WORKPLAN – SECOND AMENDMENT

FOR

WATERSHED-BASED PERMITTING

for the

POWDER RIVER BASIN, WYOMING

WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY

WATER QUALITY DIVISION

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I. NEED STATEMENT

Introduction

The Wyoming Department of Environmental Quality, Water Quality Division (WDEQ/WQD) is the primary governmental agency in Wyoming with responsibility for controlling and preventing water pollution. The Wyoming Pollutant Discharge Elimination System (WYPDES) Program within the WQD has the responsibility for issuing, monitoring, and enforcing permits to control point source discharges of pollutants into surface waters of the State. Primacy for the WYPDES Program was obtained from the U. S. Environmental Protection Agency (EPA) in 1974.

One of the many facets of WYPDES permitting within the state of Wyoming is the permitting of produced water discharged during the production of coal-bed methane gas (CBM). In order to produce CBM, producers partially dewater the coal seam in order to allow the CBM to desorb from the coal matrix. The coal seam water, which is essentially unaltered groundwater, is typically discharged on the surface to waters of the state. Such discharges require WYPDES permits. The Powder, Little Powder, Belle Fourche, Cheyenne, and Tongue River drainages will collectively be referred to as the "Greater Powder River Basin" for the remainder of this report.

Typically, untreated CBM discharges are higher in salts and sodium than perennial streams within the Greater Powder River Basin. Therefore, large-scale discharges of untreated CBM produced water have the potential to increase salt and sodium in the Greater Powder River Basin to levels damaging to existing uses (primarily agriculture). In addition to salts and sodium, some CBM untreated discharges contain concentrations of other pollutants above the maximum concentrations allowed by state standard (primarily dissolved iron, total radium 226, total barium, and pH. Occasionally, discharges are reported that are high in various heavy metals).

The WQD was allocated grant funds in June, 2005 in the amount of $198,000.00 from the EPA to assist in the implementation of watershed permitting for CBM discharges within the Greater Powder River Basin. The grant period expires on June 30, 2010, and only a small portion of grant funds have been utilized as of the date of this report. To date, a project of this type and scope has not been attempted by any other permitting entity within the United States. Initially, the WQD had a very aggressive, optimistic schedule for CBM watershed-permitting implementation within the Greater Powder River drainage from the outset in 2005. The WQD is now several watersheds into the implementation process. Due to appeals filed on the first two watershed general permits (Pumpkin Creek and Willow Creek), the WQD put a temporary hold on watershed permitting in order to determine what the outcome of the appeals would be and how the appeal decisions would impact further watershed permitting. As of the date of this report, the appeals have been finalized, and the WDEQ has developed a plan for moving forward with watershed permitting that incorporates the appeal outcomes. However, the originally-described process needs to be re-visited and updated. Therefore, the WQD is requesting that the original work plan for this project be amended to remove project items that have not proven successful, and include new project items that have been deemed necessary. This restructuring of the watershed permitting process will require redistribution of funds within the grant.

Reason for Project

This project is and has been necessary to address concerns identified by EPA and WDEQ related to the volume and density of the large-scale CBM development in the Greater Powder River Basin of Wyoming, and the resulting number of requests for CBM discharge permits. Potential impacts from large-scale CBM surface discharges are significant. Historically, the WQD has issued CBM surface discharge permits on an individual basis. However, due to the large scale of CBM development and the number of issues the development has raised from landowners, other agencies, and neighboring states, the WQD has identified a need to strengthen the CBM permitting process. In addition, many CBM operators have indicated a desire for a streamlined CBM permitting process. In order to accommodate both interests, the WQD has embarked upon a watershed-based permitting process for CBM development within the Greater Powder River Basin of Wyoming. The primary goals of WQD's watershed-based permitting implementation strategy are as follows:

Consideration of cumulative impacts to water quality on a watershed-wide basis

Development of an efficient, streamlined permitting process for CBM surface discharges within the Greater Powder River Basin of northeastern Wyoming.

Secondarily, the WQD hopes to develop a template for watershed-based WYPDES permitting that can be transferred to other watersheds and perhaps even other states. Ultimately, watershed-based permitting should improve and simplify WYPDES permit application and processing, providing a predictable process for operators, landowners, other agencies, and neighboring states to follow, and resulting in a more predictable end result. Additionally, more predictable and homogeneous permit limits and requirements within each watershed should enhance permit compliance and enforcement within the watershed.

II. GOALS

Overall, the WQD's main goal in implementing a watershed-based permitting approach is to assess cumulative impacts from CBM development and, if needed, establish limits to prevent/reduce excessive impacts due to CBM development within the drainages of the Greater Powder River Basin. In order to achieve this over-arching goal, WQD intends to pursue specific goals as follows:

Where background water quality data exists, provide baseline water quality assessments to establish end goals such as flow, parameter concentrations, and loads.
Where background water quality does not exist; attempt (within a reasonable time frame), to collect background water quality data where possible.

3. Identify "pollutants of concern" for each watershed.

4. Where such data exists, compile and interpret data related to "pollutants of concern".

5. Quantify existing and reasonably foreseeable potential future CBM development within the Greater Powder River Basin.

6. Develop a WYPDES watershed-based permitting framework for the Greater Powder River Basin that includes:
    a. Identification of potential Powder River assimilative capacity.
    b. Conceptual outline for Powder River assimilative capacity allocation.
    c. Develop an appropriate watershed-based permitting mechanism(s), which may include any or all of the following:

i. General vs. individual permit approach(es)
ii. Synchronized permitting within each watershed.
iii. Education/information dissemination
iv. Data collection – data quality control efforts (water quality data collection, information related to agricultural practices within each watershed, soil quality data collection, channel stability/channel capacity information.
v. Assimilative capacity tracking process.

7. Verify the assumptions and information utilized in establishing effluent limits and permit requirements within the watershed-based permits by conducting background water quality sampling through contract with the United States Geological Survey (USGS). Currently, water quality data from drainages within the Powder River Basin is either totally lacking or very limited. In order to assess any potential impacts (or the lack of any impacts) as the result of CBM permitting under the watershed-based permitting approach, collection of background water quality is imperative. The WDEQ prefers to utilize the USGS for collection of water quality data whenever possible to take advantage of the rigorous quality control and peer review processes that the USGS employs, and because the USGS' reputation for collecting unbiased, scientifically correct water quality data is unequaled. Please find attached (Appendix A) a description of USGS water quality sampling control and quality assurance procedures, and a description of USGS peer review procedures. Currently, a two-year contract for USGS monitoring at the "Powder River at Moorhead, MT" station is in place, cost for this two-year contract is 83,000.00.

