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Office of Water
Office of Environmental Information
Washington, DC
EPA 841-B-04-005

Wadeable Streams Assessment

Quality Assurance Project Plan

August 2004

WADEABLE STREAMS ASSESSMENT:
QUALITY ASSURANCE PROJECT PLAN

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Wadeable Streams Assessment (WSA)
Quality Assurance (QA) Project Plan

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Signature indicates that this QAPP is approved and will be implemented in conducting this project.

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QUALITY ASSURANCE PROJECT PLAN
REVIEW & DISTRIBUTION ACKNOWLEDGMENT AND
COMMITMENT TO IMPLEMENT

for
Wadeable Streams Assessment

We have read the QAPP and the methods manuals for the Wadeable Streams Assessment listed below. Our agency/organization, _____, agrees to abide by its requirements for work performed under our cooperative agreement for Demonstration of Randomized Design for Assessment of Wadeable Streams (under CWA 104(b)(3)).

Quality Assurance Project Plan	☐
Site Evaluation Guidelines	☐
Field Operations Manual	☐
Benthic Laboratory Methods	☐
Water Chemistry Laboratory Manual	☐

Print Name _____
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Retain a copy for your files.

NOTICE

The complete documentation of overall WSA project management, design, methods, and standards is contained in five companion documents, including:

- *Wadeable Streams Assessment: Quality Assurance Project PlanEPA 841-B-04-005*
- *Wadeable Streams Assessment: Site Evaluation Guidelines EPA 841-B-04-008*
- *Wadeable Streams Assessment: Field Operations Manual EPA 841-B-04-004*
- *Wadeable Streams Assessment: Benthic Laboratory MethodsEPA 841-B-04-007*
- *Wadeable Streams Assessment: Water Chemistry Laboratory Manual EPA 841-B-04-008*

This document (*Quality Assurance Project Plan*) contains elements of the overall project management, data quality objectives, measurement and data acquisition, and information management for the WSA, and is based on the guidelines developed and followed in the Western Environmental Monitoring and Assessment Program (Peck et al. 2003). Methods described in this document are to be used specifically in work relating to WSA. All Project Cooperators should follow these guidelines. Mention of trade names or commercial products in this document does not constitute endorsement or recommendation for use. More details on specific methods for site evaluation, field sampling, and laboratory processing can be found in the appropriate companion document(s) listed above.

The suggested citation for this document is:

> USEPA. 2004 (draft). Wadeable Stream Assessment: Integrated Quality Assurance Project Plan. EPA/841/B-04/005. U.S. Environmental Protection Agency, Office of Water and Office of Research and Development, Washington, DC.

DISTRIBUTION LIST

This QA Project Plan and associated manuals or guidelines will be distributed to the following EPA, Tetra Tech, Inc. (Tt), and Great Lakes Environmental Center (GLEC) senior staff participating in the WSA and to State Water Quality Agencies or cooperators who will perform the field sampling operations. The Tt and GLEC QA Officers will distribute the QA Project Plan and associated documents to participating project staff at their respective facilities and to the project contacts at participating laboratories, as they are determined.

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1.0 PROJECT PLANNING AND MANAGEMENT

1.1 Introduction

Several recent reports have identified the need for improved water quality monitoring and analysis at multiple scales. In 2000, the General Accounting Office (USGAO,2000) reported that EPA and states cannot make statistically valid inferences about water quality (via 305[b] reporting) and lack data to support key management decisions. In 2001, the National Research Council (NRC,2000) recommended EPA and states promote a uniform, consistent approach to ambient monitoring and data collection to support core water quality programs. In 2002, the H. John Heinz III Center for Science, Economics, and the Environment (Heinz Center,2002) found there are inadequate data for national reporting on fresh water, coastal and ocean water quality indicators. The National Association of Public Administrators (NAPA,2002) stated that improved water quality monitoring is necessary to help states make more effective use of limited resources. EPA's Report on the Environment 2003 (USEPA, 2003) says that there is insufficient information to provide a national answer, with confidence and scientific credibility, to the question, "What is the condition of U.S. waters and watersheds?"

In response to this need, the U.S. Environmental Protection Agency (EPA) Office of Water (OW), in concert with EPA's Office of Research and Development (ORD) and the 10 EPA Regions, conceived of the Wadeable Streams Assessment (WSA) - a national assessment of the condition of wadeable streams and rivers in the conterminous U.S. This assessment was to be the first assessment on flowing waters to be based on data collected using the same field and laboratory protocols and based on a statistical survey design that would allow inferences about all waters based on a sample of the streams across the country. The desire was to implement this effort in cooperation with the States and other eligible entities. Therefore, OW issued a Request for Pre-Proposals under Clean Water Act Section 104(b)(3) to invite eligible applicants to participate in a demonstration project to apply a consistent set of monitoring protocols and monitoring design to characterize the wadeable streams and rivers across the United States. The WSA builds upon the Environmental Monitoring and Assessment Program's (EMAP) Western Study implemented by ORD, the EPA Regions, States and Tribal nations in 12 western states. The WSA will provide important information to the public about the status of wadeable streams and rivers, information that does not currently exist for large parts of the country.

The WSA Quality Assurance Project Plan (QAPP) is designed to support the participants in this project and to ensure that the final assessment is based on high quality data and information. The QAPP contains elements of the overall project management, data quality objectives, measurement and data acquisition, and information management for the WSA. The participants in the WSA have agreed to follow this QAPP and the protocols and design laid out in this document.

The WSA was designed to work in concert with ORD's Environmental Monitoring and Assessment Program (EMAP). Between 2000 and 2004, EMAP West has successfully sampled nearly 1000 streams from 12 states in the Western United States. WSA will sample the remaining 36 states with 500 sites selected using a probability-based design and the same field and laboratory protocols to complete sampling in the 48 contiguous states. WSA has two objectives:

- Estimate the current status in selected indicators of the condition of the Nation's streams and tributaries on a regional basis with known statistical confidence.

- Seek associations between selected indicators of natural and anthropogenic stresses and indicators of condition of wadeable streams and rivers .

Monitoring and assessment tools developed for EMAP will contribute to improving the ecological assessments in WSA. These assessments will provide estimates (with quantifiable uncertainty) of the biological integrity of the macroinvertebrate communities in wadeable streams and rivers. Chemical and physical habitat information, along with watershed characteristics will also be collected to assist in explaining the patterns found in macroinvertebrate communities across the country.

1.2 WSA Project Organization

The major areas of activity and responsibilities are described here and illustrated in Figure 1. The overall coordination of the project will be provided by EPA's Office of Water (OW) in Washington, DC, with technical support from the Western Ecology Division (WED) of the Office of Research and Development (ORD) in Corvallis, Oregon and the ten EPA Regional Offices. Because this project builds upon the EMAP western study and integrates ecological data from that study, ORD will have a primary role in training field crews and managing the complex data derived from the surveys and the laboratory processing of the samples. This comprehensive quality assurance (QA) program has been established to ensure data integrity and provide support for the reliable interpretation of the findings from this project.

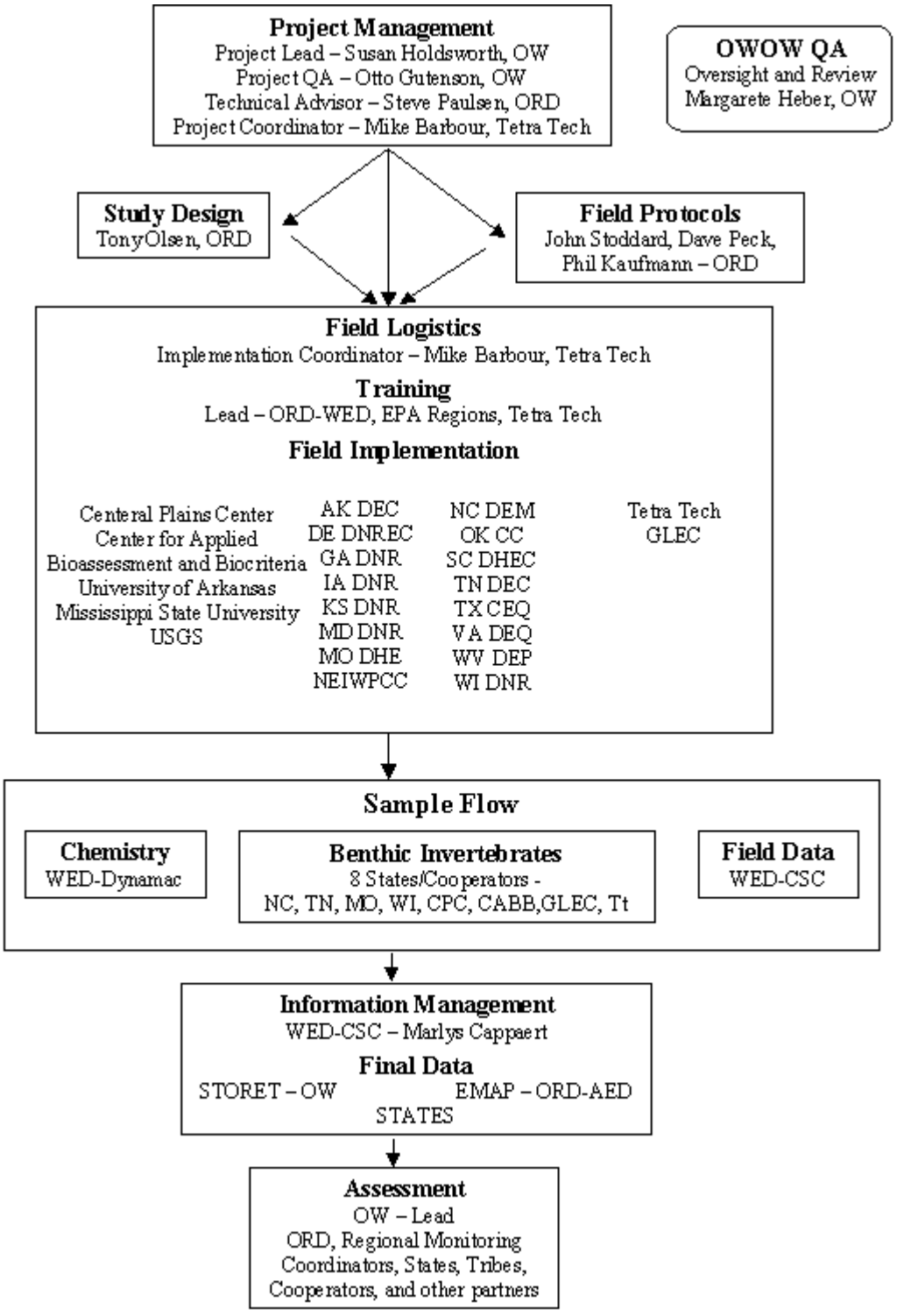


Figure 1. WSA Project Organization

Program level QA will be the responsibility of the OWOW QA Officer and the Project QA Officer. A QA records system will be used to maintain indefinitely a permanent hardcopy file of all WSA documentation from site selection to data analysis. This will be housed in OW Headquarters Office.

The primary responsibilities of the principals and cooperators are as follows:

***Project Management**:*
EPA Project Leader – provides overall coordination of the project and makes decisions regarding the proper functioning of all aspects of the project. Makes assignments and delegates authority, as needed to other parts of the project organization.

EPA Project QA Lead - provides leadership, development and oversight of project level quality assurance for WSA in Office of Water

EPA ORD Technical Advisor – advises the Project Leader on the relevant experiences and technology developed within ORD's EMAP that are to be used in this project. Serves as primary point-of-contact for project coordination in the absence or unavailability of Project Leader.

Project Coordination - contractor providing day-to-day coordination of field implementation as well as technical development of analysis of data.

***Study Design**:*
The assessment will utilize data from two separate field studies: EMAP-West and a new field effort in the eastern 36 States. The same sample survey design was used for EMAP-West as well as the eastern 36 States. The design for both was developed by ORD's Western Ecology Division to ensure comparability. Site selection is part of the study design.

***Field Protocol Development**:*
The field sampling protocols were developed by ORD for use in EMAP and were developed with the purpose of providing consistent and representative information across the country. The EMAP protocols used in the western US will be used the eastern States contributing to WSA.

***Field Logistics**:*
Implementation Coordinator – a contractor who functions on behalf of the Project Leader to support all phases of the field implementation of the project. Primary responsibility is to ensure all aspects of the project, i.e., technical, logistical, organizational, are operating as smoothly as possible. Serves as point-of-contact for questions from field crews and cooperators for all activities.

Training - eight training sessions will be conducted in various locations throughout the eastern US. The EMAP team from ORD's Western Ecology Division will conduct the

initial 2 training sessions and a third session that focuses on training the trainers. A Tetra Tech team will conduct the remaining 4 training sessions with an observer from ORD there to assist if needed. A monitoring specialist from each EPA Regional Office will also participate in each of the trainings. Each field crew must have a crew leader who has received 3 days of lecture and field training to prepare them for this study. At the end of the training period, each team will conduct a day long sampling on their own under the watch of the trainers. This field readiness review will be the final QA check of the training sessions. All field crews will be audited early in their sampling schedule to be certain any corrections will be made at the onset of sampling.

Field Implementation -Fifteen States, six cooperators and two contract teams staffed by Tetra Tech and GLEC will conduct the field implementation to collect samples using the WSA protocols.

Field Quality Evaluation and Assistance Reviews - Each field team will be visited by a trained team from either an EPA Region, GLEC or Tetra Tech. The purpose of this field evaluation and assistance review is to observe the crews implementing the protocols as trained and provide any assistance or corrections necessary. This is intended to catch deviations from the protocols before they become widespread.

Sample Flow:
Field samples will be shipped by the crews to one of several locations. All water samples will be sent to the Western Ecology Division laboratory staffed by Dynamac. The macroinvertebrate samples will be shipped to one of 6 States or Cooperator laboratories or GLEC for identification. The field data sheets will be shipped to the Western Ecology Division information management team staffed by CSC for scanning and entry into the database. Each of the organizations processing samples will electronically transfer the results to CSC using the naming conventions and standards provided by CSC.

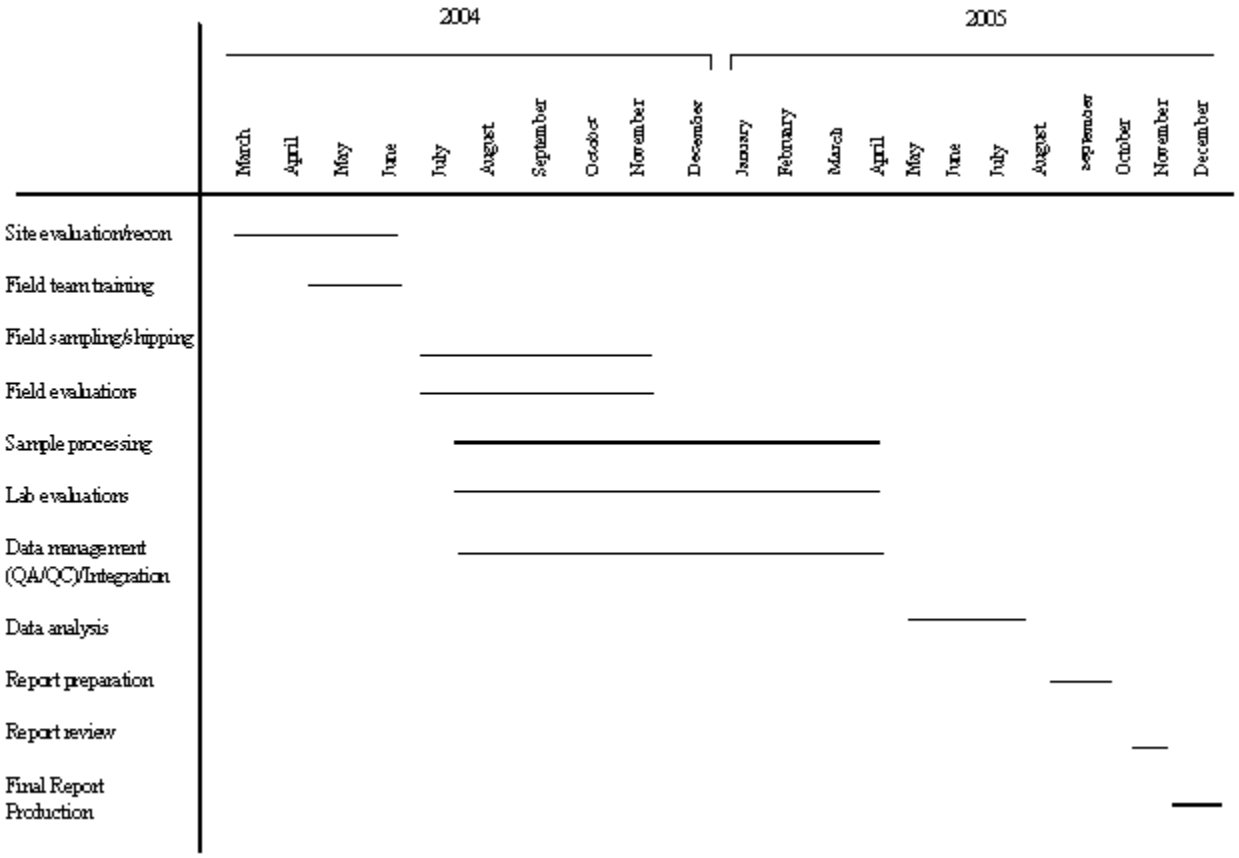
Information Management:
The first stage of data processing will be to take the input from each of the responsible laboratories and enter them into a common database for final verification and validation. Once the final data sets are made available for the assessment, copies of the data will be transferred to EPA's STORET and EPA's EMAP dataset for long-term storage and access. Working copies of the final data sets will be distributed to the States and Cooperators and maintained at WED for analysis leading to the assessment.

