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# Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies

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# Abstract

Each environmental study conducted by or for the Washington State Department of Ecology must have an approved Quality Assurance (QA) Project Plan. The QA Project Plan describes the objectives of the study and the procedures to be followed to achieve those objectives. The QA Project Plan is a product of a systematic planning process.

The preparation of a QA Project Plan helps focus and guide the planning process and promotes communication among those who contribute to the study. The completed plan provides direction to those who carry out the study and forms the basis for written reports on the outcome.

This document presents detailed guidance on preparing a QA Project Plan. It describes 14 elements to be addressed in the plan and provides supporting information relevant to the content of each element.

This document is a revision of the Ecology publication No. 01-03-003, *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies*, February 2001.

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# Introduction

Washington State Department of Ecology (Ecology) Policy 1-21 requires the preparation of a Quality Assurance (QA) Project Plan for each study that acquires new environmental measurement data or uses existing data. This document describes the content of a QA Project Plan for studies conducted by or for Ecology.

The QA Project Plan integrates the contributions of everyone involved in the study into a statement of exactly what needs to be accomplished, when and how it will be done, and by whom. It is a guide for those who implement the study as well as a basis for preparing reports on the outcome. Planners should use a "graded approach" in which the content and level of detail in a QA Project Plan depends on the type of project and the intended use of the data.

Preparing a QA Project Plan should be a team effort coordinated by the project manager. The team includes (where applicable) the client, representatives of the analytical laboratory (or laboratories), field staff, and anyone else who will contribute to the study. The team might also include specialists to provide advice on QA, information management, and statistics. A small project may not require a formal team, but rather one person interacting with people, as needed, one-on-one or in small groups.

While not usually part of the planning team, decision-makers and others with an interest in the project should be informed and consulted during planning. Once the goals of the study have been formulated, a meeting of the project team should be held to develop specific objectives for the project and to decide on the best methods to achieve them.

Field work must not begin until the plan has been approved and distributed for implementation by the appropriate personnel.

Once a QA Project Plan has been approved for a study, it may be used as a template for planning similar studies. Information specific to a new study can be inserted into the original plan. For emergency response activities, a QA Project Plan template can be prepared in advance based on available knowledge and experience, and updated as needs evolve. In this case, the plan becomes a valuable training aid for emergency response staff.

Some programs require preparation of Sampling and Analysis Plans (SAPs) that generally cover information on sampling and analysis similar to that required in a QA Project Plan. Within Ecology, the Toxics Cleanup Program requires the preparation of SAPs to comply with the Model Toxics Control Act Cleanup Regulation, Chapter 173-340 WAC. These QA Project Plan guidelines are identified by the Toxics Cleanup Program as one of the guidance documents to be used in preparing SAPs.

Preparing a QA Project Plan requires an understanding of basic concepts related to sampling, field and laboratory measurements, and assessment of data quality.

Appendices provide information, starting with a Glossary in Appendix A, to supplement the topics covered in these guidelines.

References are listed at the end of this document, followed by lists of QA requirements and guidance documents published by EPA's Quality Staff as well as additional readings on selected topics. The requirements documents provide information on satisfying the federal regulations for organizations receiving financial assistance from EPA through extramural agreements (e.g., contracts, grants, cooperative agreements, and interagency agreements). The guidance documents are intended to assist in developing and implementing a suitable Quality System, including the preparation of QA Project Plans.

This document is a revision of Ecology Publication No. 01-03-003, *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies*, February 2001.

# Overview of Quality Assurance and the Planning Process

In this document, Quality Assurance (QA) means a process for assuring the reliability of measurement data. QA principles and practices enable you to acquire data of the type and quality you need. The quality of the data must be documented in order to be scientifically and legally defensible.

In addition to the preparation of QA Project Plans, the following quality system components help ensure that data quality needs are met:

- Ecology's QA Policy (Executive Policy 1-21) and Quality Management Plan (Ecology, 2000)
- Manchester Environmental Laboratory QA Manual (Ecology, 2003a)
- Manchester Environmental Laboratory *Lab Users Manual* (Ecology, 2003b)
- Staff training in the principles and practices of QA
- Systematic planning
- Preparation and use of standard operating procedures (SOPs)
- Use of appropriate quality control (QC) procedures
- Verification and validation of data
- Assessment to determine whether the data support the project objectives
- Quality improvement through audits of systems and performance
- Accreditation of environmental laboratories providing data to Ecology

Ecology makes important decisions on strategies for protecting the environment and dealing with pollution. Physical, chemical, and biological data often form the basis for these decisions. QA helps ensure that data acquired by and for Ecology support correct decisions.

The potential consequences of inadequate data quality include:

- Faulty decisions
- Wasted resources
- Legal liability
- Increased risk to human health and the environment
- Inadequate understanding of the state of the environment
- Loss of credibility
- Unnecessary regulation
- Failure to regulate when necessary

## Systematic Planning

Systematic planning is a process in which you identify the problem to be studied and/or the decision to be made, and then define the project's objectives, the type, quantity, and quality of information needed, the technical and QC activities, and the level of oversight that will ensure project criteria are satisfied. This information is documented in a logical sequence in the QA Project Plan.

There are two main approaches to systematic planning mentioned in these guidelines: (1) the Data Quality Objectives (DQO) Process; and (2) the Performance and Acceptance Criteria (PAC) Process. A summary explanation of systematic planning, including the DQO and PAC approaches, is given in Appendix B, and a detailed explanation of the DQO Process is provided in EPA QA/G-4.

## Purpose of a QA Project Plan

The purpose of preparing a QA Project Plan is to ensure that all necessary steps are taken to acquire data of the type and quality needed.

A project or study is a logical sequence of activities grouped into three categories:

Planning $\rightarrow$ Implementation $\rightarrow$ Assessment

A QA Project Plan documents the planning phase and guides implementation and assessment.