By incorporating a multi-pronged approach, the WQD hopes to achieve the greatest degree of protection possible, while avoiding permitting practices that are unnecessarily complicated or onerous.

Likely Improvement in Results from Project Implementation:

WQD's adoption of watershed-based permitting for CBM surface discharges in the Powder River Basin is designed to improve and simplify the WYPDES permitting process, and to strengthen regulatory mechanisms and thereby enhancing compliance with established water quality standards. In addition, WQD's intent is to improve administrative efficiency (reduce time and personnel needed to process applications) and reduce costs for both WQD and CBM operators (fewer applications submitted due to watershed consolidations, improve consistency of applications submitted and permits issued).

Measuring Improvement and Accountability:

Originally, the watershed-based permitting approach was designed to achieve and demonstrate results in the near-term (3 years), and then transfer the project methodology to implement a watershed-based WYPDES permitting process for CBM surface discharges in other drainages within the Greater Powder River Basin and, ultimately, if needed, the whole state of Wyoming. Due to legal appeals, achievement and demonstration of results has been slower than was originally anticipated. However, due to certain aspects of the legal appeals, the WQD has made some realizations that should be applied to future watershed-permitting efforts, as follows:

1. Originally, watershed-based CBM permitting included a very intense and watershed-repetitive series of stakeholder meetings, with the purpose of increasing public involvement and potentially reducing public appeals. However, this intensive approach has proven to be somewhat redundant and too time-intensive for many of the targeted stakeholders. As a large portion of the meetings focused on educating the stakeholders so that all stakeholders could participate on a "level playing field", and the educational

information presented does not change greatly from watershed to watershed, the WQD believes that it may be more expeditious to hold separate educational venues outside of the watershed permitting process.

2. Originally, the WQD was not specific in stating what roles the stakeholders were expected to take, what types of information the WQD is hoping to acquire through the stakeholder process, and which portions of the permit(s) the stakeholders can expect to influence through their participation in the stakeholder groups. In future meetings, the WQD is planning to clarify stakeholder roles, information needs, and areas of influence with regards to watershed permitting.

3. Originally, the WQD expected a greater amount of data input from stakeholders than has occurred in some watersheds. For instance, WQD has requested information from landowners and operators regarding irrigation, soils, and crops within various drainages. Although WQD did receive some information from stakeholders, typically information received was incomplete. In order to efficiently address these data gaps, the WQD is now proposing that grant funds be allocated to the purchase of hardware and software that will allow WQD to obtain information regarding irrigation practices within all of the drainages within the Powder River Basin. By utilizing a software package called "Feature Analyst", WQD personnel can very efficiently analyze color infra-red photographic images to deduce the amount and potentially the type of irrigation occurring within a drainage. In addition to the Feature Analyst software package, efficient use of the software requires the use of a dedicated desktop computer with a large amount of RAM and memory to perform the data-intensive calculations required by Feature Analyst software. This reallocation of funds will require moving some funds from the contractual portion of the grant budget to a "supplies and equipment" budget entry that has not been utilized by this grant in the past.

4. Typically, if an operator desires limits protective of agricultural uses other than the default or "Tier I" limits allowed under the Wyoming's Agricultural Use Policy, WQD requires operators to conduct soil sampling to deduce the quality of irrigation water historically applied to irrigated acreage if, as in many cases with the ephemeral streams in the Powder River, insufficient background water quality data exists. Typically, the operators within a drainage pool resources and select a consultant to perform soil sampling and data analysis. There have been instances in the past where different consultants have performed the same type of analyses on overlapping stream segments and developed very different conclusions regarding the quality of water historically applied to the same irrigated lands. Therefore, the WQD is requesting that a portion of the funds from this grant be utilized in performing third-party soil sample collection and analysis in the event widely differing results are reported for the same irrigated fields. In addition, the WQD would like to repeat a small number of soil surveys as a quality control measure. By self-conducting a small number of soil surveys, WQD also hopes to alleviate the criticism that all the soil surveys were conducted by CBM operators.

To date, the WQD has invested a large amount of staff time and effort in the watershed-based permitting process. However, now that several watersheds have been included in the watershed-permitting approach, the WQD believes that it is appropriate to re-evaluate the process and fine-tune it as needed to achieve an optimal, efficient end result.

Transferring Innovation:

WQD still proposes to document the outcomes of the watershed-permitting process in a number of ways, possibly through reports, presentations, or one or more potentially-transferable computer models, as the potential for use of the watershed-based permitting approach in other drainages and for other types of WYPDES discharges within the state of Wyoming is definitely possible. It may also be possible, with some alterations, to transfer the watershed-based permitting approach to other states, particularly within the Rocky Mountain region. WQD is committed to completing this innovative and forward-thinking process, and to sharing the results and process with other states and interested parties. Currently, WQD works with counterparts in downstream states on a variety of water quality issues. The WQD hopes to strengthen these relationships in the future, and hopefully will allow the WQD opportunities to improve upon and strengthen watershed-permitting concepts, and potentially transfer them to other interested parties.

III. DESCRIPTION OF THE PROJECT

Background Information

Currently, CBM development in the Greater Powder River Basin is a high-priority issue for the WQD in terms of environmental protection, due to the large-scale development occurring within the Greater Powder River Basin. By the year 2020, development projections estimate approximately 97,500 CBM wells will have been drilled within the Greater Powder River Basin. It is also possible, should the prices of natural gas and methane rise appreciably, that CBM development within the state of Wyoming will become economically viable within other basins, as there are appreciable coal deposits in most, if not all, of the geologic basins within the state of Wyoming. EPA has been promoting the concept of a watershed-based permitting platform for about a decade; however, full implementation of watershed-based permitting within the United States has been slow. WQD realizes the long-an-short-term benefits of implementing a watershed-based permitting process for CBM surface discharges within the Greater Powder River Basin, and the potential for watershed-based permitting to aid in achieving significant water quality improvements. In addition, should CBM development within other Wyoming basins become a reality, the WQD would have the basis of a permitting strategy for new CBM discharges in place.

