standards and record the date prepared, the concentration in NTU, temperature, and the monitor reading. If there is a difference of 2 NTU at 0 NTU or a percent error of 5% in any other standard, calibrate in the high standard (turbidity is linear) and then get post calibration readings in the 3 standards and record.

14. **Final Readings.** After all calibration checks and any calibrations have been done, return the monitor and the field instrument to the tank and let the instruments stabilize. Record both the field and monitor instrument measurements on the Continuous Water-Quality Monitor Field Form. If there is a significant difference between the field and monitor readings, recheck the instruments in standards. (Specific Conductance is greater than 5%, DO is greater than .6 mg/L, or pH is greater than .3 units.)

15. **Recheck equipment.** Go back into the Handar program and make sure that the equipment is back in SDI12 mode. Additionally, force a scan to make sure that data is coming in the proper fields and check to make sure the program is in the run mode. Recheck the monitor to ensure that it is properly placed in the tank and that the DO membrane has not been damaged.

QUALITY-CONTROL OBJECTIVES AND NUMBER OF SAMPLES

1. Ensure continuous monitor measurements are indicative of the stream-water quality. Compare measurements taken manually on a stream cross section to those of the monitor at least twice per year at each site. If the site is seasonal, check yearly. If safety is an issue, do what is feasible.

2. Ensure cooperator personnel are following established protocols and procedures. Provide cooperator with written protocols. Perform yearly QC checks on cooperator personnel.

3. Ensure continuous monitors are operating properly. Perform a daily check of satellite data via computer and site visits every two weeks or as needed.

TRAINING

On-site training should be done with cooperator personnel and for personnel in the basic data section of the USGS. Staff will meet quarterly to discuss equipment problems, data, and changes in protocols.

CORRECTIVE ACTION PROCEDURES

Thresholds are currently set for all water-quality sites so that the low is near the lowest recorded known value for that site and high is near the highest recorded known value for that site. The very high and very low thresholds are set to show instrument problems and are set at values that are not in the range of the data.

If equipment is suspect or experiencing problems, cause will be determined and fixed as soon as possible.

Maximum allowable limits and criteria for water-quality data corrections for water-quality monitors can be found in Wagner and others (2006, tables 17 and 18.

Data that exceeds maximum allowable limits for error will be marked erroneous in Hydra and not used for compilation of records.

Data where there were known equipment problems will be marked erroneous in Hydra and not used for the compilation of records.

All suspect data will be further examined and determined by personnel if it should be marked erroneous or not.
Daily values for partial days caused by transmission errors, servicing the monitor, and other problems will be updated where data existed during the expected time for the occurrence of the

maximum or minimum, if at least 12 hours of values were available for the day, and if values were present adjacent to the extreme for the day.
Records, Inspections, Calibration checks, field instruments data, and cross-section survey information will be used to determine if any data corrections are needed. Personnel will update the record with data corrections using data correction criteria.
All data will be rated excellent (never), good, fair or poor by personnel using Rating Continuous WQ Criteria.

WATER-QUALITY RECORDS

Provisional real-time records will be updated and maintained quarterly. The records will be checked quarterly as well. A copy of the checklist located at X:\DATA SECTION\MONITORS\QW WY2007\Update.doc will be used to keep track of this quarterly update to the record.

Quarterly, the compiler will update each water-quality record (Temp, SC, pH, and DO) by putting in any back-up data, updating the water-quality spreadsheet, mark bad data as "X" in Hydra, filling in any missing days in Hydra with back-up data, checking Hydra for suspect data and corrections, applying corrections and printing correction sheet, and double checking corrections in Hydra. The checker will then check these items, look for additional suspect issues, and put the data "in-review" when done. By the last quarter of the year, a paper copy of the manuscript will be updated.

The primary computation tables, daily value tables, the final manuscript, the final correction sheets, the final spreadsheets, the final data analysis and final manuscript will be completed after the end of the water year.

The final record will be checked with special detail to the last quarter of data and the entire year put into "in-review" status. The record will be then reviewed and put into "approved" status.