A QA Project Plan

- Lists the goals and objectives of a study
- Identifies the type and quality of data needed
- Describes the sampling and measurement procedures needed to acquire those data
- Describes the QC and assessment procedures needed to ensure that the study objectives are met

## Preparing a QA Project Plan

A systematic or step-wise planning process is essential to the successful acquisition of useful environmental data. Once you begin field work, your options are limited by what you know and what you have with you.

Ecology Policy 1-21, *Establishing Quality Assurance*, applies to environmental data collection studies/activities conducted or funded by Ecology. The policy states that a QA Project Plan "is prepared for each environmental study/activity that acquires or uses environmental measurement data."

The levels of effort and detail in preparing a QA Project Plan should be commensurate with the scope of the study and available resources. The planning process generates performance and acceptance criteria for the quality of data as well as objectives for the quality of decisions made on the basis of those data.

Preparation of a QA Project Plan serves three important functions:

- Focuses the project team on issues affecting data quality while they can still be effectively addressed (i.e., before data are acquired).
- Promotes and facilitates communication among those involved in the project.
- Compiles information needed for project implementation and assessment.

The credibility of your data may be compromised if the procedures used to acquire them are not adequately documented. The QA Project Plan provides important initial documentation of your study and identifies other necessary documentation such as:

- Standard operating procedures (SOPs)
- Field logs
- Outputs from field instruments
- Chain-of-custody records
- Lab records and reports
- Photos and drawings
- Project reports

## Responsibility for Preparing QA Project Plans

Those with responsibility for QA Project Plans include:

- Ecology staff with overall responsibility for conducting a project (project managers) prepare QA Project Plans with input from their project teams.

- Ecology staff who administer grants or contracts for projects which acquire environmental data ensure that satisfactory QA Project Plans are prepared by the grantees or contractors.

- Ecology staff with oversight responsibility for projects conducted to comply with regulations or agreements ensure that satisfactory QA Project Plans are prepared by or for the responsible parties.

- Organizations funded by Ecology for environmental data collection studies and activities that acquire and use environmental measurement data are required to prepare QA Project Plans.

## Responsibility for Reviewing and Approving QA Project Plans

At Ecology, QA Project Plans are generally reviewed by the project manager's supervisor, the client, laboratory QA staff (if laboratory services are required), the program QA Coordinator or agency QA Officer, and other key staff as appropriate. Allow at least two weeks for review. Some Ecology programs have standard procedures governing review and approval of QA Project Plans. Ecology staff with specialized expertise may be available to review your plan. Appendix C is a checklist to aid in the review of QA Project Plans.

The project manager makes any necessary changes to the plan based on reviewers' comments and submits the revised plan for approval signatures. Plans prepared by Ecology should be approved by all reviewers. The agency QA Officer must approve all project plans submitted to EPA.

Copies of the approved QA Project Plan are distributed to the signatories and to everyone responsible for implementing the study. QA Project Plans prepared by Ecology's Environmental Assessment Program are available as publications on Ecology's internet web site at http://www.ecy.wa.gov/biblio/eap.html.

The QA Project Plan must be approved and distributed before field work is started. Conditional approval for implementation may be given when only non-critical deficiencies remain to be resolved. The plan is then resubmitted for final approval when the information is finalized. The plan is a living document that should be updated during the course of a study whenever it is appropriate to do so.

## Role of the Laboratory in a Project

The management and staff of the laboratory contribute to the success of the project by:

- Advising on selection of analytical methods that meet measurement quality objectives (MQOs)
- Advising on acceptance criteria for data drawn from existing sources (i.e., secondary sources)
- Reviewing and approving the QA Project Plan
- Providing containers and other sampling supplies (e.g., labels, forms)
- Analyzing samples using the methods selected for the project
- Carrying out appropriate QC procedures to confirm that MQOs have been met
- Reporting results for samples and QC procedures
- Documenting performance characteristics for methods used
- Providing information on how QC limits are set and how they are used for lab QC
- Reviewing data and verifying results

# Elements of a QA Project Plan

The following elements comprise a complete QA Project Plan:

1. Title Page with Approvals
2. Table of Contents and Distribution List
3. Background
4. Project Description
5. Organization and Schedule
6. Quality Objectives
7. Sampling Process Design (Experimental Design)
8. Sampling Procedures
9. Measurement Procedures
10. Quality Control
11. Data Management Procedures
12. Audits and Reports
13. Data Verification and Validation
14. Data Quality (Usability) Assessment

The project manager may decide that some elements can be omitted or merged into other elements. Factors which influence these decisions include the scope and complexity of the project, the number of staff involved and their level of expertise, and past problems which could be avoided by clearly stating expectations in the plan. Criteria to help the project manager make these decisions are provided in the discussions of the individual elements that follow. If you omit an element because it is not applicable, state why it was omitted.

The level of detail in a QA Project Plan depends on the type and complexity of the project and the intended use of the data. The information in the QA Project Plan must be sufficiently detailed to allow those responsible for review, approval, and implementation of the plan to understand what is to be done and the reasons for doing so.

Documents containing information relevant to the study are referenced in, or appended to, the QA Project Plan.

Project plans prepared to meet EPA requirements must address the elements described in the most recent versions of EPA Documents QA/R-5, *EPA Requirements for Quality Assurance Project Plans*, and QA/G-5, *Guidance for Quality Assurance Project Plans***.** See Appendix D for a list of the elements included in these documents.

For hazardous waste programs, especially those that are Superfund related, you may need to follow the *Uniform Federal Policy for Quality Assurance Project Plans* prepared by the Intergovernmental Data Quality Task Force (IDQTF, 2003).

The following pages provide guidelines for the information to be included in each of the 14 elements of a QA Project Plan. Key information to be included in each element is highlighted in **bold type**.