Originally, WQD's watershed-based permitting components were as follows:

1. Identification of stakeholders
2. Watershed characterization (land use, ownership, topography, channel capacity, climate, vegetation, hydrography)
3. Assimilation of data into ArcHydro data model
4. Description of potential water quality impairments and water quality standards
5. Pollutant source assessment and estimate of existing pollutant loads
6. Water quality goals
7. Allocation of capacity
8. Monitoring strategy

Based upon prior watershed-based permitting experience, WQD now proposes the following watershed-based permitting components:

1. Identification of stakeholders
2. General stakeholder education regarding WYPDES permitting and Wyoming Water Quality Standards
3. Watershed characterization using anecdotal information from operators, landowners, color infra-red image analysis, and soil and vegetation surveys.
4. Assessment of existing water uses within the drainage, and the quality of water necessary to maintain those uses.
5. Assessment of potential and existing CBM development within the watershed.

6. Assessment of potential water quality impairments as the result of CBM development.
7. Assessment of constituent loading from CBM development
8. Development and assessment of water quality goals
9. Monitoring strategy – which includes both self-monitoring to be performed by permittees, and verification monitoring and data collection to be performed by the USGS.

Of WQD's original components, allocation of assimilative capacity is mostly complete, allocations have been assessed for approximately 80% of potential CBM leases within the Powder River basin. The remaining 20% of potential CBM leases are not likely to be developed anytime in the near future, as they are located mainly in areas with rugged topography or areas with limited CBM potential. As development of the assimilative capacity process for the Powder River has progressed, WQD has realized that the assimilative capacity process should not be tied to the watershed-based permitting process, but should be allowed to develop on a separate, but parallel track. Severing assimilative capacity from dependence upon watershed-based permitting allows more rapid implementation, and also allows operators a greater degree of flexibility in utilizing assimilative capacity load allocations.

Stakeholder Involvement:

In past watershed-based permitting efforts, WQD has begun by identifying potential stakeholders within the watershed. Potential stakeholders are then contacted via mail and notified that the watershed has entered the beginning of the watershed-based permitting effort, and are encouraged to participate in the watershed-permitting effort. Originally, WQD did not succinctly define stakeholder roles or desired participation levels. WQD's intent in initiating the stakeholder process was to obtain drainage-specific information that was previously not provided regarding the watershed, such as the location of existing uses within the drainage, irrigation diversions, irrigation practices, the types of crops being grown within the watershed, the location of flow-constriction points, land and drainage use practices, topographical considerations, CBM development forecasts, and any soil and/or background water quality data that had not yet been provided, and to then utilize the data to draft and issue a general watershed-based permit for CBM surface discharges in the watershed. An unintended and undesired outcome of not specifically defining stakeholder participation at the beginning of the watershed-based permitting process was that stakeholders entered into watershed-permitting efforts with the expectation that the watershed-based permitting process would result in resolution of all their concerns regarding CBM development, whether or not the WQD has the legal authority to address the concerns raised. Some examples include property devaluation, trespass issues, dust control on roads, and regulating CBM flow without attendant water quality issues.

The WQD intends to conduct future watershed-permitting efforts differently in that potential stakeholders will be informed clearly from the beginning of the roles that WQD expects them to fulfill, the types of information that is being solicited, and the portions of the watershed-based permitting process that they have the ability to influence. WQD also intends to clearly inform potential stakeholders of previously-noted concerns that cannot be addressed though the avenue of WYPDES permitting at the beginning of the watershed-based permitting process.

General Stakeholder Education:

Although stakeholders may have been mis-informed or developed ideas of their own in the past regarding the degree to which their concerns can be addressed through the venue of WYPDES permitting, the WQD has, through the first groups of stakeholder meetings that have taken place, realized that there may be some utility in providing educational venues for potential stakeholders to attend. In multiple instances, the

WQD was able, through the watershed-based permitting process, to enable both operators and landowners to better understand CBM development and potential impacts, and the WYPDES permitting process. In addition, some education was necessary to allow all stakeholders to participate in the watershed-permitting process on a "level playing field". However, conducting such educational endeavors on a watershed-by-watershed basis quickly became very redundant for many stakeholders, because many are stakeholders in multiple watersheds. As these educational materials have already been developed, and do not change appreciably from watershed to watershed, the WQD plans to direct interested stakeholders to the already-developed educational materials that are available on-line in the future.

Watershed Characterization:

At this time, WQD has been and intends to continue to collect, compile, and analyze information within the watersheds of the Greater Powder River Basin related to the following:

1. Land Use
2. Ownership
3. Lease Holdings
4. Irrigation Practices
5. Topography
6. Watershed Hydrography
7. Hydrology
8. Channel Capacity and Channel Stability
9. Climactic History
10. Vegetation Cover
11. Existing and potential WYPDES surface discharges
12. Existing and potential WOGCC wells

Originally, the WQD had intended to utilize contractual services for most, if not all, the items listed above. However, due to staffing increases and changes, the WQD may be able, with the purchase of software and hardware mentioned previously, to conduct a portion of the data collection/assessment in-house. For example, purchase of "Feature Analyst" software and the hardware necessary to efficiently run it will allow the WQD to perform in-house analysis of vegetation cover and potentially, irrigation practices within the watersheds slated for watershed-based permitting.

As a result, although the estimated level of effort to complete these tasks for each watershed has not changed appreciably, the WQD does estimate that the ratio of contractual-to-staff time needed to complete data collection and data analysis on each watershed has changed significantly, and now estimates that approximately 1 contract hour will be needed for every 3 staff hours expended, provided the tools needed for WQD data collection and analysis are provided. Originally, the WQD had estimated that 2 contract hours were needed for every 1 staff hour.

Assessment of Existing and Potential Development Within the Basin, Assessment of Potential Water Quality Impairments as the Result of CBM Development, Assessment of Constituent Loading from CBM Development:

These components are being discussed as a single component, because they can be implemented and used by the same processes/modeling efforts.

As a result of WQD's first watershed-based permitting efforts, it became clear that in order to assess potential impacts to a watershed as the result of CBM discharges, it was necessary to understand the existing and future scope of discharges within watersheds slated for watershed-based permitting, in terms of both volume and water quality. Utilizing existing and future CBM development forecasts provided by the BLM, GIS software, and DMR data available from the WYPDES database, the WQD developed a year-by-year CBM discharge assessment through the year 2020 (the time period for which the BLM provided CBM well development forecasting). This intensive spreadsheet-based model provides estimates of both CBM produced water quality and quantity within watersheds of the Greater Powder River Basin. The WQD would like to include this information in their proposed ArcHydro data model, and intends to update this information as more accurate/updated CBM forecasting or additional DMR information becomes available. To date, this information has proved very useful in the watershed-based permitting effort in assisting stakeholders in understanding the scope of CBM development within a watershed, and providing information that can be utilized in mixing analyses and mass balance equations during the establishment of wasteload allocations and the establishment of effluent limits within watershed-based permits.