REFERENCE

Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., and Smith, B.A., 2006, Guidelines and standard procedures for continuous water-quality monitors—Station operation, record computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51 p. + 8 attachments; accessed July, 2008, at http://pubs.water.usgs.gov/tm1d3

Appendix C. Project Startup Checklist

Date:
Project name:
Account number:
Project start and end dates:
Project team:

What type of project work plan is best for this project?
    Not needed (i.e., projects with external QA/QC plans)—describe further

    QA/QC plan only (small projects or those of short duration)
    Work plan with QA/QC
    Quality Assurance Project Plan (QAPP)

Expected date for completion project work plan:

Expected date to begin sampling:

When do you plan to hold technical reviews?
    10-40-70
    At the start of the project only
    No technical reviews are planned—explain why they are not needed/required

    Other

Will you be using an outside laboratory for any analytical work? If so, what lab?

If using an outside lab, are you required to follow the OWQ Laboratory Evaluation Process (LEP)?

Do you plan to enter project data into NWIS? If so, what data?

Will data be published in the Annual Data Report? If not, why not?

What type of report is planned for the project?

When was the report plan last updated?

Appendix D. Annual Data Report Routing Sheet and Checklist

Project: ______________________________ Water Year: _________

Project number:___________________ Project chief: ________

ROUTING SHEET

Task	Suggested Individual	Date Received	Date Completed	Initials
Update MPL and SIMS	Project member			
Bin data	Project member			
Review table	Project member			
Review table	Project Chief[1] or outside reviewer			
Review table	QW Specialist			
Book data	Project member			
Merge data	Project member or Data Chief[2]			
Review merged data	Project member or Data Chief[2]			
Submit table	Project member or Data Chief[2]			
Change DQIs	QW Database Manager			
Remarks:				

MPL (Master Publication List), SIMS (Site Information Management System).

[1] May be other project member if project chief performed preceding steps.

[2] Coordinate with others associated with the station if other data (i.e. stream discharge or ground-water levels) are collected at the station.

CHECKLIST FOR WATER QUALITY DATA FOR THE ANNUAL REPORT

Project: ________________________________ Water Year: ______________
Project number:____________________ Project chief: ________Station number:______
____________________ Station name: _______

PROJECT HEADING

Contains:

[ ] Site name
[ ] Station number
[ ] Basin information
[ ] Water year
[ ] Location
[ ] Period of record
[ ] Remarks include objectives

FIELD MEASUREMENTS AND CALCULATIONS

[ ] Alk., acid., bacteria
[ ] Alk. codes correct (inc. vs fixed)
[ ] Tabled field data matches Watlist
[ ] Remark codes used correctly
[ ] Field values seem reasonable
[ ] Significant figures OK

LABORATORY DATA

[ ] All constituents analyzed appear in the table (see Watlists)
[ ] Laboratory generated values seem reasonable

TABLE

[ ] Remark codes included
[ ] Remark codes footnoted
[ ] Tabled values match Watlist and field notes

Appendix E. Annual Data Report Publishing Policy

Due to the change to the new online publishing of the Annual Data Report, the Ohio Water Science Center has revised the policy concerning which data will be published in the Annual Report.

The basic policy statement is:

All data collected during the Water Year will be published in the Annual Data Report (ADR) for that year unless exempted.

The exempted data must meet ALL of the following criteria:

1. Data will be collected at the site for one year or less.
2. Data collected at the site is part of a larger effort involving several sites.
3. Continuous (time-series) data were not collected at the site.
4. The data were not collected at a gage or site for which other data are being published in the annual report.
5. The data will eventually be included in a published report.
6. The funding cooperator(s) is(are) aware and agreeable with not publishing the data in the ADR

The decision on how data will be published will be made during the proposal stage of a project and must be approved by the Discipline Specialist, the Data Chief, and the Center Director. If data will not be published in the ADR, a statement to that effect must be included in the proposal to the cooperator(s).