# 1. Title Page with Approvals

**The following information is presented on the title pages of the plan:**

- **Title**
- **Author**
- **Author's organization**
- **Date the plan was prepared or revised**
- **Other information useful in identifying the study (e.g., a document, grant, geographic location, or contract identifier)**
- **Spaces for approval signatures and dates**

Plans prepared by Ecology usually include an additional cover page without the signatures. Signatures indicate both approval of the plan and commitment to support implementation of the procedures specified.

Plans prepared by Ecology should be approved by:

- The project manager
- The project manager's supervisor
- The client
- A representative of the laboratory, if a lab is involved in the project
- The program QA Coordinator or agency QA Officer
- Other key staff as appropriate

At Ecology, the agency QA Officer must approve all project plans submitted to EPA. For projects conducted under a grant or contract, the Ecology grant or contract administrator may approve the plan after comments from technical reviewers have been addressed.

## 2. Table of Contents and Distribution List

**Include a Table of Contents.**

The table should be included if it would be helpful to those using the plan, as is the case for longer plans. It directs the user to the project plan elements and to tables, figures, references, and appendices.

**Those who will receive copies of the approved plan may be listed after the Table of Contents**.

Provide names of individuals, along with their affiliation, address, phone number, and e-mail address.

# 3. Background

One of the first steps in a systematic planning process is to give an overview of why the project is needed. This element and the next describe why the project will be done and what needs to be done; these may be combined into a single element if that would improve clarity. Provide enough background information so that the reasons for conducting the study are clear. Give the reader a perspective of the present situation and the events leading up to it.

For projects in which new data are to be collected, it may be necessary to make a reconnaissance visit to gather information on conditions, accessibility, and activity in the area, before completing your plan.

Where applicable, provide the following:

**Describe the study area and surroundings.**

Include sufficient detail that reviewers can determine whether the study design and field procedures are appropriate. Include maps, photos, or drawings of the site or area.

**Mention any logistical problems with the study area.**

Note items such as limited access or the presence of hazardous substances which require unusual procedures.

**Relate the history of the study area.**

Use drawings or photographs to support the narrative.

**Identify parameters or contaminants of concern, and state why they are of concern.**

Include information on the sources, forms, quantities, and fates of known or suspected contaminants.

**Summarize the results and conclusions of previous studies.**

Provide all information relevant to the study being planned. This should include existing data, using tables and charts if necessary. State how these data are relevant to the objectives of your new study. Reference the reports that are the sources of these data.

**Identify important related criteria or standards.**

# 4. Project Description

From the information in Element 3 and outputs from your systematic planning process, provide the following:

**State your goals.**

The goals are your reasons for conducting the project.

Describe the nature of the problems that will be studied, the questions to be answered, the decisions to be made, and the actions that might result from the decisions.

**State your objectives.**

The objectives are what you want to accomplish.

It is essential to document your overall project objectives because they form the basis for the rest of the plan. Clear objectives preclude unrealistic expectations and facilitate planning and communication. More specific objectives for the quality of the decisions and measurements will be included in Element 6.

**Identify the information, including data, needed to meet your objectives.**

Provide just a summary here. Details will be covered in the subsequent elements of the plan. Indicate which information is already available from previous studies and which will require new environmental measurements. Identify which parameters or contaminants of concern need to be identified and measured.

**Identify the target population.**

The target population might be one of the strata in a lake in the springtime, contaminated soil at an abandoned industrial facility, or tissue from the shellfish in a particular estuary. The population is characterized by its boundaries in time and space as well as its relationship to its surroundings.

**Define the study boundaries.**

This will help ensure that data will be representative of that population. Use existing information and professional judgment to stratify or segregate the population into categories with homogenous characteristics.

**Identify any practical constraints on the study design**.

Include items such as seasonal or meteorological conditions, limited access, or availability of personnel or equipment.

**Summarize the tasks that will be required to collect the data.**

**Describe any decisions that will be made using the project data.**

An objective of some environmental studies is to acquire data for comparison to specific regulatory criteria or to existing data. The comparison then forms the basis for a decision on whether some action is required. Decisions are rarely made on the basis of a single result. Appendix E provides a discussion of the effects of errors on decisions. Decision quality is addressed in Element 6, *Quality Objectives.*

# 5. Organization and Schedule

**Identify members of the project planning team, decision-makers, and interested parties.**

Study participants need a clear understanding of their roles and their relationship to the overall effort. A planning team meeting is recommended to discuss individual roles and responsibilities and the schedule for implementing the plan. For a small project, it may be sufficient to have one person interacting with others, as needed, one-on-one or in small groups, rather than in formal meetings.

**Identify everyone involved in implementing the study and assessing the data.**

Include names, organizations, phone numbers, and responsibilities of key personnel.

**For large studies, include an organization chart showing the lines of communication among participants.**

**Include a schedule for the project.**

Provide proposed dates for

- Reconnaissance visits
- Preparation and approval of the QA Project Plan
- Field activities
- Delivery of samples to the laboratory
- Reporting measurement results
- Verification and validation of data
- Data entry to Ecology's Environmental Information Management System (EIM) or other database
- Progress, draft, and final reports, as needed
- Disposal of samples

The final preparation of the schedule may be one of the last steps in the preparing the project plan.

**Describe limitations imposed on the schedule.**

Discuss factors such as weather, seasonal conditions, equipment availability, etc. Plan to keep the laboratory informed of your schedule for delivery of samples.

Plan to obtain all necessary collection permits and permissions to access property and take samples before scheduling reconnaissance visits or field activities.

**Include budget information for the project, if required.**

# 6. Quality Objectives

There are several factors that affect the quality and usefulness of data, and therefore impact the decisions made on the basis of those data. The overall quality of your data will be determined by a combination of those factors. Data may be affected by systematic errors (i.e., bias) and are always subject to random errors. It is often necessary to report results at very low concentrations, where random error is generally large relative to concentration.