Development and Assessment of Water Quality Goals:

Although WQD has assessed and developed water quality goals for the watersheds that have undergone or are in the watershed-based permitting process, it has become clear that each watershed, at least to some degree, must be reassessed and different water quality goals developed due to differences in background water quality, land use, discharge water quality and quantity, and existing uses for the water in the drainage. WQD staff will continue to assess and develop water quality goals. It may be necessary to periodically reassess established goals when new watershed information becomes available, or there are changes in state water quality regulations.

Monitoring Strategy:

This component remains unchanged from the original scope of work (SOW).

IV. OUTPUTS-PROGRESS REPORTS-MILESTONES

The desired output is a transferable watershed-based permitting process, preferably a general WYPDES permit for each watershed. However, there may be instances in which a Water Management Plan might prove more appropriate, with the Water Management Plan serving as a template under which individual WYPDES CBM surface discharge permits would be issued. The degree of transferability for either of these outputs will most likely be variable, based upon the situation the output is being transferred to. The more similar to the "mother" watershed, the greater the degree of transferability to a "child" watershed the outputs will likely be. However, the WQD expects that basic concepts incorporated into the watershed-based permitting efforts within the Greater Powder River Basin will be highly transferable to almost any other watershed, providing a "platform" to which watershed-specific criteria can be developed and included.

As stated in the original SOW, progress reports will be provided to the U. S. EPA Region 8 office in Denver, Colorado on a quarterly basis. The WQD is not proposing any changes to the progress report schedule or type. A final report will be submitted to U.S. EPA upon project completion.

As stated originally, milestones for this project will follow a phased or incremental schedule. However, the WQD is proposing to compress the watershed-based permitting schedule, and to reduce the number of meetings necessary to develop a watershed-based permitting plan. The reason for schedule compression is that the WQD believes, based upon past watershed-based permitting processes, that there is a considerable amount of streamlining that can and should occur, without rendering the process invalid. As stated previously, the WQD intends to be very succinct in future watershed-based permitting processes regarding the type of information being solicited from stakeholders, and the role that the WQD intends for stakeholders to have. In addition, the WQD is proposing to conduct separate educational forums for stakeholders wishing to acquire such information, in previous watershed-based permitting processes, educational endeavors consumed substantial amounts of time and resources in the watershed-based permitting stakeholder meetings. In addition, the WQD believes that through the use of ArcHydro and Feature Analyst software, and the appropriate hardware, a great deal of information that was previously acquired through time-and-resource intensive field methods may become available remotely or with greatly reduced field time.

Therefore, the WQD believes that each watershed-based permitting process (each watershed), once the initial educational forum process has been completed, can be accomplished in 4-6 months instead of 9-12 months. The basic tasks involved in each watershed are as follows:

Task 1 (month 1) Compile lists of all potential stakeholders within all remaining watersheds of the Greater Powder River Basin that have not undergone watershed-based permitting. Contact all potential remaining stakeholders, announcing the watershed-based permitting process, give brief description of process and goals. Assess level of interest regarding attendance at educational forum(s), assess probable locations and timing for educational forum(s).

Month 2 – Schedule and conduct educational forums

Month 3 – Select the next 3 watersheds to undergo watershed-based permitting. Select meeting facilitator from list of available “approved” facilitators. Inform all stakeholders of first meeting date, request types of information to bring to meeting if available. Advertise meeting in PN in local papers. Use ArcHydro/Feature Analyst to assess any known information.

Month 4 – Conduct first meeting, inform stakeholders of information needs, provide assessment of known information. Collect any information available.

Month 5 – Provide assessment of collected information, provide first draft of watershed permit for review. Provide venue for comments on first draft of permit.

Month 6. – Provide updated permit draft, include appropriate comments, explain why and how comments were included in permit or why they weren’t.

Month 7 – Advertise draft permit in public notice.

Month 8 – Select next 3 watersheds to begin process, repeat remainder of month 3 through month 7.

BUDGET

WQD is requesting continued funding from U.S. EPA through the State Innovation Grant Program. The originally awarded fund amount was $198,000, of which only $16,107 has been either spent or proposed to be spent. WQD does not propose any increase in the original grant amount. As originally requested, a large portion of the grant funds will be utilized for contract services necessary to complete the project.

However, the WQD does propose to utilize the funds for contract services not proposed in the original grant –primarily background water quality monitoring and soil and vegetation surveys. By utilizing more in-house resources for this project, and selectively utilizing contract services for only those services WQD is unable to perform in-house, it will be possible to obtain a more robust product that can be more readily maintained/updated by WQD staff.

The WQD is proposing to change the grant's budget structure as follows:

Object Class Category	Travel	Contractual	Equipment	Supplies	Total
Originally Budgeted Amounts	8,000.00	190,000.00	0	0	198,000.00
Proposed Budget Amounts	7,991.00	181,869.40	6,269.60	1,870.00	198,000.00

APPENDIX A

FIELD MEASUREMENTS AND EQUIPMENT

The USGS measures specific conductance, pH, dissolved oxygen, water temperature, air temperature, and streamflow during site visits to the Powder River at Moorhead, MT sampling site. The USGS uses field instruments and equipment that are safe, precise, accurate, durable, reliable, and capable of performing required tasks (WRD Memorandum 95.35). Appropriate instruments for use in water-quality projects are selected based upon the specifications described in the USGS "National Field Manual for the Collection of Water-Quality Data" (TWRI book 9, chaps. A1-A9). The Hydrologic Instrumentation Facility (HIF), which provides analyses of precision and bias for water-quality instruments, also is consulted for recommendations when appropriate.