Assessment:
The final assessment will be developed by a team, led by OW, that will include Office of Water, Office of Environmental Information, several ORD research facilities, EPA Regional Monitoring Coordinators, interested States and Cooperators. All States will be invited to participate in collaborative process to interpret results and shape data assessment and report. The final assessment will include an appendix describing the quality of the data used in the assessment. The final assessment will be delivered to

the Assistant Administrator for Office of Water in December of 2005.

1.2.1 Project Schedule

The U.S. EPA has responded to a State and OW goal to report on the quality of the Nation's streams by no later than December, 2005. Figure 2 gives an overview of the



major tasks leading up to the final report. These activities are described throughout the QAPP.

Figure 2. Timeline of WSA project activities

1.3 Scope of QA Project Plan

This QA Project Plan addresses all aspects of the data acquisition efforts of WSA, which focuses on the 2004 sampling of streams in the eastern United States.

The QA plan also deals with the data integration necessary between WSA and EMAP Western Pilot Study (2001-2004) to create one complete report on the ecological status of the Nation's streams.

Data from approximately 500 stream sites in the eastern two-thirds of the United States will be integrated with data from approximately 1000 stream sites in the western United States for a comprehensive assessment. Relevant Companion documents to this QAPP are*: WSA: Site Evaluation Guidelines, WSA: Field Operations Manual*, *WSA: Benthic Laboratory Methods*, and *WSA: Water Chemistry Laboratory Manual*.

1.3.1 Overview of Field Operations

Field data acquisition activities are implemented for WSA (Table 1), based on guidance developed for earlier EMAP studies (Baker and Merritt 1990). Survey preparation is initiated with selection of the sampling locations by the EMAP Design group (WED in Corvallis). The list of sampling locations is distributed to the EPA Regional Monitoring Coordinators and cooperators. With the sampling location list, Cooperator's field crews can begin site reconnaissance on the primary sites and alternate replacement sites and begin work on obtaining access permission to each site. Specific procedures for evaluating each sampling location and for replacing non-target sites are documented in the *WSA: Site Evaluation Guidelines*. Scientific collecting permits from State and Federal agencies will be procured, as needed by the respective State or cooperating organization. The field teams will use standard field equipment and supplies which are being provided by EPA and GLEC. Field logistic coordinators (GLEC and Tetra Tech) will work with Regional Monitoring Coordinators, Cooperators, States and Contractors to make certain the field crews have the equipment and supplies they require in a timely fashion. Detailed lists of equipment required for each field protocol, as well as guidance on equipment inspection and maintenance, are contained in the Field Operations Manual.

Table 1. Critical logistics elements (from Baker and Merritt, 1990)

Logistics Plan Component	Required Elements
Project Management	Overview of Logistic Activities Staffing and Personnel Requirements Communications
Access and Scheduling	Sampling Schedule Site Access Reconnaissance
Safety	Safety Plan Waste Disposal Plan
Procurement and Inventory Control	Equipment, Supplies, and Services Requirements Procurement Methods and Scheduling

Training and Data Collection	Training Program Field Operations Scenario Laboratory Operations Scenarios Quality Assurance Information Management
Assessment of Operations	Field Crew Debriefings Logistics Review and Recommendations

Field measurements and samples are collected by trained teams. All members of each field team will attend one EPA-sponsored training session before the field season in their state. Field quality evaluation and assistance review visits will be completed for each team. Each team is comprised of 3 members; the number of teams will be determined by the site evaluation/reconnaissance teams depending on number of reaches sampled. The number and size of teams depends on the duration of the sampling window, geographic distribution of sampling locations, number and complexity of samples and field measurements, and other factors. The training program stresses hands-on practice of methods, comparability among crews, collection of high quality data and samples, and safety. Training will be provided in seven central locations for cooperators and contractors. Project organizations responsible for training oversight are identified in Figure 1. Training documentation will be maintained by the Tetra Tech Training Support Team.

For each sampling location, a dossier is prepared and contains the following applicable information: road maps, copies of written access permissions, scientific collection permits, coordinates of index sites, information brochures on the program for interested land owners, a topographic map with the index site location marked, and local area emergency numbers. Team leaders will contact landowners approximately 2 days before the planned sampling date. As the design requires repeat visits to selected sampling locations, it is important for the field teams to do everything possible to maintain good relationships with landowners. This includes prior contacts, respect of special requests, closing gates, minimal site disturbance, and removal of all materials including flagging and trash.

A variety of methods may be used to access a site, including vehicles and boats. Some sampling locations require teams to hike in, transporting all equipment in backpacks. For this reason, ruggedness and weight are important considerations in the selection of equipment and instrumentation. Teams may need to camp out at the sampling location and so are equipped with the necessary camping equipment.

The site verification process is shown in Figure 3. Upon arrival at a site, the location is verified by a Global Positioning System (GPS) receiver, landmark references, and/or local residents. Samples and measurements for various indicators are collected in a specified order (Figure 4). This order has been set up to minimize the impact of sampling for one indicator upon subsequent indicators; for example, water chemistry samples from streams are collected before collecting benthic invertebrates as the benthic invertebrate method calls for kicking up sediments. All methods are fully

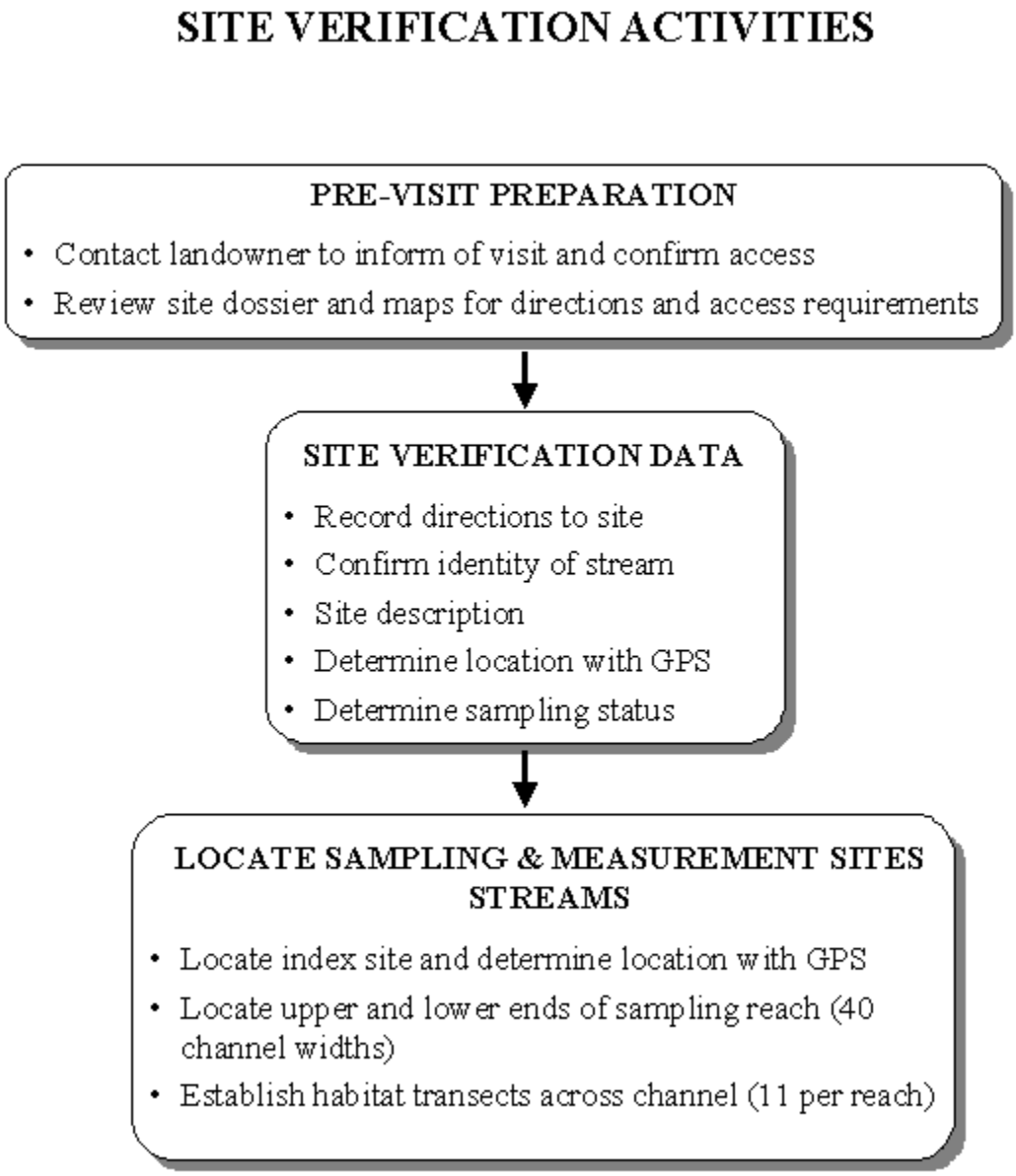


Figure 3. Site verification activities for stream field surveys.

documented in step-by-step procedures in the *WSA: Field Operations Manual* (USEPA 2004). The manual also contains detailed instructions for completing documentation, labeling samples, any field processing requirements, and sample storage and shipping. Any revision of methods must be approved in advance by the EPA Project Leader. Field communications will be available through Field Coordinators, regularly scheduled conference calls, a Communications Center, or an electronic mail/bulletin board.

Standardized field data forms are provided to the field crews as the primary means of data recording. On completion, the data forms are reviewed by a field crew member other than the person who initially entered the information. Prior to departure from the field site, the field team leader reviews all forms and labels for completeness and legibility and ensures that all samples are properly labeled and packed. Each site has a unique identifier provided by the design. All jars from a site have the same number. If additional jars are needed, extra labels are provided.

On return from a field sampling site (either to the field team's home office or to a motel), completed data forms are sent to the information management staff at WED for entry into a computerized data base. At WED, electronic data files are reviewed independently to verify that values are consistent with those recorded on the field data form or original field data file.

Samples are stored or packaged for shipment in accordance with instructions contained in the field manual. Water samples that exceed time limitations will not be used. Samples which must be shipped are delivered to a commercial carrier. The recipient is notified to expect delivery; thus, tracing procedures can be initiated quickly in the event samples are not received. Bills of lading and chain-of-custody forms are completed for all transfers of samples maintained by the labs, with copies also maintained by the field team. The implementation coordinator maintains a centralized tracking system of all shipments.

The field operations phase is completed with collection of all samples or expiration of the sampling window. Following completion of all sampling, a debriefing session will be scheduled (see Table 1). These debriefings cover all aspects of the field program and solicit suggestions for improvements.

1.3.2 Overview of Laboratory Operations

Holding times for samples vary with the sample types and analytes. Thus, some analytical analyses begin as soon as sampling (e.g., water chemistry) begins while others are not even initiated until sampling has been completed (e.g., benthic macroinvertebrates). Analytical methods are summarized in the specific SOPs (manuals) that are companion documents to this QAPP. In most cases, standard methods are used and are referenced. Where experimental methods are used or standard methods are modified, these methods are documented in the laboratory methods manual or in internal documentation, and may be described in SOPs developed by the analytical laboratory and benthic macroinvertebrate laboratory.

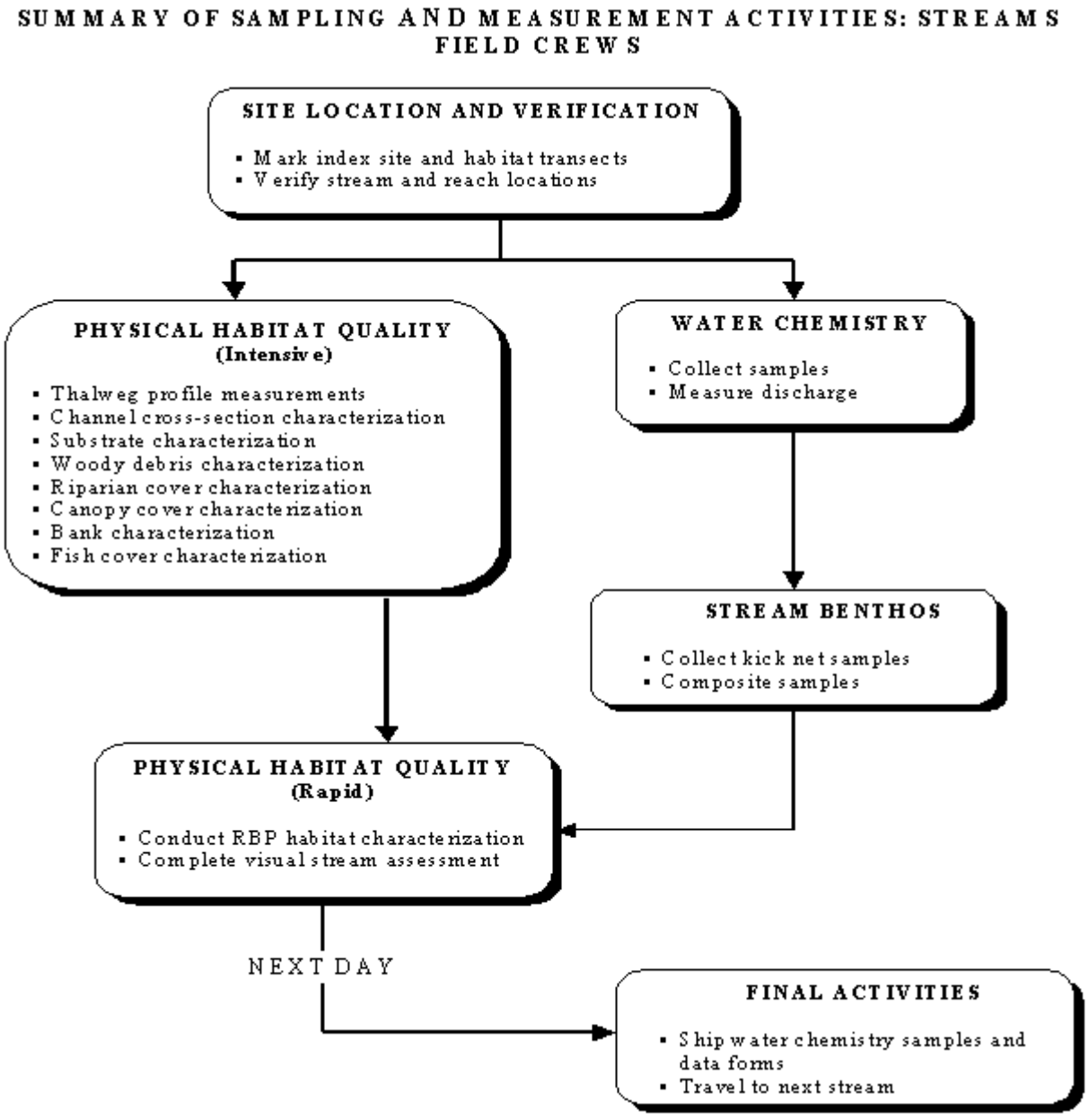


Figure 4. Summary of field activities stream and river sampling.

Chemical samples will be analyzed by the contract laboratory maintained by ORD Western Ecology Division. The physical habitat measurements are made in the field and recorded on the field data sheets and then scanned into a database at the information management center at ORD Western Ecology Division. Benthic macroinvertebrate samples will be processed by State, other Cooperator, and contractor facilities. Laboratories providing analytical support must have the appropriate facilities to properly store and prepare samples, and appropriate instrumentation and staff to provide data of the required quality within the time period dictated by the project. Laboratories

are expected to conduct operations using good laboratory practices (Table 2).

All laboratories providing analytical support to WSA (benthic and water chemistry) must adhere to the provisions of this integrated QAPP. Laboratories will provide information documenting their ability to conduct the analyses with the required level of data quality. Such information will include results from interlaboratory comparison studies, analysis of performance evaluation samples, control charts and results of internal QC sample or internal reference sample analyses to document achieved precision, bias, accuracy, and method detection limits. Contracted laboratories will be required to provide copies of their SOPs and audit reports. Water chemistry laboratories may also be required to successfully analyze at least one performance evaluation sample for target analytes before routine samples can be analyzed. Laboratory operations will be evaluated by technical systems audits, performance evaluation studies, and by participation in interlaboratory sample exchange.

Table 2. Guidelines for analytical support laboratories

- A program of scheduled maintenance of analytical balances, water purification systems, microscopes, laboratory equipment, and instrumentation.
- Checking and recording the composition of fresh calibration standards against the previous lot. Acceptable comparisons are ±2 percent of the theoretical value.
- Recording all analytical data in bound logbooks in ink, or on standardized recording forms.
- Monitoring and recording (in a logbook or on a recording form) temperatures and performance of cold storage areas and freezer units. During periods of sample collection operations, monitoring must be done on a daily basis.
- Verifying the efficiency of fume hoods.
- If needed, having a source of reagent water meeting American Society of Testing and Materials (ASTM) Type I specifications for conductivity (< 1 µS/cm at 25 °C; ASTM 1984) available in sufficient quantity to support analytical operations.
- Appropriate microscopes or other magnification for biological sample sorting and organism identification.
- Labeling all containers used in the laboratory with date prepared, contents, and initials of the individual who prepared the contents.
- Dating and storing all chemicals safely upon receipt. Chemicals are disposed of properly when the expiration date has expired.
- Using a laboratory information management system to track the location and status of any sample received for analysis.
- Reporting results using standard formats and units compatible with the information management system.