Quality objectives need to be specified at two levels when critical decisions must be made and at only one level when decision-making is not the purpose of data collection.

There are several approaches to systematic planning. Summary descriptions of these are given in Appendix B. The approach used for systematic planning will depend on whether or not decision-making is a primary purpose of data collection.

Precision, bias, and sensitivity are data quality indicators used in establishing quality objectives. Other data quality indicators are representativeness, comparability, and completeness; these are discussed in Element 7, *Sampling Process Design*.

Before reading the following guidelines for the quality objectives that need to be specified in your plan, it is recommended that you read the addendum to this element, which includes background information on the concepts of precision, bias, and sensitivity.

## Decision Quality Objectives

When data will be used to select between two clear alternative conditions or to determine compliance with a standard, such as in some hazardous-waste site cleanups, quality objectives at the level of the decision are required. They specify how good a decision must be, but do not directly set criteria for the quality of the data or express data quality characteristics. The outputs of a Decision (or Data) Quality Objectives (DQO) Process are needed to determine the number of samples that must be taken and analyzed. A brief explanation of the DQO Process is provided in Appendix B, and detailed explanations are given in EPA QA/G-4, *Guidance for the Data Quality Objectives Process* and EPA QA/G-4HW, *Data Quality Objective Process for Hazardous Waste Site Investigations*. Appendix E explains the statistical basis for decision-making.

## Measurement Quality Objectives

Measurement quality objectives (MQOs) specify how good the data must be in order to meet the objectives of the project. MQOs are the performance or acceptance thresholds or goals for the project's data, based primarily on the data quality indicators precision, bias, and sensitivity. Another name for MQOs is measurement performance criteria (MPC). For existing data, these correspond to acceptance criteria.

MQOs are included in all QA Project Plans.

In the DQO Process, the tolerable limits on decision errors are the basis for specifying the MQOs.

In other projects when data are being used to support estimation, modeling, or research and are not directly linked to a decision, the required accuracy of measurement results is the basis for establishing MQOs.

MQOs are used to select procedures for sampling, analysis, and quality control (QC).

A simple approach to specifying MQOs is recommended for most projects. In this approach, MQOs are expressed in the same units used for reporting QC sample results. This facilitates data validation, since the results for QC sample analyses can be compared directly to determine whether the MQOs have been met. Although the MQOs are expressed in the same units as QC sample results, they do not specify the analytical method or technology to be used.

The MQOs selected should be compatible with the requirements for accuracy (precision and bias), as defined in the addendum to this element. The following examples are stated in the same units used by the laboratory for reporting their QC results.

Examples of MQOs for a project analyzing metals in water samples are:

- Check Standards/Lab Control Samples – 85 to 115% Recovery
- Duplicate Sample Analyses – ≤ 20% Relative Percent Difference (RPD)
- Matrix Spike Recoveries – 75 to 125%
- Duplicate Matrix Spikes – ≤ 20% RPD

Examples of MQOs for a project analyzing orthophosphate and nitrate in water samples are:

- Check Standards/Lab Control Samples – 80 to 120% Recovery
- Duplicate Sample Analyses – ≤ 20% RPD
- Matrix Spike Recoveries – 75 to 125%
- Duplicate Matrix Spikes – ≤ 20% RPD

Examples of MQOs for a project analyzing organochlorine pesticides in water samples by EPA method 8081 are:

- Check Standards/Lab Control Samples – 30 to 150% Recovery
- Surrogate Compounds – 30 to 150% Recovery
- Duplicate Sample Analyses – ≤ 50% RPD
- Matrix Spike Recoveries – 30 to 150%
- Duplicate Matrix Spikes – ≤ 50% RPD

See Element 10, *Quality Control*, and Appendix G for explanations of the QC terms used above.

Some parameters, such as Biochemical Oxygen Demand (BOD), and bacteriological determinations are defined operationally by the procedures used in their determination. There are no standard solutions that can be used to check overall accuracy, although it may be possible to check precision. For those parameters, it is important to ensure that the written procedures are followed exactly, and MQOs may be limited to the precision for replicate analyses of samples and standards.

For some field measurements, such as pH, temperature, and electrical conductivity, fewer MQOs can be specified, since not as many QC checks can be done in the field as in the controlled environment of the laboratory. In those cases, it is important to operationally ensure that instruments are calibrated regularly and the calibration is checked frequently. MQOs can sometimes be expressed in terms of the maximum deviations allowed for calibration checks.

MQOs for sensitivity should be expressed as the lowest concentrations of interest. A rule of thumb used to determine the lowest concentration of interest is that it be ten times lower than the reference level used for decision-making (i.e., the standard, criterion, or regulatory limit). For example, if you are determining a substance subject to a water quality standard of 100 μg/L, the smallest concentration of interest should be specified as 10 μg/L. This helps ensure that the method selected for use will be precise enough for reliable decision-making when results are at or near the 100 μg/L water quality standard. For some parameters, such as pH, it may not be meaningful to specify a lowest concentration of interest.

**Prepare a table summarizing your MQOs for both lab and field measurements.**

An example of a table of MQOs is given in Appendix H.

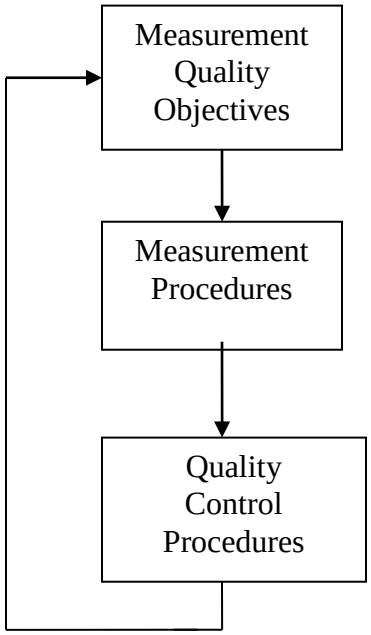
You can also specify acceptance criteria for data collected previously that will be used during the project.