Specific conductance, pH, and dissolved oxygen instruments are calibrated in the field prior to making the sample measurements, as described below. Calibration records of field equipment, including the manufacturer, make, model, and serial or property number are kept. Information that is required to be included with the calibration and maintenance records includes the date, initials and last name of the individual performing the activity, results of calibration or equipment check, and any actions taken. Calibration records are checked for completeness and accuracy. Table 2 provides summary information regarding the calibration methods, acceptance criteria, calibration frequency and location, responsible persons, and references for specific instructions for the calibration and use of water-quality instruments for field measurements. Table 3 provides information on field supplies. Expiration dates are checked (and discarded if expired) on all buffers and standards used for calibration.

Field measurements are made to 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 field conditions at each site is required for most instruments. Field-measurement data are recorded while in the field, including methods, equipment, and calibration information. Field-measurement data are stored either electronically and on field forms developed by the USGS. To document the quality of field measurements, USGS field personnel involved in the collection of water-quality data are required to participate in the National Field Quality Assurance (NFQA) Program (Stanley and others, 1992). Results of the NFQA Program are reviewed by the Regional Hydrologist, Office Chief, and the Office Water-Quality Specialist. Staff receiving an unsatisfactory rating will analyze additional samples through the NFQA program.

Table 2. Summary of calibration information for water-quality instruments used to measure selected field constituents.

[NIST, National Institute of Standards and Technology; RP, responsible party; TWRI, Techniques for Water-Resources Investigations]

Parameter	**Calibration method used**	**Acceptance criteria and response if not acceptable**	**Calibration frequency and location**	**Responsible person**	**Reference for calibration and use**
Temperature	NIST-certified thermometer	within 5 percent; replace thermometer	Annually in laboratory.	Field personnel	Wilde and Radtke, 1998, (TWRI book 9, chap. A6.1); see manufacturer's instructions.
Specific conductance	At least two standards, bracketing expected values	Within 5 percent; clean or replace probe.	Daily in field, prior to taking measurements.	Field personnel	Wilde and Radtke, 1998, (TWRI book 9, chap. A6.3); see manufacturer's instructions.
pH	Two-point calibration, bracketing expected values	Within acceptable slope range for instrument as indicated in manufacturer's instructions.	Daily in field, prior to taking measurements.	Field personnel	Wilde and Radtke, 1998, (TWRI book 9, chap. A6.4); see manufacturer's instructions.
Dissolved oxygen	Air calibration in water or air.	Within 5 percent; change membrane or replace probe.	In field, prior to taking measurements.	Field personnel	Wilde and Radtke, 1998, (TWRI book 9, chap. A6.2); see manufacturer's instructions.

Table 3. Field supply information

Supplies, equipment, and instruments	Source and guidelines for QA
Sample bottles	USGS, NWQL, One-stop shopping supplier
Coolers/shipping containers	Local vendor
Sample preservatives	USGS, NWQL, One-stop shopping supplier
pH calibration standards	USGS, NWQL, One-stop shopping supplier
Specific conductance calibration standards	USGS, NWQL, One-stop shopping supplier
Blank water for QA	USGS, NWQL, One-stop shopping supplier
Isokinetic water-quality samplers	Hydrologic Instrumentation Facility
Splitting devices	Hydrologic Instrumentation Facility
Specific conductance meters	Scientific instrument supply catalog, specifications described in the USGS "National Field Manual for the Collection of Water-Quality Data" (TWRI book 9, chaps. A1-A9
pH meters	Scientific instrument supply catalog, specifications described in the USGS "National Field Manual for the Collection of Water-Quality Data" (TWRI book 9, chaps. A1-A9
Distilled/deionized water for field operations	Produced in office laboratories; see OWQ Technical Memorandum 92.01 (USGS)

Selected references for the calibration of field equipment incude:

Reference	Subject
Wilde and Radtke, 1998, (TWRI book 9, chap. A6)	Calibration of water-quality instruments.
WRD Memorandum 95.35 (USGS)	Instrumentation plan for the WRD and the hydrologic field instrumentation and equipment policy and guidelines.

Preparations for Sampling

Before commencing field activities, field personnel ensure that the following preparations have been completed:

- Review the sampling instructions for each site and the list of sample types required.
- Ensure that the site file is current.
- Prepare bottle labels for samples.
- Obtain field sheets or notebooks and analytical services request forms (ASR's).
- Ensure that necessary supplies are available, such as bottles, standards, filters, preservatives, meter batteries, waterproof markers, shipping containers, etc.
- Ensure that all sampling equipment is thoroughly cleaned and prepared.
- Check meters and sensors for proper performance.

During a sampling trip, it is imperative that accurate notes be taken and that sample bottles be labeled and handled appropriately for the intended analysis. Otherwise, bottle mix-ups or other errors may occur, and the samples may be wasted. Field personnel conducting the sampling are responsible for ensuring that all samples are labeled and handled according to USGS procedures. All samples are in the required container type and clearly labeled with the site number, sample date, sample time, bottle type designation, and laboratory schedule. Sample handling includes the treatment and preservation for the sample designation. Further guidance on sample processing and container types can be found on the National Water Quality Laboratory (NWQL) Web page (http://wwwnwql.cr.usgs.gov/USGS/Catalog/SampleProcessingHistoric.html) and in Wilde and others (1999 c), chap. A5, sec. 5.5.

Field vehicles

A field vehicle is designated as a water-quality field vehicle when it meets criteria to maintain a non-contaminating environment for the constituents being sampled. The work area is 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 (Wilde and others, 1998, TWRI book 9, chap. A2.3) and include the following:

- Materials used for cabinets, storage, and work surfaces are easy to maintain, made of or covered with non-contaminating materials, and such that they can be cleaned with water or solvents as appropriate. Cargo is 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., are transported in the interior compartment of the vehicle.
- A dust barrier exists between the cab and work area of the vehicle.

The following is a reference for field vehicles:

Reference	Subject
Wilde and others, 1998 (National Field Manual, TWRI book 9, chap. A2.3)	Guidelines for field vehicles.

Cleaning of equipment

Procedures for cleaning equipment used for water-quality sampling and processing are described in chapter A3 of the National Field Manual (Wilde and others, 1998). To summarize, equipment are cleaned with laboratory-grade detergent, rinsed with tap water, rinsed with 5 percent trace-metal-grade hydrochloric acid, and a final rinsing with deionized water. All equipment used for water-quality sampling is cleaned in the office before being used in the field. Similarly, equipment is cleaned as soon as possible after sample collection, prior to being used again, to avoid cross-contamination between sampling sites.