1.3.3. Data Analysis and Reporting

A technical workgroup convened by and under the leadership of the EPA Project Leader is responsible for outlining the final assessment report. Data analysis to support this report will be conducted by the EMAP team at the Western Ecology Division Information management activities in support of this effort are discussed further in Section 4. Data in the database are available to Cooperators for their own use upon completion of the final verification and validation. The final data from the WSA will be transferred to the OW STORET system and the EMAP information management system administered at the Atlantic Ecology Division.

2.0 DATA QUALITY OBJECTIVES

It is a policy of the U.S. EPA and its laboratories that Data Quality Objectives (DQOs) be developed for all environmental data collection activities. Data quality objectives are statements that describe the level of uncertainty that can be associated with environmental data for their intended use. Data quality objectives thus provide the criteria to design a sampling program within cost and resource constraints or technology limitations imposed upon a project or study.

2.1 Data Quality Objectives for WSA

Target DQOs established for WSA relate to the goal of describing the current status in the condition of selected indicators of the condition of wadeable streams in the conterminous U.S. and subregions of interest. The formal statement of the DQO for national estimates is as follows:

- Estimate the proportion of stream length (± 5%) in the conterminous U.S. that falls below the designated threshold for good conditions for selected macroinvertebrates with 95% confidence.

For the subregions of interest (Omernik Level II Ecoregions) the DQO is:

- Estimate the proportion of stream length (± 15%) in a specific Level II Ecoregion that falls below the designated threshold for good conditions for selected macroinvertebrate measures with 95% confidence.

2.2 Measurement Quality Objectives

For each indicator, performance objectives (associated primarily with measurement error) are established for several different attributes of data quality (following Smith et al., 1988). Specific objectives for each indicator are presented in the indicator section of this QAPP. The following sections define the data quality attributes

and present approaches for evaluating them against acceptance criteria established for the program.

2.2.1 Method Detection Limits

For chemical measurements, requirements for the method detection limit (MDL) are established. The MDL is defined as the lowest level of analyte that can be distinguished from zero with 99 percent confidence based on a single measurement

$$MDL = t_{[\alpha = 0.01,\ \nu = n-1]} \times s \quad (1)$$

(Glaser et al., 1981). The MDL for an individual analyte is calculated as:
where t is a Students' t value at a significance level (α) of 0.01 and n-1 degrees of freedom (ν), and s is the standard deviation of a set of n measurements of a standard solution. The standard contains analyte concentrations between two and three times the MDL objective, and is subjected to the entire analytical method (including any preparation or processing stages). At least seven non-consecutive replicate measurements are required to calculate a valid estimate of the MDL. Replicate analyses of the standard should be conducted over a period of several days (or several different calibration curves) to obtain a long-term (among-batch) estimate of the MDL.

Laboratories should periodically monitor MDLs on a per batch basis. Suggested procedures for monitoring MDLs are: (1) to analyze a set of serial dilutions of a low level standard, determining the lowest dilution that produces a detectable response; and (2) repeated analysis (at least seven measurements) of a low-level standard within a single batch.

Estimates of MDLs (and how they are determined) are required to be submitted with analytical results. Analytical results associated with MDLs that exceed the detection limit objectives are flagged as being associated with an unacceptable MDL. Analytical data that are below the estimated MDL are reported, but are flagged as being below the MDL.

2.2.2 Sampling Precision, Bias, and Accuracy

Precision and bias are estimates of random and systematic error in a measurement process (Kirchmer, 1983; Hunt and Wilson, 1986). Collectively, precision and bias provide an estimate of the total error or uncertainty associated with an individual measurement or set of measurements. Systematic errors are minimized by using validated methodologies and standardized procedures. Precision is estimated from repeated measurements of samples. Net bias is determined from repeated measurements of solutions of known composition, or from the analysis of samples that have been fortified by the addition of a known quantity of analyte. For analytes with large ranges of expected concentrations, objectives for precision and bias are established in

both absolute and relative terms, following the approach outlined in Hunt and Wilson, 1986. At lower concentrations, objectives are specified in absolute terms. At higher concentrations, objectives are stated in relative terms. The point of transition between an absolute and relative objective is calculated as the quotient of the absolute objective divided by the relative objective (expressed as a proportion, e.g., 0.10 rather than as a percentage, e.g., 10%). Final estimates will be calculated by the analysis staff at WED.

Precision in absolute terms is estimated as the sample standard deviation when the number of measurements is greater than two:

$$SD = \sqrt{\frac{i = \sum_{1}^{n} \left(xi - \bar{x}\right)^2}{n-1}} \quad (2)$$

where x_i is the value of the replicate, $\bar{X}$ is the mean of repeated sample measurements, and *n* is the number of replicates. Relative precision for such measurements is estimated as the relative standard deviation (RSD, or coefficient of variation, [CV]):

$$RSD = \frac{s}{\bar{X}} \times 100 \quad (3)$$

where *s* is the sample standard deviation of the set of measurements, and $\bar{X}$ equals the mean value for the set of measurements.

Precision based on duplicate measurements is estimated based on the range of measured values (which equals the difference for two measurements). The relative percent difference (RPD) is calculated as:

$$RPD = \left(\frac{|A - B|}{A + B}\right) \times 100 \quad (4)$$

where A is the first measured value, B is the second measured value. Precision objectives based on the range of duplicate measurements can be calculated as:

$$Critical\ \ Range = s \times \sqrt{2} \quad (5)$$

where *s* represents the precision objective in terms of a standard deviation. Range-based objectives are calculated in relative terms as:

$$Critical\ \ RPD\ =\ RSD \times \sqrt{2} \tag{6}$$

where *RSD* represents the precision objectives in terms of a relative standard deviation.

For repeated measurements of samples of known composition, net bias (*B*) is estimated in absolute terms as:

$$B = \overline{X} - T \tag{7}$$

where $\overline{X}$ equals the mean value for the set of measurements, and *T* equals the theoretical or target value of a performance evaluation sample. Bias in relative terms (*B[%]*) is calculated as:

$$B(\%) = \frac{\overline{X} - T}{T} \times 100 \tag{8}$$

where $\overline{X}$ equals the mean value for the set of measurements, and *T* equals the theoretical or target value of a performance evaluation sample.

Accuracy is estimated for some analytes from fortified or spiked samples as the percent recovery. Percent recovery is calculated as:

$$\%\ recovery = \frac{C_{is} - C_i}{C_s} \times 100 \tag{9}$$

where C_{is} is the measured concentration of the spiked sample, C_i is the concentration of the unspiked sample, and C_s is the concentration of the spike.

2.2.3 Taxonomic Precision and Accuracy

For WSA, taxonomic precision will be quantified by comparing whole-sample identifications completed by independent taxonomists or laboratories. Accuracy of taxonomy will be qualitatively evaluated through specification of target hierarchical levels (e.g., family, genus, or species); and the specification of appropriate technical taxonomic literature or other references (e.g., identification keys, voucher specimens). To calculate taxonomic precision, 10 percent of the benthic macroinvertebrate samples will be randomly-selected by Tetra Tech, the QA lab, sent by the WSA labs for re-identification by Mike Winnell, Freshwater Benthic Services (FBS), 3250 Krause Rd. Petoskey, MI 49770 (Dr. Winnell's extensive reference book bibliography is in the QA file at OWOW

Hq and is available upon request.). Comparison of the results of whole sample re-identifications will provide a Percent Taxonomic Disagreement (PTD) calculated as:

$$PTD = \left[1 - \left(\frac{comp_{pos}}{N}\right)\right] \times 100$$

where $comp_{pos}$ is the number of agreements, and N is the total number of individuals in the larger of the two counts. The lower the PTD, the more similar are taxonomic results and the overall taxonomic precision is better. A measurement quality objective (MQO) of 15% is recommended for taxonomic difference or disagreement (overall mean $\leq$15% is acceptable based on similar projects). Individual samples exceeding 15% are examined for taxonomic areas of substantial disagreement, and the reasons for disagreement investigated.

Sample enumeration is another component of taxonomic precision. Sample enumeration agreement will be checked with the same 10% of samples used to check taxonomic precision. Final specimen counts for samples are dependent on the taxonomist, not the rough counts obtained during the sorting activity. Comparison of counts is quantified by calculation of percent difference in enumeration (PDE), calculated as:

$$PDE = \left(\frac{|Lab1 - Lab2|}{Lab1 + Lab2}\right) \times 100$$

An MQO of 5% is recommended (overall mean of $\leq$5% is acceptable). Individual samples exceeding 5% are examined to determine reasons for the exceedance.

Corrective actions for samples exceeding these MQOs can include defining the taxa for which re-identification may be necessary (potentially even by third party), for which samples (even outside of the 10% lot of QC samples) it is necessary, and where there may be issues of nomenclatural or enumeration problems. Taxa lists will be changed when disagreements are resolved by a third party.

Taxonomic accuracy is evaluated by having individual specimens representative of selected taxa identified by recognized experts, usually contract or university affiliated persons who have peer-reviewed publications for the taxonomic group they are reviewing. Samples will be identified using the most appropriate technical literature that is accepted by the taxonomic discipline and reflects the accepted nomenclature. The Integrated Taxonomic Information System (ITIS, http://www.itis.usda.gov/) will be used to verify nomenclatural validity and reporting. A reference collection will be compiled by each lab as the samples are identified. Specialists in several taxonomic groups will verify selected individuals of different taxa, as determined by the WSA workgroup.

2.2.4 Completeness

Completeness requirements are established and evaluated from two perspectives. First, valid data for individual indicators must be acquired from a minimum number of sampling locations in order to make subpopulation estimates with a specified level of confidence or sampling precision. The objective of this study is to complete sampling at 95% or more of the 500 initial sampling sites and the 100 reference sites. Percent completeness is calculated as:

$$\%C = V / T \times 100$$

where V = number of measurements/samples judged valid, and T = total number of planned measurements/samples. Within each indicator, completeness objectives are also established for individual samples or individual measurement variables or analytes. These objectives are estimated as the percentage of valid data obtained versus the amount of data expected based on the number of samples collected or number of measurements conducted. Where necessary, supplementary objectives for completeness are presented in the indicator-specific sections of this QAPP.

2.2.5 Comparability

Comparability is defined as the confidence with which one data set can be compared to another (Stanley and Verner, 1985; Smith et al., 1988). For all indicators, comparability is addressed by the use of standardized sampling procedures, sampling equipment and analytical methodologies by all sampling crews and laboratories. These are also the same used to collect data in EMAP West studies. Comparability of data within and among indicators is also facilitated by the implementation of standardized quality assurance and quality control techniques and standardized performance and acceptance criteria. For all measurements, reporting units and format are specified, incorporated into standardized data recording forms, and documented in the information management system. Comparability is also addressed by providing results of QA sample data, such as estimates of precision and bias, conducting methods comparison studies when requested by the grantees and conducting interlaboratory performance evaluation studies among state, university, and WSA contract laboratories. If some incompatibility between sampling crews comes to light, the data will be rejected.

2.2.6 Representativeness

Representativeness is defined as "the degree to which the data accurately and precisely represent a characteristic of a population parameter, variation of a property, a process characteristic, or an operational condition" (Stanley and Verner, 1985, Smith et al., 1988). At one level, representativeness is affected by problems in any or all of the other attributes of data quality.

At another level, representativeness is affected by the selection of the target

surface water bodies, the location of sampling sites within that body, the time period when samples are collected, and the time period when samples are analyzed. The probability-based sampling design should provide estimates of condition of surface water resource populations that are representative of the region. The individual sampling programs defined for each indicator attempt to address representativeness within the constraints of the sampling design and index sampling period. Holding time requirements for analyses ensure analytical results are representative of conditions at the time of sampling. Use of QC samples which are similar in composition to samples being measured provides estimates of precision and bias that are applicable to sample measurements.

3.0 SURVEY DESIGN

Many of the questions which USEPA's Office of Water, States and Tribes are attempting to address fundamentally require information about large numbers of systems rather than individual systems. ORD has studied the role of monitoring surveys, their evolution and the nature of existing federal monitoring programs, and can provide information and assistance to the States and Tribes in this area.

The survey design for WSA is the same as used for EMAP-West. The design is a sample survey design (a.k.a. probability design) that ensures a representative set of sample sites from which inferences can be made about the target population. For the WSA, the target population is all wadeable streams and rivers in the conterminous US.

There is a large body of statistical literature dealing with sample survey designs which addresses the problem of making statements about many by sampling the few (e.g., Cochran 1977, Kish 1965, Kish 1987, Sarndal et al. 1992). Sample surveys have been used in a variety of fields (e.g., election polls, monthly labor estimates, forest inventory analysis, national wetlands inventory) to determine the status of populations (large groups of sites) of interest, especially if the population is too numerous to census or if it is unnecessary to census the population to reach the desired level of precision for describing the population's status. A key point in favor of probability based designs is that they allow lower cost sampling programs because a smaller number of sites are able to support conclusions with known accuracy and precision about status and trends of a region.

Probability sampling surveys have been consistently used in some natural resource fields. The National Agricultural Statistics Survey (NASS) conducted by the U.S. Department of Agriculture and the Forest Inventory Analysis (FIA) conducted by the U.S. Forest Service (Bickford et al. 1963, Hazard and Law 1989) have both used probability based sampling concepts to monitor and estimate the condition and productivity of agricultural and forest resources from a commodity perspective. National Resources Inventory (NRI) was instituted initially because of concerns about the impact of soil erosion on crop production. More recently, the National Wetland Inventory (NWI) developed by the U.S. Fish and Wildlife Service (Wilen 1990) to estimate the extent of

wetland acreage in the United States has used a probability based sampling design. But no thorough review of all national programs has occurred until recently.

The survey designs used in EMAP to date have been documented in published reports for each resource group and in the peer reviewed literature. Below a brief description of the design concepts and the specific application for riverine systems is provided. Much of this is extracted from various publications and from Stevens (1994) which provides an excellent overview of the design concepts, issues and applications for the entire program.

The EMAP sampling design strategy is based on the fundamental requirement for a probability sample of an explicitly defined regional resource population, where the sample is constrained to reflect the spatial dispersion of the population.

A key property of a probability sample is that every element in the population has some chance of being included in the sample. If this were not the case, then some parts of the population might as well not exist, since no matter what, their condition could have no influence on estimates of population characteristics. This property has a side benefit, in that it forces an explicit and complete definition of the population being described. This may seem trivial; however, in practice, it is almost never easy to tightly delimit a real, physical population. For example, "lake" is a concept that has meaning for most people, and the notion of "all lakes in the continental United States" would seem to define a population. Nevertheless, an operational definition of membership is missing. The operational definition must be complete enough to establish any body of water, from a rain puddle up to Lake Superior, as either in or out of the population. Thus, the definition must address such aspects as size limits (at least lower limits on area and depth), natural lake versus constructed reservoir, temporal fluctuation (If a "lake" dries up during a drought, is it still a lake? Was it a lake before the drought?), and amount of open water. Without such an operational definition, any statement about "all lakes in the United States" has an unquantifiable vagueness.

The stream resource does not fall neatly into either the discrete or extensive category. The National Stream Survey (Messer et al., 1986; Overton, 1985) split streams into reaches defined as the length of stream between confluences, or from the headwaters down to the first confluence. Thus, streams were treated as a finite discrete population. A grid was used to sample stream reaches by randomly placing a grid over a topographic map of the area of interest, and then proceeding downhill along the fall line until a stream reach was intersected. The approach that was taken avoids the necessity of delimiting the resource areal units. The approach of EMAP-West is somewhat different. The program focuses on the population of stream miles rather than stream reaches. We wish to characterize the population in terms of the condition of length of streams rather than numbers of stream reaches. Therefore, we want a sampling method that samples a stream in proportion to its length; this is accomplished by viewing streams as an extensive resource with length. The method described here is currently being used in a pilot study, which among other goals, will examine the suitability of the method for a larger study.

Stream traces are identified on 1:100,000-scale Digital Line Graphs, and a Geographical Information System is used to intersect these with the sampling templates. Each stream segment within a template is identified and its length determined. The endpoints of a segment are defined as confluences, headwaters ends, or intersections with a template edge. Sets of connected segments of the same order are always kept together in the sample selection process. The appropriate Strahler stream order is also determined for each segment.

Some differential weighting by size is necessary because of the predominance of lower-order streams. The sample selection proceeds with inclusion probability for a segment proportional to its length times the weight for its order. The total inclusion probability for each template is calculated as the weighted sum of stream lengths in the template, the templates are partitioned into groups using the partitioning algorithm described for lakes, and the samples are selected in an analogous manner: the partitions are randomized, the templates are randomized within the partitions, and the sets of connected segments are randomized within the templates. The same systematic selection protocol is used; however, in this case, the selection not only identifies the stream segment to be sampled, but also identifies the point on that segment where the sample is to be located. This is accomplished by recording the relative distance from the beginning of the segment to the selected point on the segment.

The types of questions which have been posed from various State and Tribal agencies suggest that they would like to make statements about all streams and rivers. Clearly, sampling every mile of stream in the country is not economically feasible nor is it necessary. Probability designs have been used in wide range of disciplines to address this need (Converse 1987).