MQOs also may be specified for total random error due to sampling and analysis. However, since there can be many variables affecting sampling error, it is best to set MQOs based on historical data for the parameter in a similar matrix. The most frequently stated MQO for total random error is the precision of duplicate (collocated) field samples in terms of the RPD.

An example of another way to express an MQO that includes both sampling and analysis is: “The overall precision of lead measurements taken on the soil in the bins must be less than 50% relative standard deviation when at least 10 samples are taken from each bin.” This and other examples for specifying MQOs in hazardous site characterization and cleanup projects are included in an article by Crumbling (2001).

The Water Research Centre (WRC) in England has recommended a statistically based approach to analytical quality control (AQC) for water quality monitoring that (1) defines MQOs in terms of precision, bias, and lowest concentration of interest, (2) confirms that those objectives have been met prior to routine sample analysis, and (3) subsequently verifies that the objectives are met on a continuing basis. The WRC approach, summarized in Appendix F, is recommended for water quality monitoring projects if time and resources permit. This approach can be particularly useful when several laboratories are involved in a project.

As stated previously, MQOs provide the basis for choosing measurement procedures. And once measurement procedures are chosen, appropriate QC procedures are specified. This stepwise process is summarized in the following diagram.




Note that this flowchart has a feedback loop. This is to ensure that the measurement procedures and QC procedures are compatible with the MQOs. In actual practice, during the early stages of project planning, the planning team will be considering which specific methods and procedures may be applicable. It may be necessary to adjust the MQOs or the way analyses are done if methods or QC procedures are not available to meet the MQOs. For example, if the MQOs cannot be met by analyses of individual samples, it may be possible to take replicate field samples and/or do replicate analyses to obtain mean results with better precision that allows those MQOs to be met. If methods are not available to meet the initially-stated MQOs, you can evaluate whether the MQOs can be changed without compromising the overall objectives of the project. Of course, in some cases it may be necessary to develop analytical methods that will meet the MQOs before the project can proceed.

It may not be possible to meet your MQOs for precision at very low concentrations because relative error increases rapidly near the detection limit. Also, for matrix spikes, the ratio of the amount spiked to the amount present before spiking will affect the percent recoveries. These factors must be taken into account when setting MQOs and interpreting results. See Element 10, *Quality Control*, for more detail.

While emphasis has been placed on defining analytical or measurement MQOs rather than sampling MQOs, it does not imply that measurement error is always greater or more important than sampling error. For many projects, in particular the investigation and restoration of contaminated sites, sampling error rather than analytical error has been found to be the largest source of uncertainty in environmental data. When this is the case, little is gained by minimizing analytical uncertainty if sampling uncertainty is not also addressed.

One way to minimize sampling uncertainty is to collect more samples. As cost is often a concern in analyzing samples, one solution may be to use low-cost field analytical methods when available. In this way, many more samples can be analyzed to get a more accurate appraisal of contamination than is possible using conventional laboratory analyses.

The next element, Element 7, considers the importance of sampling process design in achieving MQOs.

## Addendum – Background Information on Precision, Bias, and Sensitivity

**Precision**

Precision is a measure of the variability in the results of replicate measurements due to random error. Random errors are always present because of normal variability in the many factors that affect measurement results. Precision can also be affected by the variations of the actual concentrations in the media being sampled.

Potential sources of random errors include:

- Field sampling procedures
- Handling, transporting, and preparing samples for shipment to the laboratory
- Obtaining a subsample from the field sample for analysis
- Preparing the sample for analysis at the laboratory
- Analysis of the sample (including data handling errors)

The magnitude of these errors can be expected to vary during the measurement process and make it more difficult to determine the natural variability of contaminants in the environment.

The dispersion (width) of the familiar bell-shaped curve, or normal distribution, provides an estimate of precision. See Appendix G for a discussion of the normal distribution and equations for estimating standard deviation and other measures of precision. Note that any estimate of a population parameter can be improved by increasing the number of results used in the calculation. Historical data may offer an indication of the precision you can expect for the data you plan to acquire.

It may be more efficient to use less precise and less expensive screening techniques or measurement procedures if they can meet your MQOs. The standard error (i.e., precision) of the mean is given by $s/\sqrt{n}$, where s is the estimated standard deviation for the population of individual analytical results. Therefore, if you use the mean of n values as your result, the precision of that result is improved by a factor of $1/\sqrt{n}$ over that of an individual result (see Appendix G). Thus, a result obtained by averaging the values from several replicate measurements may be as precise as a single value obtained by a procedure with better precision.

Composite sampling (i.e., physically combining and homogenizing environmental samples or sub-samples to form a new sample) can also lower the cost of improving precision. Averaging the analytical results of a few composites can produce an estimated mean that is as precise as one based on many more individual sample results.

**Bias**

If a physical or chemical measurement is repeated many times using sufficiently sensitive procedures, the results will be distributed symmetrically about their mean value. Conceptually, the analyst could make an infinite number of analyses; this is termed the *population*. Bias is the difference between the population mean and the true value of the parameter being measured. Unlike random error, bias is generally not reduced by making more measurements.

Potential sources of bias include:

- Sampling procedures (including faults in sampling design)
- Instability of samples during transportation, storage, or processing
- Interference and matrix effects
- Inability to measure all forms of the parameter of interest
- Calibration of the measurement system
- Contamination of equipment, reagents, or containers

Bias due to sample collection, transportation, and storage must usually be inferred through careful observation and professional judgment. These errors can be avoided or minimized through use of standardized procedures by properly trained staff. Bias affecting measurement procedures can be inferred from the results of QC procedures involving the use of blanks, check standards, and spiked samples described in Element 10.

Generally, it is not possible to directly estimate the total bias of analytical results. Instead, each of the potential sources of bias is evaluated separately. For example, where interference or matrix effects are found, additional cleanup steps may help correct for this source of bias in some analyses.