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 in environmental samples. Routine equipment blanks may be processed in the field or office laboratory, depending on study objectives. In addition to routine equipment blanks, an annual equipment blank, collected in the office laboratory, is processed for equipment used to collect water-quality samples for parts-per- billion analysis (Horowitz and others, 1994; Wilde and others, 1998, chap. A3). Annual equipment blanks that indicate detectable levels of constituents above laboratory reporting levels 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 is performed to eliminate contamination, or the equipment is replaced.

SAMPLE COLLECTION AND PROCESSING

The primary objective in collecting a water-quality sample is to obtain environmental data that are representative of the stream that is being studied. All field personnel involved in collecting and processing water-quality data are informed and trained regarding water-quality data-collection and processing procedures established by the USGS. Guidelines for the collection of stream-water samples are provided in chapter A4 of the National Field Manual (Wilde and others, 1999 b). 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. The standard procedure for stream sampling is to collect the sample through the entire depth of the water column at multiple vertical transects by either the equal-discharge or equal-width increment method. 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 non-integrated or non-flow-weighted methods may be appropriate because of hydrologic, climatic or safety conditions. For example, dip samples from the centroid are acceptable when the stream is too small for the sampler and precludes the collection of the integrated sample. Sampling equipment is rinsed with native stream water onsite before environmental samples are collected.

Documentation of sampling equipment and methods that are used is required in field records associated with water-quality samples. Specific procedures employing two-person sampling teams with specific, designated roles in sample collection and handling are used when sampling for trace inorganic constituents with ambient concentrations less than about 10 parts per billion (ppb), as described in Horowitz and others (1994). 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.

All samples collected for water-quality analysis are processed according to procedures in the National Field Manual (Wilde and others, 1999 c, chap. A5) as soon as possible following collection. Integrated samples are composited in a plastic churn. Guidelines for using the churn for sample compositors are described in the National Field Manual (Wilde and others, 1998 d, chap. A2).

Sample filtration and preservation

Filtration is required in order to separate particulates from the water and constituents in solution. A description of filtration procedures is provided in the National Field Manual (Wilde and others, 1999 c, chap. A5). For samples collected in the Powder River Basin, the filtration system consists of a reversible, variable-speed battery-operated peristaltic pump and 0.45-micron pore size disposable capsule filter.

Sample preservation techniques are used for some constituent groups to prevent reduction or loss of target analytes and to stabilize analyte concentrations for a limited time. Protective equipment is used when handling chemical preservative, particularly acids. A description of sample preservation techniques are provided in the National Field Manual (Wilde and others, 1999 c, chap. A5), and the NWQL Services Catalog.

The sample filtration and preservation requirements are determined by the sample bottle type required by the laboratory. A description of sample bottle designations for sample processing follows:

Bottle
250mL FA **Description:** 250 mL Polyethylene bottle, acid-rinsed **Treatment and Preservation:** , Filter through 0.45-um filter, use filtered sample to rinse containers and acidify sample with nitric acid (HNO3) to pH < 2
250mL FU **Description:** 250 or 500 mL Polyethylene bottle, **Treatment and Preservation:** Filter through 0.45-um filter. Use filtered sample to rinse containers
250mL RA **Description:** 250 mL Polyethylene bottle, acid-rinsed **Treatment and Preservation:** Use unfiltered sample to rinse bottles, then acidify collected sample with nitric acid (HNO3) to pH < 2
250mL RU **Description:** **Treatment and Preservation:** 250 or 500 mL Polyethylene bottle, Use unfiltered sample to rinse bottles

A summary of references used for collecting and processing water-quality samples follows:

Reference	Subject
Edwards and Glysson, 1988	Representative sampling techniques for surface water.
Horowitz and others, 1994	Protocol for collecting and processing inorganic constituents at ppb concentrations.
Lane and Fay, 1998 (TWRI book 9, chap. A9)	Safety in field activities.
OWQ Memorandum 97.06 (USGS)	Comparison of splitting capabilities of the churn and cone splitters.
Shelton, 1994	Collecting and processing stream-water samples (NAWQA).
Stanley and others, 1992	National field quality-assurance program.
Ward and Harr, 1990	Representative sampling techniques for surface water.
Wilde and others, 1998 a (TWRI book 9, chap. A3)	Cleaning equipment used to collect and process water-quality samples.
Wilde and others, 1999 b (TWRI book 9, chap. A4)	Collecting water-quality samples from surface and ground water.
Wilde and others, 1999 c (TWRI book 9, chap. A5)	Processing water-quality samples.
Wilde and others, 1998 d (TWRI book 9, chap. A2)	Selection of equipment used to collect and process water-quality samples.
OWQ Technical Memorandum 92.06 (USGS)	Recommended guidelines for shipping samples to the NWQL.
Branch of Operations Technical (OP) Memoran dum 91.01 (USGS)	Safety Chemical-Hygiene Plan.
NWQL Memorandum 92.01 (USGS)	Availability of equipment blank water for inorganics and organics.

Quality-control samples

Quality-control samples are collected as an integral part of the sampling program to determine the acceptability of performance in the data-collection process and provide a basis for evaluating the adequacy of procedures that were used to obtain data. Quality-control samples, including equipment blanks and replicates are used to estimate the extent to which contamination, measurement variability, and matrix interference affect the interpretation of the environmental data (Mueller and others, 1997). Equipment blank samples were prepared in the field at each of the sites by processing inorganic-grade deionized water through the sampling equipment immediately before collecting the environmental sample. Replicate samples were prepared at each of the fixed sites by splitting the environmental sample into duplicate samples. Guidelines for the collection of specific types of quality-control (QC) samples and the use of QC data are provided in the National Field Manual (Wilde and others, 1999 b, chap. A4).

SAMPLE ANALYSIS

Samples collected are analyzed at the USGS NWQL. A description of the laboratory schedules collected at stream sampling sites are shown in table 4 and table 5. The type of laboratory schedule collected at a site is listed in table 1. The constituents selected for analysis and, thus, the type of schedule collected at a site varies based on the data-quality objectives for a site.

Samples collected from the mainstem and major tributary sites generally are analyzed using laboratory schedule 1757 (table 4). Laboratory schedule 1757 includes a complete analysis for major ions and selected trace elements that are of concern in CBNG waters. The laboratory reporting levels (RL) for major-ion constituents generally are less than 1 milligram per liter (table 4); exceptions to this are alkalinity and dissolved solids, which have slightly higher reporting levels. The filtered or unfiltered matrix selected for analysis for the trace metals constituents was based on water-quality criteria established by the States of Wyoming and Montana.. The laboratory reporting levels for the selected trace elements are in the micrograms to submicrogram per liter range. The reporting levels for the major ions and selected trace elements meet the data-quality objectives for these mainstem and major tributary waters which are typically high-ionic strength waters.