The primary objectives of this study are to estimate the condition of mapped perennial wadeable streams and rivers, and the extent (total length) of mapped channels, in conterminous states of the U.S. The objectives specify an interest in the target population of wadeable perennial streams and rivers.

One estimate of extent is provided by River Reach File Version 3 (RF3) which is based on digitized blue lines from 1:100,000 scale maps. Based on prior information, it is known that RF3 incorrectly codes some stream segments. Incorrect code information occurs for (1) designating Strahler stream order; (2) delineating perennial and intermittent, (3) defining natural versus constructed channels, including newly modified channels, and (4) distinguishing irrigation return flow from irrigation delivery channels. In some cases, RF3 includes stream channels that are not actually present, due to (1) no definable channel present, (2) location is wetland/marsh with no defined channel, or (3) channel may be an impoundment. RF3 may also exclude some stream channels due to (1) mapping inconsistencies in construction of 1:100,000 maps, (2) digitization of map blue lines, or (3) inadequacy of photo information used to develop maps, e.g. heavily forested areas with low order streams. This study assumes that RF3 includes all stream channels specified by the definition of the target population. That is, if stream channels exist that are not included in RF3, they will not be addressed by this study.

A secondary outcome of estimating the extent of the stream channel resource will be estimates on the amount of miscoding present in RF3. Those stream segments actually selected in the survey sample that are found to be miscoded will be submitted to RF3 staff for correction.

3.1 Probability-Based Sampling Design and Site Selection

Target Population: Within the conterminous U.S, all wadeable stream and river channels (natural and constructed) mapped at 1:100,000 scale

Sample Frame: RF3 stream and river channel segments coded as R, S, T, N, W, (412, 413, 999) and U (414, 415).

This frame is subdivided into two major parts: (1) all RF3 stream, river and canal segments coded as perennial, and (2) all RF3 stream, river and canal segments coded as non-perennial, ie, all other stream, river and canal segments. The purpose of subdividing the frame is to allow a sampling focus on systems that have an exceedingly high probability of being flowing waters during the index sampling period.

Sites were selected for the WSA project using a hierarchical randomization design process described by Stevens and Olsen (1999, 2003, 2004). The national hydrography database (NHD) served as the frame representing streams and rivers in the US. Data from approximately 500 stream sites in the eastern two-thirds of the United States will be integrated with data from approximately 1000 stream sites in the western United States for a comprehensive assessment. This total sample size will allow national reporting as well as regional reporting at the scale of Omernik Level II ecoregions, the ten EPA Regions and 10-15 major drainage basins.

Key features of the approach are (1) utilizing survey theory for continuous populations within a bounded area, (2) explicit control of the spatial dispersion of the sample through hierarchical randomization, (3) unequal probability of selection by Strahler order, and (4) nested subsampling to incorporate intensified sampling in special study regions.

Revisit Sites: Of the sites visited in the field and found to be target sites, a total of 10% will be revisited. The 10% will be the first 10% of the sites visited. The primary purpose of this revisit set of sites is to allow variance estimates that would provide information on the extent to which the population estimates might vary.

Site Evaluation Sites: The number of sites that must be evaluated to achieve the expected number of field sites that can be sampled can only be estimated based on assumptions concerning expected error rates in RF3, percent of landowner refusals, and percent of physically inaccessible sites. Based on the estimates gained in previous studies, a list of alternate sites was selected at the same time as the base sites. These alternate sites will be using in order until the desired sample size of 50 per region has been achieved.

4.0 INFORMATION MANAGEMENT

Like QA, information management (IM) is integral to all aspects of the WSA from initial selection of sampling sites through dissemination and reporting of final, validated data. QA and QC measures implemented for the IM system are aimed at preventing corruption of data at the time of their initial incorporation into the system and maintaining the integrity of data and information after incorporation into the system. The general organization of, and QA/QC measures associated with, the IM system are described in this section.

Long-term data from WSA, which includes data from the EMAP-West survey activities and the survey activities conducted directly under WSA in the eastern 36 States, will be maintained in STORET and the EMAP data system at ORD's Atlantic Ecology Division. Project data management activities will be handled at EPA's Western Ecology Division and will be compliant with all relevant EPA and Federal data standards. Data will be shipped from sample processing laboratories to WED no later than March 2005.

4.1 Data Policy

The WSA requires a continuing commitment to the establishment, maintenance, description, accessibility, and long-term availability of high-quality data and information. All data used in the WSA will be maintained, following final verification and validation of dataset, in EPA's STORET and EPA's EMAP data system.

Full and open sharing of the full suite of data and published information produced by the study is a fundamental objective. Data and information will be available without restriction for no more than the cost of reproduction and distribution. Where possible, the access to the data will be via the World Wide Web through STORET and EMAP to keep the cost of delivery to a minimum and to allow distribution to be as wide as possible. All data collected by this study will be publicly available following verification and validation of the dataset.

Organizations and individuals participating in the Study will ship all samples in a timeline consistent with the field operations manual. Field data sheets will be sent directly to WED for data entry. All laboratories processing samples will send final electronic dataset to WED by March 2005. Data and metadata will be available for assessment preparation by June 2005. Final dataset with metadata will be available via STORET and EMAP at the time of delivery of the final report, December 2005.

All data sets and published information used in the study will be identified with a citation; for data sets an indication of how the data may be accessed will be provided. Data from this study will be maintained indefinitely. All EPA data policies will be followed including EPA data standards, GIS, etc., as discussed in section 4.3.

4.2 Overview of System Structure

At each point where data and information are generated, compiled, or stored, the information must be managed. Thus, the IM system includes all of the data-generating activities, all of the means of recording and storing information, and all of the processes which use data. The IM system includes both hardcopy and electronic means of generating, storing, and archiving data. All participants in the WSA have certain responsibilities and obligations which make them a part of the IM system. In its entirety, the IM system includes site selection and logistics information, sample labels and field data forms, tracking records, map and analytical data, data validation and analysis processes, reports, and archives. IM staff supporting the WSA at WED provide support and guidance to all program operations in addition to maintaining a central data base management system for the WSA data.

The central repository for data and associated information collected for use by the WSA is a DEC Alpha server system located at WED-Corvallis. The general organization of the information management system is presented in Figure 5. Data are stored and managed on this system using the Statistical Analysis System (SAS) software package. This centrally managed IM system is the primary data management center for the WSA research conducted at WED and elsewhere. The IM staff receives, enters, and maintains data and information generated by the site selection process (see Section 3), field sample and data collection, map-based measurements, laboratory analyses, and verification and validation activities completed by the states, cooperators and contractors. In addition to this inflow, the IM system provides outflow in provision of data files to WSA staff and other users. The IM staff at WED is responsible for maintaining the security integrity of both the data and the system.

The following sections describe the major inputs to the central data base and the associated QA/QC processes used to record, enter, and validate measurement and analytical data collected for EMAP surface waters research projects. Activities to maintain the integrity and assure the quality of the contents of the IM system are also described.

4.2.1 Design and Logistics Data Bases

The site selection process described in Section 3 produces a list of candidate sampling locations, inclusion probabilities, and associated site classification data (e.g., target status, ecoregion, stream order, etc.). This “design” data base is provided to the IM staff, implementation coordinators, and field coordinators. Field coordinators determine ownership and contacts for acquiring permission to access each site, and conduct reconnaissance activities. Ownership and reconnaissance information for each site are compiled into a “logistics” data base. Generally, standardized forms are used

during reconnaissance activities. Information from these forms may be entered into a SAS compatible data management system. Whether in electronic or hardcopy format, a copy of the logistics data base is provided to the IM for archiving storage.

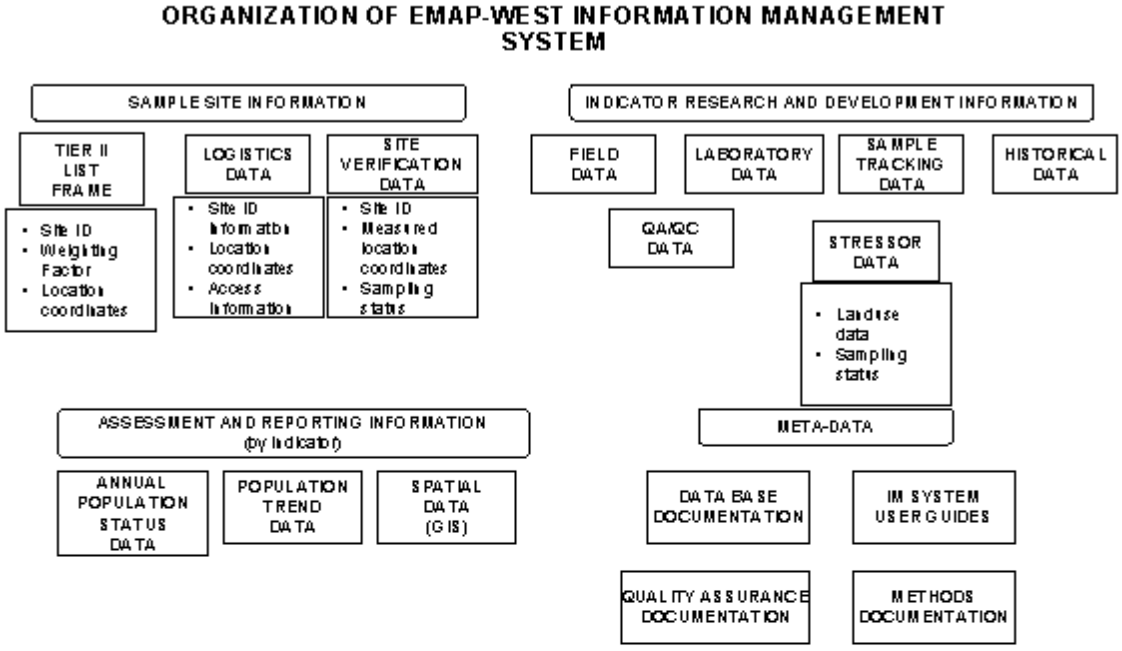


Figure 5. Organization of information management system modeled after EMAP-WEST for WSA.

4.2.2 Sample Collection and Field Data Recording

Prior to initiation of field activities, the IM staff works develops standardized field data forms and sample labels. Preprinted adhesive labels having a standard recording format are completed and affixed to each sample container. Precautions are taken to ensure that label information remains legible and the label remains attached to the sample. Examples of sample labels are presented in the field operations manual.

Field sample collection and data forms are designed in conjunction with IM staff to ensure the format facilitates field recording and subsequent data entry tasks. All forms which may be used onsite are printed on water-resistant paper. Copies of the field data forms and instructions for completing each form are documented in the field operations manuals. Recorded data are reviewed upon completion of data collection and recording activities by a person other than the one who completed the form. Field crews check completed data forms and sample labels before leaving a sampling site to ensure information and data were recorded legibly and completely. Errors are corrected if possible, and data considered as suspect are qualified using a flag variable. The field crew enters explanations for all flagged data in a comments section. Completed field data forms are transmitted to the IM staff at WED for entry into the central data base management system.

All samples are tracked from the point of collection. Hardcopy tracking and custody forms are completed by the field crews. Copies of the shipping and custody record accompany all sample transfers; other copies are transmitted to the IMC and applicable indicator lead. Samples are tracked to ensure that they are delivered to the appropriate laboratory, that lost shipments can be quickly identified and traced, and that any problems with samples observed when received at the laboratory are reported promptly so that corrective action can be taken if necessary. Detailed procedures on shipping and sample tracking can be found in Section 8.2 of the Field Operations Manual

Procedures for completion of sample labels and field data forms, and use of PCs are covered extensively in training sessions. General QC checks and procedures associated with sample collection and transfer, field measurements, and field data form completion for most indicators are listed in Table 3. Additional QA/QC checks or procedures specific to individual indicators are described in the indicator sections in Section 5 of this QAPP.

4.2.3 Laboratory Analyses and Data Recording

Upon receipt of a sample shipment, analytical laboratory receiving personnel check the condition and identification of each sample against the sample tracking record. Each sample is identified by information written on the sample label and by a barcode label. Any discrepancies, damaged samples, or missing samples are reported to the IM staff and indicator lead by telephone.

Table 3. Sample and field data quality control activities

Quality Control Activity	Description and/or Requirements
Contamination Prevention	All containers for individual site sealed in plastic bags until use; specific contamination avoidance measures covered in training
Sample Identification	Pre-printed labels with unique ID number on each sample
Data Recording	Data recorded on pre-printed forms of water-resistant paper; field crew reviews data forms for accuracy, completeness, and legibility
Data Qualifiers	Defined qualifier codes used on data form; qualifiers explained in comments section on data form
Sample Custody	Unique sample ID and tracking form information entered in LIMS; sample shipment and receipt confirmed
Sample Tracking	Sample condition inspected upon receipt and noted on tracking form with copies sent to Indicator Lead, Communications Center, and/or IM
Data Entry	Data entered using customized entry screens that resemble the data forms; entries reviewed manually or by automated comparison of double entry
Data Submission	Standard format defined for each measurement including units, significant figures, and decimal places, accepted code values, and required field width
Data Archival	All data archived in an organized manner for a period of seven years or until written authorization for disposition has been received from the Surface Waters Technical Director.

Most of the laboratory analyses for the WSA indicators, particularly chemical and physical analyses, follow or are based on standard methods. Standard methods generally include requirements for QC checks and procedures. General laboratory QA/QC procedures applicable to most WSA indicators are described in Table 4. Additional QA/QC samples and procedures specific to individual indicator analyses are described in the indicator sections in Part II of this QAPP. Biological sample analyses are generally based on current acceptable practices within the particular biological discipline. Some QC checks and procedures applicable to most WSA biological samples are described in Table 5. Additional QA/QC procedures specific to individual biological indicators are described in the indicator sections in Part II of this QAPP.

A laboratory's IM system may consist of only hardcopy records such as bench sheets and logbooks, an electronic laboratory information management system (LIMS), or some combination of hardcopy and electronic records. Laboratory data records are reviewed at the end of each analysis day by the designated laboratory onsite QA

coordinator or by supervisory personnel. Errors are corrected if possible, and data considered as suspect by laboratory analysts are qualified with a flag variable. All flagged data are explained in a comments section. Private contract laboratories generally have a laboratory quality assurance plan and established procedures for recording, reviewing, and validating analysis data.

Once analytical data have passed all of the laboratory's internal review procedures, a submission package is prepared and transferred to the IM staff. The contents of the submission package are largely dictated by the type of analysis (physical, chemical, or biological), but generally includes at least the elements listed in Tables 4 or 5. All samples and raw data files (including logbooks, bench sheets, and instrument tracings) are to be retained for a period of seven years or until authorized for disposal, in writing, by the WSA Project Leader.

Table 4. Laboratory data quality control activities

Quality Control Activity	Description and/or Requirements
Instrument Maintenance	Follow manufacturer's recommendations and specific guidelines in methods; maintain logbook of maintenance/repair activities
Calibration	Calibrate according to manufacturer's recommendations and guidelines given in Section 6; recalibrate or replace before analyzing any samples
QC Data	Maintain control charts, determine MDLs and achieved data attributes; include QC data summary in submission package
Data Recording	Use software compatible with EMAP-SW IM system; check all data entered against the original bench sheet to identify and correct entry errors. Review other QA data (e.g. condition upon receipt, etc.) for possible problems with sample or specimens.
Data Qualifiers	Use defined qualifier codes; explain all qualifiers
Data Entry	Automated comparison of double entry or 100% manual check against original data form
Submission Package	Includes: Letter by the laboratory manager; data, data qualifiers and explanations; electronic format compatible with EMAP-SW IM system, documentation of file and data base structures, variable descriptions and formats; summary report of any problems and corrective actions implemented

Table 5. Biological sample quality control activities

Quality Control Activity	Description and/or Requirements
Sorting/Enumeration	Re-sort 10% of samples and check counts of organisms
Taxonomic Nomenclature	Use accepted common and scientific nomenclature and unique entry codes
Taxonomic Identifications	Use standard taxonomic references and keys; maintain bibliography of all references used
Independent Identifications	Uncertain identifications to be confirmed by expert in particular taxa
Duplicate Identifications	At least 5% of all samples completed per taxonomist reidentified by different analyst; less than 10% assigned different ID
Taxonomic Reasonableness Checks	Species or genera known to occur in given conditions or geographic area

4.2.4 Data Review, Verification, Validation Activities

Raw data files are created from entry of field and analytical data, including data for QA/QC samples and any data qualifiers noted on the field forms or analytical data package. After initial entry, data are reviewed for entry errors by either a manual comparison of a printout of the entered data against the original data form or by automated comparison of data entered twice into separate files. Entry errors are corrected and reentered. For biological samples, species identifications are corrected for entry errors associated with incorrect or misspelled codes. Errors associated with misidentification of specimens are corrected after voucher specimens have been confirmed and the results are available. Files corrected for entry errors are considered to be raw data files. Copies of all raw data files are maintained in the centralized IM system.