When a measurement result is used to decide whether the true value exceeds a criterion or standard, the possibility of bias must be considered since unidentified bias can lead to an erroneous conclusion.

Keep in mind that the most effective way to deal with bias is to select sampling and measurement procedures that are not likely to introduce systematic error in the first place.

Note that if a decision will be based on the difference between two results that are equally biased, that difference may not be biased. An example might be the comparison of measurement results from the same laboratory for samples taken upstream and downstream of an outfall.

**Sensitivity**

For some projects, an important consideration is selection of a method capable of producing accurate results at or near the reference level(s) for decision-making (i.e., the standard, criterion, or regulatory limit). It is important that the method used for analysis

has a detection limit well below the reference level, since precision is poor near the detection limit and decisions should not be based on imprecise data.

Sensitivity in analytical chemistry reflects the ability to discern the difference between very small amounts of a substance. In general, sensitivity denotes the rate at which the analytical response (e.g., absorbance, volume, meter reading) varies with the concentration of the parameter being determined.

However, as a data quality indicator in this document, sensitivity is also defined in a specialized sense as the lowest concentration of a substance that can be detected or the lower limit of detection described by Morrison (1965). *The MQO for sensitivity is the smallest concentration of interest for a project.* A rule of thumb is that the smallest concentration of interest be specified as one-tenth the concentration at the reference level for decision-making. The laboratory must be capable of reporting results down to that level. Element 9, *Measurement Procedures*, discusses how the MQO of smallest concentration of interest is used when choosing an appropriate analytical method.

**MQOs and Accuracy**

When MQOs are expressed in the same units as QC sample results, their implications for the accuracy (precision and bias) of sample results may not be apparent. It is important to understand these relationships in order to choose MQOs consistent with the fundamental accuracy requirements for your data.

For example, a check standard (lab control sample) recovery range of 85 to 115% indicates that the maximum acceptable percent relative standard deviation (%RSD) for those QC results is 5% or less, assuming that the range corresponds to action limits of ± 3 standard deviations from the mean. Because the recovery limits are symmetrical around 100%, it also indicates that calibration is not a source of bias for these analyses. The only source of bias for analyses of check standards prepared in pure water is calibration, since there should be no interference or matrix effects.

A value of 20% RPD for analytical duplicate results corresponds to approximately 14% RSD, using the equation in Appendix G.

Matrix spike recoveries that exceed QC limits may indicate the presence of bias due to interference or matrix effects, but there are many variables that can make it difficult to interpret the results of spike recoveries. In general, spike recovery results are most reliable when the ratio of the amount spiked to the concentration before spiking is approximately equal to one. When the ratio is too low, random error makes it more difficult to identify the presence of bias. When the ratio is too high, interference effects at lower concentrations may not be apparent.

# 7. Sampling Process Design (Experimental Design)

Prepare your design using the information developed in Elements 3, 4, and 6. It may be helpful to evaluate alternatives and select the most efficient design that will satisfy your objectives. Some regulatory programs have specific requirements for sampling design, and these should be described or referenced in this element.

**Describe the sampling process design for your study.**

Include:

- Samples to be collected
- Chemical, physical, and biological parameters to be determined
- Measurements to be done in the field
- Measurements to be done in the laboratory
- Locations and schedule for sampling and measurements

**Provide maps or diagrams.**

Show the physical boundaries of the study area as well as proposed measurement and sampling locations.

Some studies may need to include reconnaissance sampling to aid in the selection of sampling locations.

Simple conceptual models may be helpful in sampling process design. From a look at the hydrograph, you might conclude there is little difference in dissolved solids from mid-summer through fall because stream discharge remains fairly constant. Therefore minimal sampling during this time should describe the discharge-dissolved solids relationship.

Or you might construct a simple diagram of the visitor or population curve as a function of season for a study to determine the influence of domestic waste discharged from a resort area to a river, and sample accordingly.

**Discuss any assumptions that underlie the design.**

**Indicate how the design relates to the study objectives and to characteristics of the site/area described in the background information.**

Explain how the proposed sampling frequency and locations relate to the expected temporal and spatial variability of the parameters of interest.

A measurement result is an estimate of the amount or concentration of the parameter being determined. The validity of that estimate is affected by the location, timing, and procedures selected for field measurements, sampling, and laboratory analyses.

Sometimes sampling locations are defined by the project objectives (e.g., characterize a specific effluent). In other cases, a sampling strategy must be developed.

Sampling may be based on probability or professional judgment. Remember that statistical methods are tools to be used in support of common sense and professional judgment, not as a substitute for either.

**When decisions on sampling will be made in the field, describe the process for making those decisions.**

## Representativeness

Obtaining representative measurements or samples requires a good sampling design as well as good execution of that design. A result is representative of a population when it reflects accurately the desired characteristic of that population. A set of representative samples is said to be valid if it provides a true representation of the temporal and spatial variations of the population characteristic. These seem like simple concepts, but obtaining representative and valid data requires careful planning. The target population must be clearly identified in Element 4, *Project Description*. The sample must be taken, or measurement made, at the appropriate time and place using appropriate equipment and procedures. Finally, the sample must be handled in such a way that it remains unchanged until it is analyzed. Procedures for obtaining representative results are described in Element 8, *Sampling Procedures*.

The sampler must consider how a pollutant is transported through a medium and the fate of the pollutant. For example, pollutants may be entrained in different parts of an aquatic ecosystem (e.g., water, sediment, and biota). The sampler needs to identify the dynamics of the pollutant in the river, stream, or lake and focus on sampling where the pollutant is most concentrated. Designing a monitoring program that focuses on degraded portions of an aquatic environment provides a more accurate description of current conditions and a more effective cleanup.