Table 4. Constituents analyzed for laboratory schedule 1757.

Analyte	Parameter code	CAS Number	RL	Unit	RL Type	Con-tainer
Alkalinity, laboratory	29801	471-34-1	2	mg/L	mrl	FU
Aluminum, unfiltered	01105	7429-90-5	2	ug/L	lrl	RA
arsenic, filtered	01000	7440-38-2	0.2	ug/L	lrl	FA
barium, unfiltered	01007	7440-39-3	0.2	ug/L	lrl	RA
beryllium, unfiltered	01012	7440-41-7	0.06	ug/L	lrl	RA
calcium, filtered	00915	7440-70-2	0.02	mg/L	lrl	FA
chloride, filtered	00940	16887-00-6	0.20	mg/L	lrl	FU
fluoride, filtered	00950	16984-48-8	0.10	mg/L	lrl	FU
iron, filtered	01046	7439-89-6	6	ug/L	lrl	FA
magnesium, filtered	00925	7439-95-4	0.008	mg/L	lrl	FA
manganese, filtered	01056	7439-96-5	0.6	ug/L	lrl	FA
pH, laboratory	00403		0.1	pH	mrl	RU
potassium, filtered	00935	7440-09-7	0.16	mg/L	lrl	FA
residue, 180 degrees Celsius	70300		10	mg/L	mrl	FU
selenium, unfiltered	01147	7782-49-2	0.4	ug/L	lrl	RA
silica, filtered	00955	7631-86-9	0.04	mg/L	lrl	FA
sodium, filtered	00930	7440-23-5	0.20	mg/L	lrl	FA
specific conductance, laboratory	90095		2.6	uS/cm	mrl	RU
sulfate, filtered	00945	14808-79-8	0.18	mg/L	lrl	FU

A listing of references for analytical methods used in laboratory schedule 1757 follows:

1. **OFR 93-125**

   Fishman, M.J., ed., 1993, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory--Determination of inorganic and organic constituents in water and fluvial sediments: U.S. Geological Survey Open-File Report 93-125, 217 p.

   Method ID: I-1472-87

2. **OFR 96-225**

   Hoffman, G.L., Fishman, M.J., and Garbarino, J.R., 1996, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory--In-bottle acid digestion of whole-water samples: U.S. Geological Survey Open-File Report 96-225, 28 p.

   Method ID: I-3486-95

3. **OFR 98-165**

   Garbarino, J.R., and Struzeski, T.M., 1998, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory -- Determination of elements in whole-water digests using inductively coupled plasma- optical emission spectrometry and inductively coupled plasma-mass spectrometry: U.S. Geological Survey Open-File Report 98-165, 101 p.

   Method ID: I-4471-97

4. **TWRI B5-A1/89**

   Fishman, M.J., and Friedman, L.C., 1989, Methods for determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A1, 545 p.

   Method ID: I-1750-89 , I-2030-89 , I-2057-85 , I-2327-89 , I-2587-89 , I-2781-89

5. **Std Meth 20th Edition - 3120**

   American Public Health Association, 1998, Standard methods for the examination of water and wastewater (20th ed.); Washington, D.C., American Public Health Association, American Water Works Association, and Water Environment Federation, p.3-37 - 3-43.

   Method ID: 3120-ICP

6. TWRI B5-A1/89

   Fishman, M.J., and Friedman, L.C., 1989, Methods for determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. A1, 545 p.

   Method ID: I-1750-89 , I-2030-89 , I-2057-85 , I-2327-89 , I-2587-89 , I-2781-89

7. OFR 99-093

   Garbarino, J.R., 1999, Methods of analysis by the U.S. Geological Survey National Water Quality Laboratory **--** Determination of dissolved arsenic, boron, lithium, selenium, strontium, thallium, and vanadium using inductively coupled plasma-mass spectrometry: U.S. Geological Survey Open-File Report 99-093, 31 p.

   Method ID: I-2477-92

Data review

All field notes and field measurements are reviewed for completeness and accuracy as soon as possible after returning from the field trip by the field personnel. Chemical analyses are reviewed as soon as they are received from the laboratory. All chemical analyses are reviewed for completeness of the analytical tests. Prompt review is necessary to allow analytical re-analysis to be performed before sample holding times have been exceeded for accuracy and precision. The specific data-review criteria for constituents are outlined in table 6. Values that do not meet these data-review criteria are noted by the office water-quality specialist and analytical reruns of the constituents are requested. In some cases, values that are rerun still may not meet the data-review criteria. In this case, further review of the data are warranted. Data relations are reviewed and multiple lines of evidence are used to further qualify results where data fall outside of the data-quality objectives. In some cases, matrix interference as a result of the high ionic strength waters that are typical of those present in the Powder River Basin can result in a raising of the laboratory reporting level. Data may be qualified in the data base that do not meet objectives.

Table 6. Constituents and data-review criteria.

Constituent	Data-review criteria
All field and chemical constituents	Data fall within historical statistical summaries determined for constituents and sites.
pH	Field and laboratory values agree within one pH unit
Specific conductance	Field and laboratory values agree within 10 percent
Dissolved solids	The dissolved solids and specific conductance ratio in the range of 0.55 to 0.81; computed dissolved solids and residue on evaporation percent difference in the range of 10 percent or less.
Major cations	Sum of cations (in milliequivalents) and specific conductance ratio in the range of 0.92 to 1.24.
Major anions	Sum of anions (in milliequivalents) and specific conductance ratio in the range of 0.92 to 1.24.
Major ions	Sum of cations (in milliequivalents) and sum of anions (in milliequivalents) have a percent difference of 5.49 percent or less.
Dissolved/ total fractions	For a given constituent, dissolved and total fractions percent difference in the range of 10 percent or less.