Table 6. Data review, verification, and validation quality control activities

Quality Control Activity	Description and/or Requirements
Review any qualifiers associated with variable	Determine if value is suspect or invalid; assign validation qualifiers as appropriate
Summarize and review replicate sample data	Identify replicate samples with large variance; determine if analytical error or visit-specific phenomenon is responsible
Determine if data quality objectives have been achieved	Determine potential impact on achieving research and/or program objectives
Exploratory data analyses (univariate, bivariate, multivariate) utilizing all data	Identify outlier values and determine if analytical error or site-specific phenomenon is responsible
Confirm assumptions regarding specific types of statistical techniques being utilized in development of metrics and indicators	Determine potential impact on achieving research and/or program objectives

Some of the typical checks made in the processes of verification and validation are described in Table 6. Automated review procedures may be used. The primary purpose of the initial checks is to confirm that a data value present in an electronic data file is accurate with respect to the value that was initially recorded on a data form or obtained from an analytical instrument. In general, these activities focus on individual variables in the raw data file and may include range checks for numeric variables, frequency tabulations of coded or alphanumeric variables to identify erroneous codes or misspelled entries, and summations of variables reported in terms of percent or percentiles. In addition, associated QA information (e.g., sample holding time) and QC sample data are reviewed to determine if they meet acceptance criteria. Suspect values are assigned a data qualifier until they can be corrected or confirmed as unacceptable and replaced with a new acceptable value from sample reanalysis.

A second review is conducted after all analyses have been completed and the raw data file is created. The internal consistency among different analyses or measurements

conducted on a sample is evaluated. Examples of internal consistency checks include calculation of chemical ion balances or the summation of the relative abundances of taxa. Samples identified as suspect based on internal consistency checks are qualified with a flag variable and targeted for more intensive review. Data remain qualified until they can be corrected, are confirmed as acceptable in spite of the apparent inconsistency, or until new acceptable values are obtained from sample reanalysis. Upon completion of these activities, copies of the resultant data files are transmitted for archival storage.

In the final stage of data verification and validation, exploratory data analysis techniques may be used to identify extreme data points or statistical outliers in the data set. Examples of univariate analysis techniques include the generation and examination of box-and-whisker plots and subsequent statistical tests of any outlying data points. Bivariate techniques include calculation of Spearman correlation coefficients for all pairs of variables in the data set with subsequent examination of bivariate plots of variables having high correlation coefficients. Recently, multivariate techniques have been used in detecting extreme or outlying values in environmental data sets (Meglen, 1985; Garner et al., 1991; Stapanian et al., 1993). A software package, SCOUT, developed by EPA and based on the approach of Garner et al. (1991) may be used for validation of multivariate data sets.

Suspect data are reviewed to determine the source of error, if possible. If the error is correctable, the data set is edited to incorporate the correct data. If the source of the error cannot be determined, data are qualified as questionable or invalid. Data qualified as questionable may be acceptable for certain types of data analyses and interpretation activities. The decision to use questionable data must be made by the individual data users. Data qualified as invalid are considered to be unacceptable for use in any analysis or interpretation activities and will generally be removed from the data file and replaced with a missing value code and explanatory comment or flag code. After completion of verification and validation activities, a final data file is created, with copies transmitted for archival and for uploading to the centralized IM system.

Once verified and validated, data files are made available for use in various types of interpretation activities, each of which may require additional restructuring of the data files. These restructuring activities are collectively referred to as "data enhancement." In order to develop indicator metrics from one or more variables, data files may be restructured so as to provide a single record per stream site. To calculate site population estimates based on individual measurements or indicators, missing values and suspect data points may need to be replaced with alternate data (such as a value from a replicate measurement) or values calculated from predictive relationships based on other variables.

4.3 Data Transfer

Field crews may transmit data electronically via modem or floppy disc; hardcopies of completed data and sample tracking forms may be transmitted to the IM staff at WED via portable facsimile (FAX) machine or via express courier service. Copies of raw, verified, and validated data files are transferred from states, cooperators, and contractors to the IM staff for inclusion in the central IM system. All transfers of data are conducted

using a means of transfer, file structure, and file format that has been approved by the IM staff. Data files that do not meet the required specifications will not be incorporated into the centralized data access and management system.

4.4 Core Information Management Standards

Participants will adhere to the "Core Information Management Standards for the EMAP Western Study." National and international standards will be used to the greatest extent possible. This section details a list of standards pertaining to information management that all participants in the WSA agree to follow. The goal of these core standards is to maximize the ability to exchange data with other studies conducted under the monitoring framework of the Committee on the Environment and Natural Resources (CENR 1997). The main standards are those of the Federal Geographic Data Committee (FGDC 1999), the National Spatial Data Infrastructure (NSDI 1999), and the National Biological Information Infrastructure (NBII 1999).

4.4.1 Metadata

Federal Geographic Data Committee Content standard for digital geospatial metadata, version 2.0. FGDC-STD-001-1998 (FGDC 1998), including the Biological Data Profile and the Biological Names and Taxonomy Data Standards developed by the National Biological Information Infrastructure (NBII 1999).

For tabular data, metadata that meet the FGDC content standard are contained by a combination of the EMAP Data Directory and the EMAP Data Catalog. For ARC/INFO coverages, the metadata are in the .DOC file embedded in the coverage. This file stays with the coverage. When the coverage is moved to the EMAP public web sites, it will be duplicated to an ASCII text file.

4.4.2 Data Directory

The EMAP Data Directory is maintained as an Oracle database. The guidelines are given in Frithsen and Strebel (1995), Frithsen (1996a, b) and USEPA (1996b).

Other data: Environmental Information Management system (EIMS 1999). EMAP Directory entries are periodically uploaded to the EIMS. The EIMS will become EPA's node for the National Spatial Data Infrastructure and will make directory information available to other federal agencies through the Z39.50 protocol in accordance with the US Global Change Research Program (USGCRP 1998)

4.4.3 Data Catalog

Data catalog standards are given in Frithsen and Strebel (1995), Frithsen (1996a), and USEPA (1996c).

4.4.4 Data Formats

4.4.4.1 Attribute data

ASCII files: comma-separated values, or space-delimited, or fixed column
SAS export files

Oracle

4.4.4.2 GIS data

ARC/INFO export files; compressed .tar file of ARC/INFO workspace
Spatial Data Transfer Standard (SDTS) (FGDC 1999) format available on request

4.4.5 Parameter Formats

Sampling Site (EPA Locational Data Policy (USEPA 1991)
- Latitude and Longitude in decimal degrees (+/- 7.4)
- Negative longitude values (west of the prime meridian)
- NAD83

Date: YYYYMMDD (year, month, day)
Hour: HHMMSS (hour, minute, second)
- Greenwich mean time
- Local time

Data loaded to STORET will take on the STORET formats upon loading.

4.4.6 Standard Coding Systems

Chemical Compounds: Chemical Abstracts Service (CAS 1999)
Species Names: Integrated Taxonomic Information system (ITIS 1999)
Land cover/land use codes: Multi-Resolution Land Characteristics (MRLC 1999)

4.5 Hardware and Software Control

All automated data processing (ADP) equipment and software purchased for or used in WSA surface waters research is subject to the requirements of the federal government, the particular Agency, and the individual facility making the purchase or maintaining the equipment and software. All hardware purchased by EPA is identified with an EPA barcode tag label; an inventory is maintained by the responsible ADP personnel at the facility. Inventories are also maintained of all software licenses; periodic checks are made of all software assigned to a particular PC.

The development and organization of the IM system is compliant with guidelines and standards established by the EMAP Information Management Technical Coordination Group, the EPA Office of Environmental Information (OEI), and the EPA office of Administrative Resources Management (OARM). Areas addressed by these policies and guidelines include, but are not limited to, the following:

- Taxonomic Nomenclature and Coding
- Locational data
- Sampling unit identification and reference
- Hardware and software
- Data catalog documentation

The WSA is committed to compliance with all applicable regulations and guidance concerning hardware and software procurement, maintenance, configuration control, and

QA/QC. As new guidance and requirements are issued, the WSA information management staff will assess the impact upon the IM system and develop plans for ensuring timely compliance.

4.6 Data Security

All data files in the IM system are protected from corruption by computer viruses, unauthorized access, and hardware and software failures. Guidance and policy documents of EPA and management policies established by the IM Technical Coordination Group for data access and data confidentiality are followed. Raw and verified data files are accessible only to the WSA collaborators. Validated data files are accessible only to users specifically authorized by the EPA Project Leader. Data files in the central repository used for access and dissemination are marked as read-only to prevent corruption by inadvertent editing, additions, or deletions.

Data generated, processed, and incorporated into the IM system are routinely stored as well as archived on redundant systems. This ensures that if one system is destroyed or incapacitated, IM staff will be able to reconstruct the data bases. Procedures developed to archive the data, monitor the process, and recover the data are described in IM documentation.

Several backup copies of all data files and of the programs used for processing the data are maintained. Backups of the entire system are maintained off-site. System backup procedures are utilized. The central data base is backed up and archived according to procedures already established for WED. All laboratories generating data and developing data files must have established procedures for backing up and archiving computerized data.

5.0 INDICATORS

5.1 Benthic Macroinvertebrates

5.1.1 Introduction

The benthic invertebrate assemblage found in sediments and on substrates of streams reflect an important aspect of the biological condition of the stream. The response of benthic communities to various stressors can often be used to determine the type of stressor and to monitor trends (Klemm et al., 1990). The overall objectives of the benthic invertebrate indicators are to detect stresses on community structure in wadeable streams and to assess and monitor the relative severity of those stresses. The benthic invertebrate indicator procedures are based on various recent bioassessment literature (Barbour et al. 1999, Hawkins et al. 2000, Peck et al. 2003).

5.1.2 Sampling Design

Benthic invertebrates are collected at randomly selected sampling locations on the cross-sectional transects established along the stream reach. A composite of invertebrates is collected from a multi-habitat approach and consists of sampling pools, riffles, runs, and glides. The index sampling design is illustrated in Figure 6.

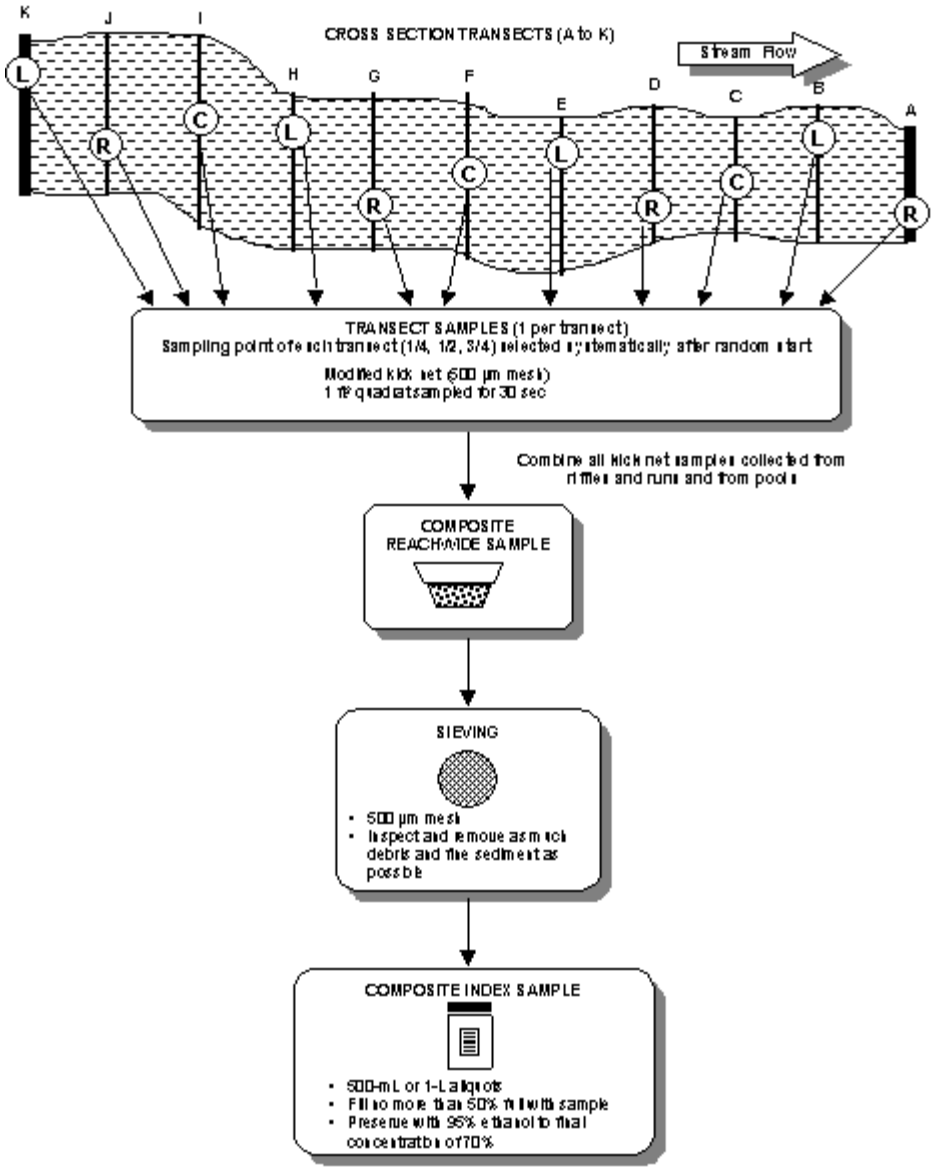


Figure 6. Sampling design for the benthic indicator.

5.1.3 Sampling and Analytical Methodologies

Sample Collection: Benthic invertebrates are collected from an approximately 930 cm^2 (0.09 m^2) area randomly selected at each of 11 cross-sectional transects. Samples collected using a modified D-frame kick-net (500 µm mesh) procedure are composited together to produce a 1.02 m^2 areal sample. Samples are field-processed to remove large detritus(rinsed and inspected for organisms) and preserved in ethanol. Detailed sampling and processing procedures are described in section of the field operations manual. A condensed description of key elements of the field activities is provided for easy reference onsite.

Analysis: Preserved composite samples are sorted, enumerated, and invertebrates identified to the genus level (see Attachment 4 of the Benthic Laboratory Manual) using specified standard keys and references. Processing and archival methods are based on standard limnological practices. Detailed procedures are contained in the laboratory operations manual and cited references. There is no maximum holding time associated with preserved benthic invertebrate samples. Five hundred benthic organism count is the target number to match the EMAP West protocal. A 10% external check is standard QA for EMAP West. For operational purposes of the WSA, laboratory sample processing should be completed by March 2005. Table 7 summarizes field and analytical methods for the benthic invertebrates indicator.

Table 7. Field and laboratory methods: benthic indicator

Variable or Measurement	QA Class	Expected Range and/or Units	Summary of Method	References
Sample Collection	C	NA	One-man D-frame kick net (500 µ mesh) used to collect organisms, which are composited from 11 transects	Barbour et al. 1999, Peck et al. 2003, WSA Field Operation Manual 2004
Sorting and Enumeration	C	0 to 500 organisms	Random systematic selection of grids with target of 500 organisms from sample	WSA Benthic Laboratory Methods 2004
Identification	C	genus	Specified keys and references	

C = critical, N = non-critical quality assurance classification.

5.1.4 Quality Assurance Objectives

Measurement quality objectives (MQOs) are given in Table 8. General requirements for comparability and representativeness are addressed in Section 2. The MQOs given in Table 8 represents the maximum allowable criteria for statistical control purposes. Precision is calculated as percent efficiency, estimated from examination of randomly selected sample residuals by a second analyst and independent identifications of organisms in randomly selected samples. The MQO for picking accuracy is estimated from examinations (repicks) of randomly selected residues by experienced taxonomists.

Table 8. Measurement data quality objectives: benthic indicator

Variable or Measurement	Precision	Accuracy	Completeness
Sort and Pick	95%	90%	99%
Identification	85%	90%[a]	99%

NA = not applicable
[a] Taxonomic accuracy, as calculated using Equation 10 in Section 2.

The completeness objectives are established for each measurement *per site type* (e.g., probability sites, revisit sites, etc.). Failure to achieve the minimum requirements for a particular site type results in regional population estimates having wider confidence intervals. Failure to achieve requirements for repeat and annual revisit samples reduces the precision of estimates of index period and annual variance components, and may impact the representativeness of these estimates because of possible bias in the set of measurements obtained.

5.1.5 Quality Control Procedures: Field Operations

Specific quality control measures are listed in Table 9 for field operations.

5.1.6 Quality Control Procedures: Laboratory Operations

Specific quality control measures are listed in Table 10 for laboratory operations. Figure 6 presents the general process for collecting and analyzing benthic invertebrate samples.

5.1.7 Data Management, Review, and Validation

Checks made of the data in the process of review, verification, and validation are summarized in Table 11. The Project Facilitation Team is ultimately responsible for ensuring the validity of the data, although performance of the specific checks may be delegated to other staff members. Once data have passed all acceptance requirements, computerized data files are prepared in a format specified for the WSA project by EMAP and copied onto a floppy diskette. The diskettes are transferred to the WSA IM Coordinator (Marlys Cappaert) for entry into a centralized data base. A hard copy output of all files accompanies each diskette.

A reference specimen collection is prepared as new taxa are encountered in samples. This collection consists of preserved specimens in vials and mounted on slides and is provided to the responsible EPA laboratory as part of the analytical laboratory contract requirements. The reference collection is archived at the responsible EPA laboratory.