**If the order of sampling is important, it should be described here.**

For example, it is usually important to collect the samples in order of suspected increasing concentration to minimize cross-contamination from the sampling equipment. When wading streams, it is important to sample downstream first to avoid contaminating the samples with re-suspended sediment from upstream. However, for time-of-travel sampling, it is necessary to sample from upstream to downstream since the objective is to sample the same block of water as it moves downstream.

Sample collection should be scheduled to best characterize the problem. For example, nonpoint impacts on water quality often are related to certain land-use activities and weather conditions. If samples are not collected when those activities are going on or during typical weather patterns, the results may not be representative of their impact on water quality. Another example is that dissolved oxygen concentrations are generally

lowest at night; therefore, samples taken in late afternoon will probably not be representative of the lowest oxygen conditions.

Be aware of ancillary parameters that are necessary to evaluate a contaminant of interest against a criterion or standard. For example, hardness is a factor in calculating the water quality standard for several metals, and pH is needed to assess toxicity.

Information on representative sampling designs is available in several references. EPA Document QA/G-5S, *Guidance for Choosing a Sampling Design for Environmental Data Collection*, provides information on environmental study design. Ecology's *Technical Guidance for Assessing the Quality of Aquatic Environments* (Ecology, 1994) includes chapters on planning and study design, water quality assessment, TMDL analysis, and biological surveys. *Guidance on Sampling and Data Analysis Methods* (Ecology, 1995) provides information for cleanup actions conducted under the Model Toxics Control Act Cleanup Regulation.

Specialists in Ecology's Environmental Assessment Program have extensive experience in sampling environmental media and can be consulted for advice.

## Comparability

If you want to compare your data with other data sets, and combine those data for the decision to be made, the issue of comparability will need to be addressed in the project plan. Comparability is ensured by selecting and documenting standardized procedures for sampling and analysis, and by clearly stating any non-standard requirements.

**Describe the quality objectives for comparability of data.**

Then select procedures that will ensure your project data will match those objectives. These might include a requirement that the same standard operating procedures be used for all sampling and analysis. All laboratories involved in the project might be required to meet the same MQOs and use the same QC acceptance criteria. Some critical characteristics might involve the type of sampler used, the analytical or measurement method selected, holding times, and QC procedures.

## Completeness

EPA has defined completeness as a measure of the amount of valid data needed to be obtained from a measurement system.

**You may define an MQO for completeness in terms of the number or percentage of valid measurements needed to meet the project's objectives.**

# 8. Sampling Procedures

The procedures selected for sampling affect the accuracy, representativeness, and comparability of your results. Sampling may account for more variability in your results than the measurement process.

A field survey may be needed in order to identify any logistical problems and hazards that can affect sampling. Sampling procedures and equipment proposed for use may also need to be tested before they are included in the project plan. You do not want to find out that the procedure or equipment does not work when you go out to collect samples for the first time.

Sample collection activities must not significantly disturb the environment being sampled. For instance, sediments in streams, lakes, and estuaries are easily resuspended; the surface microlayer concentrates some contaminants in quiet waters; and exhaust or fluids from a vehicle can contaminate your samples. These kinds of potential problems must be addressed in the planning process in order to obtain representative samples. After collection, samples must remain stable during transport and storage. Careful adherence to documented procedures for sample collection, preservation, and storage will minimize errors due to sampling and sample instability.

**Describe in detail or reference the procedures for collecting samples.**

Referenced SOPs or published procedures must be up-to-date and readily available. If a referenced method offers various options, specify the particular option to be used in this study. It may be useful to include SOPs as appendices to the plan to facilitate project implementation.

*Stream Sampling Protocols for the Environmental Monitoring and Trends Section* (Ecology, 2001) provides guidance on field sampling. The Puget Sound Water Quality Action Team publishes *Puget Sound Protocols and Guidelines* covering procedures for environmental sampling and analysis. These documents are available at the web sites listed in Appendix J.

**Include a table listing containers, sample size, preservation, and holding times for each parameter.**

Requirements for containers, sample size, preservation, and holding times should be discussed with the laboratory. A table with this information for different parameters and matrices is included on Ecology's website and also in the Manchester Environmental Laboratory *Lab Users Manual* (Ecology, 2003b) When planning the number of containers that are needed, be sure to include QA field samples as well as environmental samples. An example of a completed table is found in Appendix H.

**Describe the procedures for decontaminating sampling equipment and disposing of waste from field operations.**

Decontamination waste must be disposed of according to federal, state, and local regulations.

**Describe the sample identification scheme.**

List the information to be recorded on the sample labels and tags, such as:

- identifying number
- location
- date & time
- sampler's initials
- parameters
- preservatives

Plan to prepare labels, tags, and forms before you leave for the field. Duplicate labeling with sample labels and tags is recommended, since labels can smudge or detach from the container. To avoid smudging, use waterproof ink to fill out the labels and tags.

**Describe the procedures and assign responsibility for transporting samples to the lab.**

Make sure the samples will arrive in time for analysis before the holding times expire. Include in the plan a copy of the form, with examples of required entries, which will accompany the samples to the laboratory.

**Describe or reference chain-of-custody procedures.**

If your data may be needed for regulatory purposes, follow formal chain-of-custody procedures, such as those described in the Manchester Environmental Laboratory *Lab Users Manual* (Ecology, 2003b). You have custody of a sample if it is in your possession, under your control, or in a secure area with access restricted to authorized personnel.

It is recommended that detailed notes on field activities be kept in a bound notebook with consecutively numbered pages. Notebooks with waterproof paper are available for field notes. Entries should be made in permanent, waterproof ink and initialed and dated. Corrections are made by drawing a single line through the error so it remains legible, writing the corrections adjacent to the errors, and initialing the correction. These practices ensure that data are legally defensible, since all changes in the data are part of the record.

Notes on the collection and handling of samples should be sufficiently detailed to allow the data user to understand and evaluate the procedures.