Analyzing laboratory

The U.S. Geological Survey's NWQL that analyzes the stream-water samples collected conforms to the following guidelines:

1. Uses approved and published analytical methods—Analytical methods are approved and published by one of the following sources: USGS; U.S. Environmental Protection Agency (USEPA); American Public Health Association, American Water Works Association, and Water Environmental Federation (Standard Methods); or American Society for Testing and Materials (ASTM). A list of some analytical methods currently used at the NWQL can be found on the World Wide Web at http:// wwwnwql.cr.usgs.gov/Public/ref_list.html. Other analytical methods from the USEPA that are currently used at the NWQL can be found on the World Wide Webb at http://www.epa.gov./epahome/publications.htm. Analytical methods from the ASTM that are currently used at the NWQL can be found on the World Wide Web at http://www.astm.org.
2. Has standard operating procedures (SOP's) for analytical methods—All analytical methods have documented SOP's that are approved in accordance with procedures contained in the laboratory QA plan.
3. Has an approved laboratory QA plan—provides internal guidance and documentation that ensures the laboratory is operating under a standardized, rigorous QA program and is producing analytical results of a known and documented quality. The laboratory QA plan describes QA activities, QC procedures and requirements, performance acceptance criteria, and required corrective actions that will be taken if the criteria are not met. The NWQL quality-assurance plan is contained in Pritt and Raese (1995). A copy of this report can be obtained by sending an Email request to GS-W-COden NWQL LabHelp@USGS.gov.
4. Has a documented QC program that provides the data necessary to continuously track the bias and variability of analytical data.

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 GS-W-COden NWQL LabHelp@USGS.gov. Information about the external blind sample program can be found at the following World Wide Web location: http:// btdqs.usgs.gov/bsp/Fact.Sheet.html. 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 GS-W-COden NWQL LabHelp@USGS.gov. Laboratory reviews—External agencies and customer organizations audit the NWQL to assess analytical methods and 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 GS-W-COden NWQL LabHelp@USGS.gov.

A summary of references for USGS quality assurance criteria for laboratories is shown below.

Reference	Subject
OWQ Technical Memorandum 98.03 (USGS)	Policy for the evaluation and approval of production analytical laboratories.
Pritt and Raese, 1995	Quality assurance/quality control manual NWQL.
WRD Memorandum 82.028 (USGS)	Acceptability and use of water-quality analytical methods.
WRD Memorandum 92.035 (USGS)	Policy for approval of all laboratories providing analytical services to the WRD for non-research purposes.
WRD Memorandum 92.036 (USGS)	Policy of the WRD on the use of laboratories by national water-quality programs.

SAMPLE HANDLING AND TRACKING

All water-quality samples are uniquely identified, documented, handled, shipped, and tracked appropriately. Protocols for sample handling, shipping, and tracking ensures that samples are processed correctly and expeditiously to preserve sample integrity between the time of collection and the time of analysis. Upon completion of a sampling trip, samples are packaged and shipped to the laboratory for analysis as soon as possible. Generally, the shorter the time between sample collection and processing and sample analysis, the more reliable the analytical results will be. Before shipping samples to the laboratory, the field personnel complete the following:

1. Check that sample sets are complete and that sample bottles are labeled correctly, with all required information.
2. Complete the ASR for all samples being sent to the NWQL.
3. 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 NWQL. Additional information is contained in the NWQL Technical Memorandum 95.04 and the National Field Manual (Wilde and others, 1999).

All samples collected are tracked and stored electornically. An electronic field catalog contains all the sampling information, including site information, sampling schedule, laboratory schedules, bottle types, and other instructions is maintained for the field personnel. The electronic tracking of sample data is accomplished with the water-quality system (QWDATA) within NWIS. Sample identification information (site number, sample date, sample time, sample medium, and other sample coding) and field measurements are entered into QWDATA after completion of a field sampling visit. A record number is assigned by the system, recorded on the field sheet, and used for tracking the sample in QWDATA. Sample information for environmental samples and quality-control samples are separated in the QWDATA system so that there is no misinterpretation of sample types. Analytical results from NWQL are electronically transferred to reduce transcription errors into QWDATA on a weekly basis. Hard copies of the analytical reports (WATLIST's) are reviewed in Cheyenne and storage in project files. The NWIS data base receives daily incremental backup and weekly full backup by the office site administrator. All streamflow and water-quality data are electronically available to the public at URL: http://nwis.waterdata.usgs.gov/wy/nwis/. Provisional data may not be available electronically but can be obtained by contacting the USGS.

In accordance with USGS policy, all water data collected as part of any sampling program are stored in the NWIS computer data base. The Science Center site administrator has responsibility for maintaining backups of data stored electronically in NWIS or online. In addition to electronically stored data, other project data and information, including field notes, ASR's, WATLIST's, and other data sheets are retained in station folders and maintained by project personnel in the Casper and Cheyenne offices while the sampling program is active.

According to USGS policy, all original data that are published or support published scientific analyses will be archived (WRD Memorandum 92.059; Hubbard, 1992). Original data on paper include field notes, field measurements, ASR's, WATLIST's, continuous water-quality monitoring records, and calibration notes. These data are archived when the project is complete**.** It is the responsibility of the project chief and Science Center data-base administrator to ensure that project files entered into the Science Center archive are organized and complete. Water-quality analysis files are located in the USGS Cheyenne office. Data from the USGS offices may be transferred to the permanent, national archive in Denver, Colorado, when project data is published and routine access to the data is no longer required.

A summary of references for managing water-quality data and records

Reference	Subject
Dempster, 1990	NWIS ADAPS user's guide.
Hubbard, 1992	Policy recommendations for managing and storing hydrologic data.
Maddy and others, 1997	NWIS QWDATA user's guide.
NWQL Memorandum 92.06 (USGS)	Science Center rerun requests.
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.

CONTINUOUS MONITORING DATA

Continuous monitoring data are water-quality records collected onsite by electronic sensors and data loggers. Continuous monitoring data for specific conductance and temperature are collected for sites on the Powder River at Moorhead. Guidelines and standard procedures are documented in the report, "Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and Data Reporting", Techniques and Methods 1-D3, by Richard J. Wagner and others (2006). This report describes the types of monitor configuration; placement of sensors in the cross section; field calibration; operation and maintenance; and records computation. These data are maintained electronically in NWIS. Data are available in real-time at URL: http://waterdata.usgs.gov/wy/nwis/current/?type=quality.

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. 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.

So that personnel are aware of and follow established procedures and protocols that promote all aspects of safety, information about safety is communicated through memorandum, electronic mail, videotapes, and training courses. Specific policies and procedures related to safety are documented in the Science Center safety plan. General safety information for field personnel are available from an internal web page from the USGS.

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