Table 9. Laboratory Quality Control: benthic macroinvertebrate sample processing

Check or Sample Description	Frequency	Acceptance Criteria	Corrective Action
SAMPLE PROCESSING (PICK AND SORT)			
Sample residuals examined by different analyst within lab	10% of all samples completed per analyst	Efficiency ≥90%	If <90%, examine all residuals of samples by that analyst and retrain analyst
Sorted samples sent to indepen-dent lab	10% of all samples	Accuracy of contractor laboratory picking and identification ≥90%	If picking accuracy <90%, all samples in batch will be reanalyzed by contractor

Table 10: Laboratory Quality Control: benthic macroinvertebrate taxonomic identification

Check or Sample Description	Frequency	Acceptance Criteria	Corrective Action
Duplicate identification by different taxonomist within lab	10% of all samples completed per laboratory	Efficiency ≥85%	If ≤85%, reidentify all samples completed by that taxonomist
Independent identification by outside taxonomist	All uncertain taxa	Uncertain identifications to be confirmed by expert in particular taxa	Record both tentative and independent IDs
Use widely/com monly excepted taxonomic references	For all identificatio ns	All keys and references used must be on bibliography prepared by another laboratory	If other references desired, obtain permission to use from Project QA Officer
Prepare reference collection	Each new taxon per laboratory	Complete reference collection to be maintained by each individual laboratory	Benthic Lab Manager periodically reviews data and reference collection to ensure reference collection is complete and identifications are accurate

Sample residuals, vials, and slides are archived by each laboratory until the WSA Project Leader has authorized, in writing, the disposition of samples. All raw data (including field data forms and bench data recording sheets) are retained in an organized fashion indefinitely or until written authorization for disposition has been received from the WSA Project Leader.

Table 11: Data validation quality control: benthic indicator

Check Description	Frequency	Acceptance Criteria	Corrective Action
Taxonomic "reasonableness" checks	All data sheets	Genera known to occur in given stream conditions or geographic area	Second or third identification by expert in that taxon

5.1.8 Data Analysis Plan

Specific research issues to be addressed from this year's activities and the ecological attributes or metrics associated with the benthic indicator are summarized in Table 12.

Table 12. Research issues: benthic indicator

Research Issues	Design Strategy
Variance Estimates	Obtain estimates of variance components from duplicate samples and revisits to sites.
Indicator Development and Evaluation	Identify best set of ecological attributes or metrics that are broadly applicable to assessing biological condition and are informative as to detection and characterization of impairment. Candidate attributes are selected measures of richness, O/E, representatives of sensitive taxa. These are based on EPA's biological condition graient attributes as part of the aquatic life use initiative.
Methods Comparability	Use standardized guidelines (from the NWQMC Methods and Data Comparability Board) for methods comparability studies (to measure precision and sensitivity along environmental and disturbance gradients), and select ecological attributes best suited to compare performance of methods (e.g., compositional metrics, or richness adjusted for reference).
Threshold Development for Assessment	Develop general expectations for each attribute (for each ecoregion) from collection of reference sites sampled with WSA methods. Supplement with information from states and existing data where methods differences are not an issue. Combining data for an integrated assessment is based on minimizing sampling bias. Explore the use of thresholds based on % difference, e.g., 20% deviation from reference as a consistent means of evaluating biological condition across ecoregions.
Biological Condition	Develop an ordinal scale related to a biological condition gradient to reflect varying degrees of quality.

5.2 Physical Habitat Quality Indicator

5.2.1 Introduction

Naturally occurring differences in physical habitat structure and associated hydraulic characteristics among surface waters contributes to much of the observed variation in species composition and abundance within a zoogeographic province. Structural complexity of aquatic habitats provides the variety of physical and chemical conditions to support diverse biotic assemblages and maintain long-term stability. Anthropogenic alterations of riparian physical habitat, such as channel alterations, wetland drainage, grazing, agricultural practices, weed control, and streambank modifications such as revetments or development, generally act to reduce the complexity of aquatic habitat and result in a loss of species and ecosystem degradation. References are in Table 13.

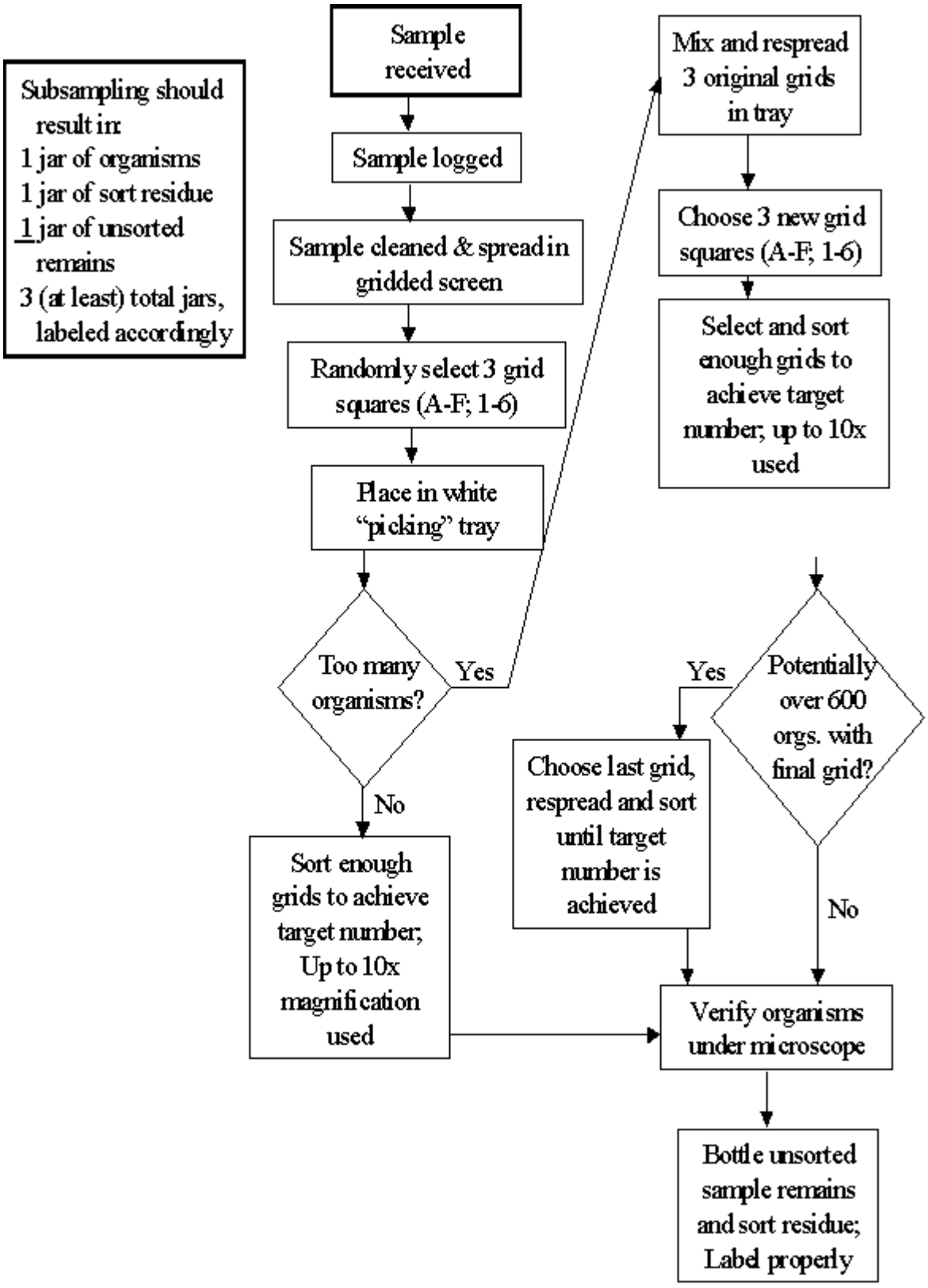


Figure 7: Laboratory Processing Activities for the benthic indicator

For WSA, indicators derived from data collected on physical habitat quality will be used to help explain or characterize stream condition relative to biological response and trophic state indicators. Specific groups of physical habitat attributes important in stream ecology include: channel dimensions, gradient, substrate; habitat complexity and cover; riparian vegetation cover and structure; anthropogenic alterations; and channel-riparian interaction (Kaufmann, 1993). Overall objectives for this indicator are to develop quantitative and reproducible indices, using both multivariate and multimetric approaches, to classify streams and to monitor biologically relevant changes in habitat quality and intensity of disturbance.

5.2.2 Sampling Design

As the physical habitat indicator is based on field measurements and observations, there is no sample collection associated with this indicator. Field crews are provided with 1:24,000 maps with the midpoint (index site) of the stream reach marked. At WSA sites, eleven cross-sectional measurement transects are spaced at equal intervals proportional to baseflow channel width, thereby scaling the sampling reach length and resolution in proportion to stream size. A systematic spatial sampling design is used to minimize bias in the selection of the measurement sites. Additional measurements are made at equally spaced intervals between the cross-sectional sites. A “rapid” assessment of habitat quality of the entire sampling reach is conducted based on the Rapid Bioassessment Protocol (RBP; Barbour et al., 1999).

5.2.3 Sampling Methodologies

Field Measurements: Field measurements, observations, and associated methodology for the protocol are summarized in Table 13; methodology for the RBP is described in Barbour et al. (1999) and in the WSA Field Operations Manual (2004). Detailed procedures for completing both protocols are provided in the field operations manual; equipment and supplies required are also listed. All measurements and observations are recorded on standardized forms which are later entered in to the central EMAP surface waters information management system at WED-Corvallis.

There are no sample collection or laboratory analyses associated with the physical habitat measurements.

5.2.4 Quality Assurance Objectives

Measurement data quality objectives (measurement DQOs or MQOs) are given in Table 14. General requirements for comparability and representativeness are addressed in Section 2. The MQOs given in Table 14 represent the maximum allowable criteria for statistical control purposes. Precision is determined from results of revisits by a different crew (field measurements) and by duplicate measurements by the same crew on a different day.

The completeness objectives are established for each measurement *per site type* (e.g., WSA sites, revisit sites, state comparability sites). Failure to achieve the minimum

requirements for a particular site type results in regional population estimates having wider confidence intervals. Failure to achieve requirements for repeat and annual revisit samples reduces the precision of estimates of index period and annual variance components, and may impact the representativeness of these estimates because of possible bias in the set of measurements obtained.

Table 13. Field measurement methods: physical habitat indicator.

Variable or Measurement	Units	QA Class	Summary of Method	References
THALWEG PROFILE				
Thalweg depth	cm	C	Measure maximum depth at 100-150 points along reach with surveyor's rod and meter stick	
Wetted width	0.1m	C	Measure wetted width with meter stick or measuring tape on perpendicular line to mid-channel line	
Habitat class	none	N	Visually estimate channel habitat using defined class descriptions	Frissell et al, 1986
WOODY DEBRIS TALLY				
Large woody debris	number of pieces	N	Visually estimate amount of woody debris in baseflow channel using defined class descriptions	Robison and Beschta, 1990
CHANNEL AND RIPARIAN CROSS-SECTIONS				
Slope and bearing	percent/ degrees	C	Backsight between cross-section stations using clinometer, rangefinder compass, and tripod	Stack, 1989; Robison and Kaufmann, in prep.
Substrate size	mm	C	At 5 points on cross section, estimate size of one selected particle using defined class descriptions	Wollman, 1954; Bain et al, 1985; Plafkin et al, 1989
Bank angle	degrees	N	Use clinometer and surveyors rod to measure angle	Platts et al, 1983
Bank incision	0.1m	N	Visually estimate height from water surface to first terrace of floodplain	
Bank undercut	cm	N	Measure horizontal distance of undercut	
Bankful width	0.1m	N	Measure width at top of bankful height	
Bankful height	0.1m	N	Measure height from water surface to estimated water surface during bankful flow	

Table 13. Field measurement methods: physical habitat indicator.

Variable or Measurement	Units	QA Class	Summary of Method	References
Canopy cover	points of inter-section	C	Count points of intersection on densiometer at specific points and directions on cross-section	Lemmon, 1957; Mulvey et al, 1992
Riparian vegetation structure	percent	N	Observations of ground cover, understory, and canopy types and coverage of area 5 m on either side of cross section and 10 m back from bank	
Fish cover, algae, macrophytes	percent	C	Visually estimate in-channel features 5 m on either side of cross section	
Human influence	none	C	Estimate presence/absence of defined types of anthropogenic features	
STREAM DISCHARGE				
Discharge	m/s or L/min.	N	Velocity-Area method, Portable Weir method, timed bucket discharge method	Linsley et al, 1982

Table 14. Measurement data quality objectives: physical habitat indicator

Variable or Measurement	Precision	Accuracy	Completeness
Field Measurements and Observations	±10%*	NA	90%
Map-Based Measurements	±10%	NA	100%

NA = not applicable *Not for RBP measures

5.2.5 Quality Control Procedures: Field Operations

Specific quality control measures are listed in Table 15 for field measurements and observations.

5.2.6 Quality Control Procedures: Laboratory Operations

There are no laboratory operations associated with this indicator.

Table 15. Field quality control: physical habitat indicator

Check Description	Frequency	Acceptance Criteria	Corrective Actions
Check totals for cover class categories (vegetation type, fish cover)	Each transect	Sum must be reasonable (best professional judgement)	Repeat observations
Check completeness of thalweg depth measurements	Each site	Depth measurements for all sampling points	Obtain best estimate of depth where actual measurement not possible
Check calibration of multiprobe	Prior to each sampling day	Specific to instrument	Adjust and recalibrate, redeploy gear

5.2.7 Data Management, Review, and Validation

Checks made of the data in the process of review, verification, and validation are summarized in Table 16. The Indicator Lead is ultimately responsible for ensuring the validity of the data, although performance of the specific checks may be delegated to other staff members. All raw data (including all standardized forms and logbooks) are retained in an organized fashion for seven years or until written authorization for disposition has been received from the WSA Project Coordinator.

Table 16. Data validation quality control: physical habitat indicator

Check Description	Frequency	Acceptance Criteria	Corrective Action
Estimate precision of measurements based on repeat visits by different crews	At least 2 teams visit stream 1 time each at 10% of streams (may be same team or different teams)	Measurements should be within 10 percent	Review data for reasonableness; Determine if acceptance criteria need to be modified

5.3 Water Chemistry Indicator

5.3.1 Introduction

Ecological indicators based on lake and stream water chemistry information attempt to evaluate stream condition with respect to stressors such as acidic deposition and other types of physical or chemical contamination. Data are collected for a variety of physical and chemical constituents to provide information on the acid-base status of each stream, water clarity, primary productivity, nutrient status, mass balance budgets of constituents, color, temperature regime, and presence and extent of anaerobic conditions.

At each stream site, crews fill one 4-L Cubitainer and two 60-mL syringes with stream water. These samples are stored in a cooler packed resealable plastic bags filled with ice and shipped to the analytical laboratory within 24 hours of collection. The primary function of the water chemistry information is to determine:

- Acid-base status
- Trophic state (nutrient enrichment)
- Chemical stressors
- Classification of water chemistry type

Specific research questions and hypotheses to be addressed from this year's activities are listed in Table 17.

Table 17. Research questions and hypotheses: water chemistry indicator

WSA Design Evaluation: Obtain estimates of regional variation.
Indicator Development and Evaluation: Development of chemical classes based on different types of chemical stressors (e.g., acid min drainage), examine relationship of chemical condition/stress to watershed landuse, and develop indicator(s) of chemical condition (e.g., trophic state [Carlson, 1977]).

5.3.2 Sampling Design

The plot design for stream sampling is shown in Figure 7. The plot design for water chemistry sampling is based on that used for the Wadeable Streams Assessment (Kaufmann et al., 1988). At each stream, a single index site is located at the midpoint of the designated stream reach. At each index site, a single water sample is collected. .

5.3.3 Sampling and Analytical Methodologies

Sample Collection: At the stream index site, a water sample is prepared from a series of eight 500-mL grab samples collected from the upper portion of the water column. In lotic systems the flowing water gives a composite from different parcels. These grab samples are composited into a single 4-L bulk water sample. Two syringe samples for closed system measurements are collected by immersing each 60 ml syringe into the stream at the index site and drawing water from under the surface into the syringe without exposure to the atmosphere. Detailed procedures for sample collection and handling are described in the field operations manual.

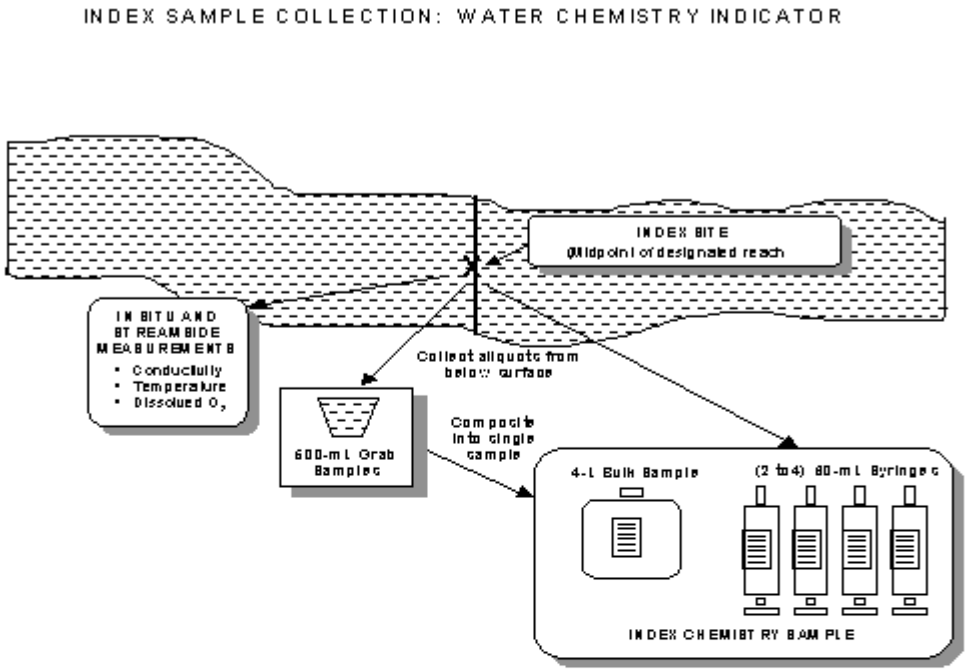


Figure 8. Stream index sampling design for the water chemistry indicator.

Analysis: Table 18 summarizes analytical methodologies for the chemical parameters. Analytical methods are based on EPA-validated methods, modified for use with aqueous samples of low ionic strength. Modified methods are thoroughly documented in the laboratory methods handbook prepared for the Aquatic Effects Research Program (U.S. EPA, 1987).

5.3.4 Quality Assurance Objectives

Measurement data quality objectives (measurement DQOs or MQOs) are given in Table 19. General requirements for comparability and representativeness are addressed in Section 2. The MQOs given in Table 19 represent the maximum allowable criteria for statistical control purposes. Method detection limits are monitored over time by repeated measurements of low level standards and calculated using Equation 2-1. For major

cations and anions, the required MDLs are approximately equivalent to 1.0 µeq/L (0.5 µeq/L for nitrate). The analytical laboratory may report results in mg/L; these results are converted to µeq/L for interpretation. For total suspended solids determinations, the "detection limit" is defined based on the required sensitivity of the analytical balance.

For precision, the objectives presented in Table 19 represent the 99 percent confidence intervals about a single measurement and are thus based on the standard deviation of a set of repeated measurements ($n > 1$). Precision objectives at lower concentrations are equivalent to the corresponding MDL. At higher concentrations, the precision objective is expressed in relative terms, with the 99 percent confidence interval based on the relative standard deviation (Section 2). Objectives for accuracy are equal to the corresponding precision objective, and are based on the mean value of repeated measurements. Accuracy is generally estimated as net bias or relative net bias (Section 2). For total phosphorus and total nitrogen measurements, accuracy is also determined from analyses of matrix spike samples (also sometimes called fortified samples) as percent recovery (Section 2). Precision and bias are monitored at the point of measurement (field or analytical laboratory) by several types of QC samples described in the Section 5.3.6, and from performance evaluation (PE) samples

Table 18. Analytical methodologies: water chemistry indicator

Analyte	QA Class	Expected Range	Summary of Method	References
pH, closed system	C	3 to 9 pH units	Sample collected and analyzed without exposure to atmosphere; electrometric determination (pH meter and glass combination electrode)	EPA 150.6 (modified); U.S. EPA (1987)
pH, equilibrated	N	3 to 9 pH units	Equilibration with 300 ppm CO_2 for 1 hr prior to analysis; Electrometric determination (pH meter and glass combination electrode)	EPA 150.6 (modified); U.S. EPA (1987)
Acid Neutralizing Capacity (ANC)	C	-100 to 5,000 µeq/L	Acidimetric titration to pH ≤ 3.5, with modified Gran plot analysis	EPA 310.1 (modified); U.S. EPA (1987)
Carbon, dissolved[a] inorganic (DIC), closed system	N	0.1 to 50 mg C/L	Sample collected and analyzed without exposure to atmosphere; acid-promoted oxidation to CO_2, with detection by infrared spectrophotometry	U.S. EPA (1987)
Carbon, dissolved organic (DOC)	C	0.1 to 30 mg C/L	UV-promoted persulfate oxidation, detection by infrared spectrophotometry.	EPA 415.2, U.S. EPA (1987)
Conductivity	C	1 to 500 µS/cm	Electrolytic (conductance cell and meter)	EPA 120.6, U.S. EPA (1987)

Analyte	QA Class	Expected Range	Summary of Method	References
Aluminum, total dissolved	C	10 to 1,000 µg/L	Atomic absorption spectroscopy (graphite furnace)	EPA 202.2; U.S. EPA (1987)
Aluminum, monomeric and organic monomeric	N	0 to 500 µg/L	Collection and analysis without exposure to atmosphere. Portion of sample passed through a cation exchange column before analysis to obtain estimate of organic-bound fraction. Colorimetric analysis (automated pyrocatechol violet).	APHA 3000-Al E.; APHA (1989), U.S. EPA (1987)
Major Cations (dissolved)				
Calcium	C	0.02 to 76 mg/L (1 to 3,800 µeq/L)	Atomic absorption spectroscopy (flame)	EPA 200.6, U.S. EPA (1987)
Magnesium	C	0.01 to 25 mg/L (1 to 2,000 µeq/L)		
Sodium	C	0.01 to 75 mg/L (0.4 to 3.3 µeq/L)		
Potassium	C	0.01 to 10 mg/L (0.3 to 250 µeq/L)		
Ammonium	N	0.01 to 5 mg/L (0.5 to 300 µeq/L)	Colorimetric (automated phenate)	EPA 350.7; U.S. EPA (1987)
Major Anions, dissolved				
Chloride	C	0.03 to 100 mg/L (1 to 2,800 µeq/L)	Ion chromatography	EPA 300.6; U.S. EPA (1987)
Nitrate	C	0.06 to 20 mg/L (0.5 to 350 µeq/L)		
Sulfate	C	0.05 to 25 mg/L (1 to 500 µeq/L)		
Silica, dissolved	N	0.05 to 15 mg/L	Automated colorimetric (molybdate blue)	EPA 370.1 (modified), U.S. EPA (1987)
Phosphorus, total	C	0 to 1000 µg/L	Acid-persulfate digestion with automated colorimetric determination (molybdate blue)	USGS I-4600-78; Skougstad et al. (1979), U.S. EPA (1987)

Analyte	QA Class	Expected Range	Summary of Method	References
Nitrogen, total	N	0 to 25,000 µg/L	Alkaline persulfate digestion with determination of nitrate by cadmium reduction and determination of nitrite by automated colorimetry (EDTA/sulfanilimide).	EPA 353.2 (modified); U.S. EPA (1987)
True Color	N	0 to 300 Platinum Cobalt Units (PCU)	Visual comparison to calibrated glass color disks	EPA 100.2 (modified), APHA 204 A.; U.S. EPA (1987)
Turbidity	N	1 to 100 Nephelometric Turbidity Units (NTU)	Nephelometric	APHA 214 A., EPA 180.1; U.S. EPA (1987)
Total Suspended Solids (TSS)	N	1 to 200 mg/L	Gravimetric	EPA 160.3; APHA (1989)

Table 19. Measurement data quality objectives: water chemistry indicator

Variable or Measurement	Method Detection Limit	Precision and Accuracy	Transition Value[a]	Completeness
Oxygen, dissolved	NA	±0.5 mg/L	NA	95%
Temperature	NA	±1 ±C	NA	95%
pH, closed system and equilibrated	NA	±0.075 or ±0.15 pH units	pH 5.75	95%
Acid Neutralizing Capacity	NA	±5 µeq/L or ±5%	100 µeq/L	95%
Carbon, dissolved inorganic, closed system	0.10 mg/L	0.10 mg/L or 10%	1 mg/L	95%
Carbon, dissolved organic	0.1 mg/L	±0.1 mg/L or ±10%	1 mg/L	95%
Conductivity	NA	±1 µS/cm or ±2%	50 µS/cm	95%
Aluminum, total dissolved, total monomeric, and organic monomeric	10 µg/L	±10 µg/L or ±10%	100 µg/L	95%
Major Cations:				95%
Calcium	0.02 mg/L	±0.02 mg/L or ±5%	0.4 mg/L	
Magnesium	0.01 mg/L	±0.01 mg/L or ±5%	0.2 mg/L	
Sodium	0.02 mg/L	±0.02 mg/L or ±5%	0.4 mg/L	
Potassium	0.04 mg/L	±0.04 mg/L or ±5%	0.8 mg/L	
Ammonium	0.02 mg/L	±0.02 mg/L or ±5%	0.4 mg/L	95%

Variable or Measurement	Method Detection Limit	Precision and Accuracy	Transition Value[a]	Completeness
Major Anions:				
Chloride	0.03 mg/L	±0.03 mg/L or ±5%	0.6 mg/L	95%
Nitrate	0.03 mg/L	±0.03 mg/L or ±5%	0.6 mg/L	
Sulfate	0.05 mg/L	±0.05 mg/L or ±5%	1 mg/L	
Silica	0.05 mg/L	±0.05 mg/L or ±5%	1 mg/L	95%
Phosphorus, total	1 µg/L	±1 µg/L or ±5%	20 µg/L	95%
Nitrogen, total	1 µg/L	±1 µg/L or ±5%	20 µg/L	95%
True Color	NA	±5 PCU or ±10%	50 PCU	95%
Turbidity	NA	±2 NTU or ±10%	20 NTU	95%
Total Suspended Solids	0.1 mg	±1 mg/L or ±10%	10 mg/L	95%

NA = not applicable
[a] Represents the value above which precision and bias are expressed in relative terms.

.5.3.5 Quality Control Procedures: Field Operations

Water chemistry field measurements are optional for this project.

5.3.6 Quality Control Procedures: Laboratory Operations

5.3.6.1 Sample Receipt and Processing

QC activities associated with sample receipt and processing are presented in Table 20. The communications center and information management staff are notified of sample receipt and any associated problems as soon as possible after samples are received. The general schemes for processing stream water chemistry samples for analysis is presented in Figure 9. In addition to the four syringes prepared in the field, several additional aliquots are prepared from bulk water samples. Ideally, all analyses are completed within a few days after processing to allow for review of the results and possible reanalysis of suspect samples within seven days. Critical holding times for the various analyses are the maximum allowable holding times, based on current EPA and American Public Health Association (APHA) requirements (American Public Health Association, 1989). Analyses of samples after the critical holding time is exceeded will likely not provide representative data.

5.3.6.2 Analysis of Samples

QC protocols are an integral part of all analytical procedures to ensure that the results are reliable and the analytical stage of the measurement system is maintained in a state of statistical control. Most of the QC procedures described here are detailed in

the references for specific methods. However, modifications to the procedures and acceptance criteria described in this QAPP supersede those presented in the methods references. Information regarding QC sample requirements and corrective actions are summarized in Table 21. Figure 10 illustrates the general scheme for analysis of a batch of water chemistry samples, including associated QC samples.

5.3.7 Data Reporting, Review, and Management

Checks made of the data in the process of review, verification, and validation are summarized in Table 22. Data reporting units and significant figures are given in Table 23. The Indicator Lead is ultimately responsible for ensuring the validity of the data, although performance of the specific checks may be delegated to other staff members.

Table 20. Sample processing quality control: water chemistry indicator

Quality Control Activity	Description and Requirements	Corrective Action
Sample Storage	Store samples in darkness at 4˚C Monitor temperature daily	Qualify sample as suspect for all analyses
Holding time	Complete processing bulk samples within 48 hours of collection	Qualify samples
Aliquot Containers and Preparation	Rinse collection bottles 2 times with stream water to be sampled	
Filtration	0.4 µm polycarbonate filters required for all dissolved analytes except DIC (0.45 µm) Rinse filters and filter chamber twice with 50-ml portions of deionized water, followed by a 20-mL portion of sample. Repeat for each filter used on a single sample. Rinse aliquot bottles with two 25 to 50 mL portions of filtered sample before use.	
Preservation	Use ultrapure acids for preservation. Add sufficient acid to adjust to pH < 2. Check pH with indicator paper. Record volume of preservative on container label. Store preserved aliquots in darkness at 4˚C until analysis.	
Holding Times for preserved aliquots	Closed system determinations from syringe samples must be completed within 72 hours of collection. Holding times for other analyses holding times range from 3 days to 6 months, based upon current APHA criteria.	Sample results are qualified as being in violation of holding time requirements.

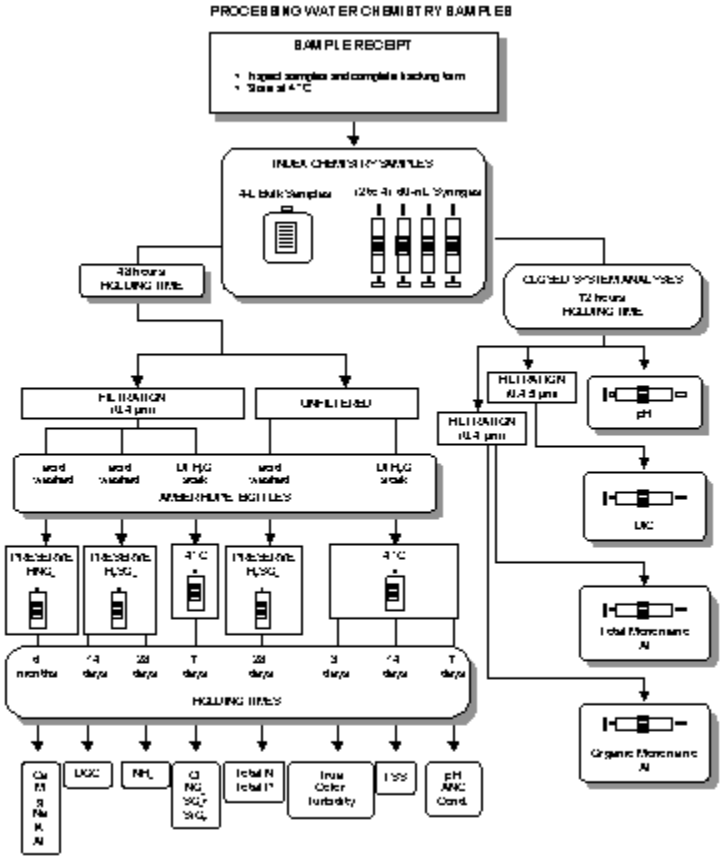


Figure 9. Sample processing activities for water chemistry samples.

Table 21. Laboratory quality control samples: water chemistry indicator

QC Sample Type (Analytes), and Description	Frequency	Acceptance Criteria	Corrective Action
Laboratory Blank: (all analyses except pH and total suspended solids[TSS]) Reagent Blank: (DOC, Al [total, monomeric, and organic monomeric], ANC, NH_4^+, SiO_2)	Once per batch prior to sample analysis	Control limits < ±MDL	Prepare and analyze new blank. Determine and correct problem (e.g., reagent contamination, instrument calibration, or contamination introduced during filtration) before proceeding with any sample analyses. Reestablish statistical control by analyzing three blank samples.
Filtration Blank: (All dissolved analytes, excluding syringe samples) ASTM Type II reagent water processed through filtration unit.	Prepare once per week and. archive	Measured concentrations < MDL	Measure archived samples if review of other laboratory blank information suggest source of contamination is sample processing.
Detection Limit Quality Control Check Sample (QCCS): (All analyses except true color, turbidity, and TSS) Prepared so concentration is approximately four to six times the required MDL.	Once per batch	Control limits < ±MDL	Confirm achieved MDL by repeated analysis of appropriate standard solution. Evaluate affected samples for possible re-analysis.
Calibration QCCS: For turbidity, a QCCS is prepared at one level for routine analyses (U.S. EPA, 1987). Additional QCCSs are prepared as needed for samples having estimated turbidities greater than 20 NTU. For total suspended solids determinations, QCCS is a standard weight having mass representative of samples.	Before and after sample analyses	Control limits < precision objective: Mean value < bias objective	Repeat QCCS analysis. Recalibrate and analyze QCCS. Reanalyze all routine samples (including PE and field replicate samples) analyzed since the last acceptable QCCS measurement.

QC Sample Type (Analytes), and Description	Frequency	Acceptance Criteria	Corrective Action
Internal Reference Sample: (Suggested when available for a particular analyte)	One analysis in a minimum of five separate batches	Control limits < precision objective. Mean value < bias objective	Analyze standard in next batch to confirm suspected imprecision or bias. Evaluate calibration and QCCS solutions and standards for contamination and preparation error. Correct before any further analyses of routine samples are conducted. Reestablish control by three successive reference standard measurements which are acceptable. Qualify all sample batches analyzed since the last acceptable reference standard measurement for possible reanalysis.
Laboratory Replicate Sample: (All analyses) For closed system analyses, a replicate sample represents a second injection of sample from the sealed syringe.	One per batch	Control limits < precision objective	If results are below MDL: Prepare and analyze split from different sample (volume permitting). Review precision of QCCS measurements for batch. Check preparation of split sample. Qualify all samples in batch for possible reanalysis.

QC Sample Type (Analytes), and Description	Frequency	Acceptance Criteria	Corrective Action
Matrix spike samples: (Only prepared when samples with potential for matrix interferences are encountered)	One per batch	Control limits for recovery cannot exceed 100±20%	Select two additional samples and prepare fortified subsamples. Reanalyze all suspected samples in batch by the method of standard additions. Prepare three subsamples (unfortified, fortified with solution approximately equal to the endogenous concentration, and fortified with solution approximately twice the endogenous concentration.

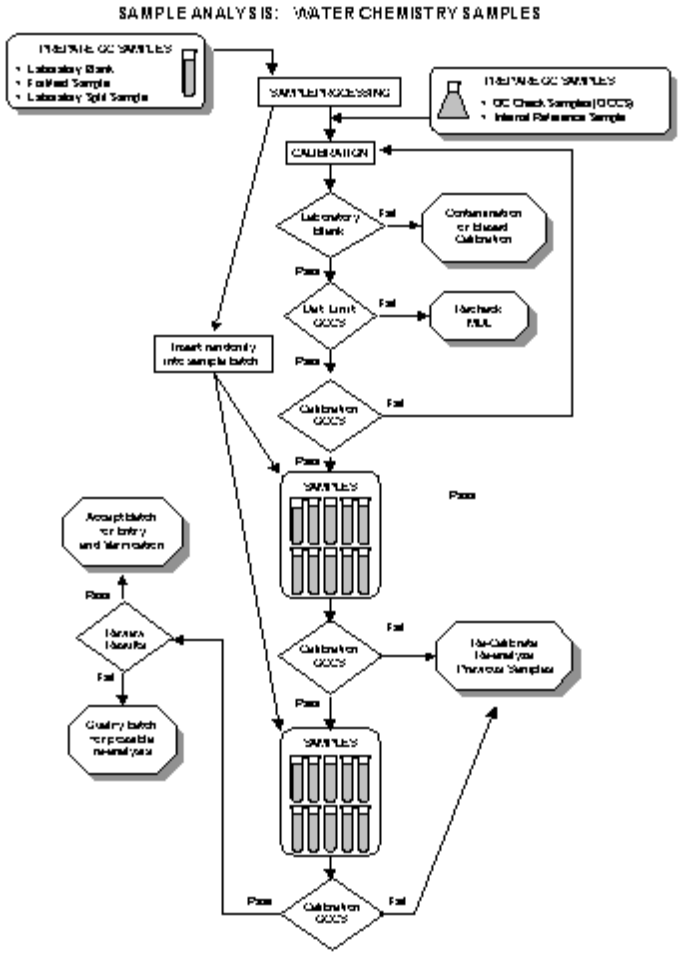


Figure 10. Analysis activities for water chemistry samples.

Table 22. Data validation quality control: water chemistry indicator

Activity or Procedure	Requirements and Corrective Action
Range checks, summary statistics, and/or exploratory data analysis (e.g., box and whisker plots)	Correct reporting errors or qualify as suspect or invalid.
Review holding times	Qualify value for additional review
Ion balance: Calculate percent ion balance difference (%IBD) using data from cations, anions, pH, and ANC.	If total ionic strength ≤ 100 µeq/L, %IBD ≤ ±25%. If total ionic strength > 100 µeq/L, %IBD ≤ ±10%. Determine which analytes, if any, are the largest contributors to the ion imbalance. Review suspect analytes for analytical error and reanalyze. If analytical error is not indicated, qualify sample to attribute imbalance to unmeasured ions. Reanalysis is not required. Flag= unacceptable %IBD Flag= %IBD outside acceptance criteria due to unmeasured ions
Conductivity check: Compare measured conductivity of each sample to a calculated conductivity based on the equivalent conductances of major ions in solution (Hillman et al., 1987).	If measured conductivity ≤ 25 µS/cm, ([measured – calculated] ÷ measured) ≤ ±25%. If measured conductivity > 25 µS/cm, ([measured – calculated] ÷ measured) ≤ ±15%. Determine which analytes, if any, are the largest contributors to the difference between calculated and measured conductivity. Review suspect analytes for analytical error and reanalyze. If analytical error is not indicated, qualify sample to attribute conductivity difference to unmeasured ions. Reanalysis is not required.
Aluminum check: Compare results for organic monomeric aluminum, total monomeric aluminum, and total dissolved aluminum.	[organic monomeric] < [total monomeric] < [total dissolved]. Review suspect measurement(s) to confirm if analytical error is responsible for inconsistency.
ANC check: Calculate ANC based on pH and DIC. Compare to measured ANC	Review suspect measurements for samples with results outside of acceptance criteria. Determine if analytical error or non-carbonate alkalinity are responsible for lack of agreement.
Review data from QA samples (laboratory PE samples, and interlaboratory comparison samples)	Compare with results from other years to determine comparability. Determine impact and possible limitations on overall usability of data

Table 23. Data reporting criteria: water chemistry indicator

Measurement	Units	No. Significant Figures	Maximum No. Decimal Places
Dissolved Oxygen	mg/L	2	1
Temperature	˚C	2	1
pH	pH units	3	2
Carbon, dissolved inorganic	mg/L	3	2
Carbon, dissolved organic	mg/L	3	1
Acid neutralizing capacity	µeq/L	3	1
Conductivity	µS/cm at 25 ˚C	3	1
Aluminum (total dissolved, total monomeric, and organic monomeric)	µg/L	3	0
Calcium, magnesium, sodium, potassium, ammonium, chloride, nitrate, and sulfate	µeq/L	3	1
Silica	mg/L	3	2
Total phosphorus and total nitrogen	µg/L	3	0
Turbidity	NTU	3	0
True color	PCU	2	0
Total suspended solids	mg/L	3	1

The ion balance for each sample is computed using the results for major cations, anions, and the measured acid neutralizing capacity. The percent ion difference (%IBD) for a sample is calculated as:

$$\%IBD = \frac{(\Sigma\ cations - \Sigma\ anions) - ANC}{ANC + \Sigma\ anions + \Sigma\ cations + 2[H^+]}$$

where ANC is the acid neutralization capacity, cations are the concentrations of calcium, magnesium, sodium, potassium, and ammonium, converted from mg/L to µeq/L, anions are chloride, nitrate, and sulfate (converted from mg/L to µeq/L), and H^+ is the hydrogen ion concentration calculated from the antilog of the sample pH. Factors to convert major ions from mg/L to µeq/L are presented in Table 24. For the conductivity check, equivalent conductivities for major ions are presented in Table 25.

Table 24. Constants for converting major ion concentrations from mg/L to µeq/L

Analyte	Conversion from mg/L to µeq/L[a]
Calcium	49.9
Magnesium	82.3
Potassium	25.6
Sodium	43.5
Ammonium	55.4
Chloride	28.2
Nitrate	16.1
Sulfate	20.8

[a] Measured values are multiplied by the conversion factor.

Table 25. Factors to calculate equivalent conductivities of major ions[a]

Ion	Equivalent Conductance per mg/L (µS/cm at 25 ˚C)	Ion	Equivalent Conductance per mg/L (µS/cm at 25 ˚C)
Calcium	2.60	Nitrate	1.15
Magnesium	3.82	Sulfate	1.54
Potassium	1.84	Hydrogen	3.5×10^5 [b]
Sodium	2.13	Hydroxide	1.92×10^5 [b]
Ammonium	4.13	Bicarbonate	0.715
Chloride	2.14	Carbonate	2.82

[a] From Hillman et al. (1987).

[b] Specific conductance per mole/L, rather than per mg/L.

6.0 FIELD AND BIOLOGICAL LABORATORY QUALITY EVALUATION AND ASSISTANCE VISITS

No national program of accreditation for benthic macroinvertebrate collections and sample processing currently exists. However, national standards of performance and audit guidance for biological laboratories are being considered by the National Environmental Laboratory Accreditation Conference (NELAC). For this reason, a rigorous program of field and laboratory evaluation and assistance visits has been developed to support the Wadeable Streams Assessment Program.

Procedural review and assistance personnel are trained to the specific implementation and data collection methods detailed in the WSA field operations manual. Plans and checklists for field evaluation and assistance visit have been developed to reinforce the specific techniques and procedures for both field and laboratory applications. The plans and checklists are included in this section and describe the specific evaluation and corrective actions procedures.

It is anticipated that evaluation and assistance visits will be conducted with each Field Team early in the sampling and data collection process, and that corrective actions will be conducted in real time. These visits provide a basis for the uniform evaluation of the data collection techniques, and an opportunity to conduct procedural reviews as required to minimize data loss due to improper technique or interpretation of program guidance. Through uniform training of field crews and review cycles conducted early in the data collection process, sampling variability associated with specific implementation or interpretation of the protocols will be significantly reduced. The field visits evaluations, while performed by a number of different supporting collaborator agencies and participants, will be based on the uniform training, plans, and checklists. This review and assistance task will be conducted for each unique crew collecting and contributing data under this program; hence no data will be recorded to the project database that were produced by an 'unaudited' process, or individual.

Similarly, laboratory evaluation and assistance visits will be conducted early in the project schedule and soon after sample processing begins at each laboratory to ensure that specific laboratory techniques are implemented consistently across the multiple laboratories generating data for the program. Laboratory evaluation and checklists have been developed to ensure uniform interpretation and guidance in the procedural reviews. These laboratory visits are designed such that full corrective action plans and remedies can be implemented in the case of unacceptable deviations from the documented procedures observed in the review process without recollection of samples.

The Field and Laboratory Evaluation and Assistance Visit Plans are described in sections 6.1 and 6.2.

6.1 NATIONAL WADEABLE STREAMS ASSESSMENT FIELD QUALITY EVALUATION AND ASSISTANCE VISIT PLAN

Evaluators: One or more designated EPA or Contractor staff members who are qualified (i.e., have completed training) in the procedures of the WSA field sampling operations.

To Evaluate: Field Sampling Teams during sampling operations on site.

Purpose: To identify and correct deficiencies during field sampling operations.

1. Tetra Tech project staff will review the Field Evaluation and Assistance Visit Plan and Check List with each Evaluator during field operations training sessions.

2. The Tetra Tech QA Officer or authorized designee will send a copy of the final Plan and 4-part carbonless copy versions of the final Check List pages, envelopes to return the Check Lists, a clipboard, pens, and WSA QAPP and *Field Operations Manua*l to each participating Evaluator.

3. Each Evaluator is responsible for providing their own field gear sufficient to accompany the Field Sampling Teams (e.g., protective clothing, sunscreen, insect repellent, hat, hip boots or waders, water bottle, food, back pack, cell phone) during a complete sampling cycle. Schedule of the Field visits will be made by the Evaluator in consultation with the Tetra Tech QA Officer and respective Field Crew Leader. **Evaluators should be prepared to spend additional time in the field if needed (see below).**

4. Tetra Tech and the Regional Monitoring Coordinators will arrange the schedule of visitation with each Field Team, and notify the Evaluators concerning site locations, where and when to meet the team, and how to get there. Ideally, each Field Team will be evaluated within the first two weeks of beginning sampling operations, so that procedures can be corrected or additional training provided, if needed. GLEC or EPA Evaluators will visit Tetra Tech Field Teams and Tetra Tech or EPA Evaluators will visit GLEC Field Teams. Any EPA or Contractor Evaluator may visit State Field Teams.

5. A Field Team for the WSA consists of a three-person crew where, at a minimum, the Field Crew Leader is fully trained.

6. If members of a Field Team changes, and a majority (i.e., two) of the members have not been evaluated previously, the Field Team must be evaluated again during sampling operations as soon as possible to ensure that all members of the Field Team understand and can perform the procedures.

7. The Evaluator will view the performance of a team through one complete set of sampling activities as detailed on the Field Evaluation and Assistance Check List.

    a. Scheduling might necessitate starting the evaluation midway on the list of tasks at a site, instead of at the beginning. In that case, the Evaluator will follow the team to the next site to complete the evaluation of the first activities on the list.

    b. If the Team misses or incorrectly performs a procedure, the Evaluator will note this on the checklist and *immediately point this out so the mistake can be corrected on the spot*. The role of the Evaluator is to provide additional training and guidance so that the procedures are being performed consistent with the *Field Operations Manual*, all data are recorded correctly, and paperwork is properly completed at the site.

    c. When the sampling operation has been completed, the Evaluator will review the results of the evaluation with the Field Team before leaving the site (if practicable),

noting positive practices and problems (i.e., weaknesses [might affect data quality], deficiencies [would adversely affect data quality]). The Evaluator will ensure that the Team understands the findings and will be able to perform the procedures properly in the future.

d. The Evaluator will record responses or concerns, if any, on the Field Evaluation and Assistance Check List.

e. If the Evaluator's findings indicate that the Field Team is not performing the procedures correctly, safely, or thoroughly, the Evaluator must continue working with this Field Team until certain of the Team's ability to conduct the sampling properly so that data quality is not adversely affected.

f. If the Evaluator finds major deficiencies in the Field Team operations (e.g., less than three members, equipment or performance problems) the Evaluator must contact one of the following QA officials:

Dr. Esther Peters, Tetra Tech QA Officer (703-385-6000)
Ms. Robin Silva-Wilkinson, GLEC QA Officer (231-941-2230)
Mr. Otto Gutenson, EPA WSA Project QA Officer (202-566-1183)

The QA official will contact the Project Implementation Coordinator (Michael Barbour – 410-356-8993) or Project Technical Advisor (Steve Paulsen – 541-754-4428) to determine the appropriate course of action.

Data records from sampling sites previously visited by this Field Team will be checked to determine whether any sampling sites must be redone.

g. Complete the Field Evaluation and Assistance Check List, including a brief summary of findings, and ensure that all Team members have read this and signed off before leaving the Team.

8. Retain the back copy of each page of the Field Evaluation and Assistance Check List (color: _____). Fasten the pages of the check list for each Field Team together with a paper clip.

9. Mail the remaining pages of each completed Field Evaluation and Assistance Check List to

Dr. Esther Peters
Tetra Tech, Inc.
10306 Eaton Place, Suite 340
Fairfax, VA 22030

10. The Tetra Tech QA Officer or authorized designee will review the returned Field Evaluation and Assistance Check Lists, note any issues, check off the completion of the evaluation for each Field Team, and distribute the remaining pages of each

check list as follows:

Original: Tetra Tech QA Officer file, Fairfax, VA

Color: _____ Tetra Tech Project Manager file, Owings Mills, MD

Color: _____ WSA QA Officer file, Washington, DC

6.2 NATIONAL WADEABLE STREAMS ASSESSMENT LABORATORY QUALITY EVALUATION AND ASSISTANCE VISIT PLAN

Evaluators: One or more designated Contractor staff members who are qualified (i.e., have completed training) in the procedures of the WSA biological laboratory operations.

To Evaluate: Biological laboratories performing subsampling, sorting, and taxonomic procedures to analyze collected stream samples.

Purpose: To identify and correct deficiencies during laboratory operations.

1. Tetra Tech project staff will review the Laboratory Evaluation and Assistance Visit Plan and Check List with each Evaluator prior to conducting laboratory evaluations.

2. The Tetra Tech QA Officer or authorized designee will send a copy of the final Plan and 4-part carbonless copy versions of the final Check List pages, envelopes to return the Check Lists, a clipboard, pens, and WSA QAPP and *Benthic Laboratory Methods* manual to each participating Evaluator.

3. Schedule of lab visits will be made by the Evaluator in consultation with the Tetra Tech QA Officer and the respective Laboratory Supervisor Staff. **Evaluators should be prepared to spend additional time in the laboratory if needed (see below)**.

4. Tetra Tech will arrange the schedule of visitation with each participating Laboratory, and notify the Evaluators concerning site locations, where and when to visit the laboratory, and how to get there. Ideally, each Laboratory will be evaluated within the first two weeks following initial receipt of samples, so that procedures can be corrected or additional training provided, if needed.

5. The Evaluator will view the performance of the laboratory sorting process and QC Officer through one complete set of sample processing activities as detailed on the Laboratory Evaluation and Assistance Check List.

    a. Scheduling might necessitate starting the evaluation midway on the list of tasks for

processing a sample, instead of at the beginning. In that case, the Evaluator will view the activities of the Sorter when a new sample is started to complete the evaluation of the first activities on the list.

b. If a Sorter or QC Officer misses or incorrectly performs a procedure, the Evaluator will note this on the checklist and *immediately point this out so the mistake can be corrected on the spot*. The role of the Evaluator is to provide additional training and guidance so that the procedures are being performed consistent with the *Benthic Laboratory Methods* manual, all data are recorded correctly, and paperwork is properly completed at the site.

c. When the sample has been completely processed, the Evaluator will review the results of the evaluation with the Sorter and QC Officer, noting positive practices and problems (i.e., weaknesses [might affect data quality], deficiencies [would adversely affect data quality]). The Evaluator will ensure that the Sorter and QC Officer understand the findings and will be able to perform the procedures properly in the future.

d. The Evaluator will record responses or concerns, if any, on the Laboratory Evaluation and Assistance Check List.

e. If the Evaluator's findings indicate that Laboratory staff are not performing the procedures correctly, safely, or thoroughly, the Evaluator must continue working with these staff members until certain of their ability to process the sample properly so that data quality is not adversely affected.

f. If the Evaluator finds major deficiencies in the Laboratory operations, the Evaluator must contact one of the following QA officials:

Dr. Esther Peters, Tetra Tech QA Officer (703-385-6000)
Mr. Dennis McCauley, GLEC QA Officer (231-941-2230)
Mr. Otto Gutenson, EPA WSA Project QA Officer (202-566-1183)

The QA official will contact the Project Implementation Coordinator (Michael Barbour – 410-356-8993) or Project Technical Advisor (Steve Paulsen – 541-754-4428) to determine what should be done.

Data records from samples previously processed by this Laboratory will be checked to determine whether any samples must be redone.

g. Complete the Laboratory Evaluation and Assistance Check List, including a brief summary of findings, and ensure that the Sorter and QC Officer have read this and signed off before leaving the Laboratory.

6. Retain the back copy of each page of the Laboratory Evaluation and Assistance

Check List (color: _____). Fasten the pages of the check list for each Sorter together with a paper clip.

Mail the remaining pages of each completed Laboratory Evaluation and Assistance Check List to

Dr. Esther Peters
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7. The Tetra Tech QA Officer or authorized designee will review the returned Laboratory Evaluation and Assistance Check Lists, note any issues, check off the completion of the evaluation for each participating Laboratory, and distribute the remaining pages of each check list as follows:

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   Color: _____ Tetra Tech Project Manager file, Owings Mills, MD

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