**Include a list of the required field log entries such as:**

- Name of the project and the location
- Identity of field personnel
- Sequence of events
- Changes to the plan
- Site and atmospheric conditions
- Number of samples collected
- Date, time, location, identification, and description for each sample
- Instrument calibration procedures
- Field measurement results
- Identity of QC samples
- Unusual circumstances which affect interpretation of the data

**Describe plans for taking pictures of key features of the site or of the sampling process.**

Require documentation of the exact locations where the pictures were taken. This information will be particularly useful if there is a need to return and take pictures to document changes over time.

**You may want to describe other activities such as:**

- Briefings and training for field staff
- Periodic preventive maintenance (PM) of measurement and test equipment
- Procedures and equipment for homogenizing non-aqueous matrices
- Procedures for notifying the lab about sample shipments

# 9. Measurement Procedures

Measurements can be made in the laboratory or the field, and written procedures or methods need to be specified for both, preferably in the form of standard operating procedures (SOPs). A method is the set of written instructions completely defining the procedure to be used.

Before submitting samples to the laboratory, coordinate with lab staff for their services. The first contact might be a phone call or e-mail indicating what you are planning to do. If you hold a planning team meeting, include a representative from the lab. Lab staff can help select analytical methods with documented performance characteristics that meet the measurement quality objectives (MQOs) stipulated in Element 6, *Quality Objectives*.

The method(s) selected should have performance characteristics that meet the MQOs for precision, bias, and sensitivity. An important consideration is the potential bias for the analytes in the matrices of interest. Additional considerations in choosing a method include:

- Definition of the parameter and the form or forms to be measured (e.g., dissolved and total metals)
- Concentration range of interest
- Frequency of analysis and the number of samples to be analyzed per batch
- Size of sample available
- Sample preservation and holding time requirements
- Cost of analysis

For some parameters, MQOs for the lowest concentrations of interest may have been specified in Element 6. In selecting a method, the lowest concentration of interest is usually equated with the limit of detection. Consult with the laboratory to choose a method with a limit of detection at or below the specified lowest concentration of interest. There are some differences in the way laboratories determine their limit of detection. Many laboratories calculate a method detection limit (MDL) as defined by EPA.

Regardless of how the laboratory has determined its limit of detection, the important consideration is that the laboratory can routinely report results at or below your lowest concentration of interest. Recall that the lowest concentration of interest was chosen to be 10 times lower than the reference level (standard or criteria) of concern, in order to ensure precise results at the reference level. If occasionally the laboratory fails to report down to the lowest concentration of concern (due to matrix effects, for example), you may still be able to obtain usable data at or near the reference level.

Sometimes the selection of analytical methods is restricted. For example, some federal and state programs require the use of specific methods. If you plan to compare your

results with those from another study, or to conduct a trend analysis, select procedures comparable to those used previously. Another consideration in selecting an appropriate method is turnaround time (i.e., the total time necessary to analyze a sample and report the result). Some methods may not be able to meet your required turnaround time.

The method must be fully documented either in a publication or in an SOP and validated by the lab before it is used.

The Manchester Environmental Laboratory uses a *Pre-Sampling Notification* form and *Sample Container Request* form to aid in coordinating analytical services. The lab also requires that a completed copy of their *Laboratory Analyses Required* form (which also serves as the chain-of-custody form) accompany the samples. Much of the information on these forms is included in this element of the QA Project Plan.

**Prepare a table with the following information:**

- Analyte
- Sample Matrix
- Number of Samples and Arrival Date
- Reporting Limit
- Expected Range of Results (if known)
- Schedule of Delivery
- Analytical Method(s) (including sample preparation procedures)

An example of a completed table is found in Appendix H.

**Specify sample preparation procedures if they are not included in the analytical method or when multiple options are offered in the method.**

**Describe or reference any specialized procedures or modifications to established methods.**

**A separate table is recommended for measurements that will be done in the field.**

For field measurements, some of the information in the table may not apply. Reference an SOP or other written description of the field measurement procedure. The SOP should include the procedures for calibration and analysis. If an instrument is used, specify the manufacturer and model. Describe QC procedures that will be used to check the accuracy of measurement, along with the frequency of the checks.

Some projects require rapid turnaround on-site measurements. If many measurements at low cost can be done, the method selected may not need to be as precise as a more costly laboratory method. The rationale for this approach is explained under the precision heading in the Addendum to Element 6, *Quality Objectives*.

Ecology Policy 1-22 requires that data from analyses of "water, sediment, sludge, air, soil, plant and animal tissue, and hazardous waste" come from laboratories accredited for the parameters and methods used. Contact Ecology's Environmental Assessment Program Lab Accreditation Section for information on accredited labs. A list of accredited labs is available at the web site listed in Appendix J.

Keep in mind that accreditation means that the lab has the capability to provide accurate data. However, MQOs must be specified to ensure that the laboratory uses methods and QC procedures appropriate to meet the needs of your project. The specification of MQOs and the use of QC procedures are always required to ensure the quality of your data.

A list of available methods at the Manchester Laboratory can be found at the intranet site listed in Appendix J and also in the *Lab Users Manual* (Ecology, 2003b). Standard operating procedures corresponding to these methods are maintained by the laboratory. Other methods may be available by special request. In addition, analyses by other methods may be contracted by the laboratory. The project manager should contact the laboratory with any questions related to analytical methods and sample shipment. Ecology QA staff (agency QA Officer as well as program and lab QA Coordinators) may be able to advise you on method selection and applicability.

If analytical services are contracted to private laboratories, be sure that all state and agency requirements for purchasing products or services are followed.

In some cases, competitive bidding requirements for contracts mean that the QA Project Plan is prepared before it is known which laboratory will perform the work. In those cases, a consultant with expertise in environmental analyses may be engaged, the plan may be revised, or a lab addendum may be prepared after the laboratory becomes part of the project team.

# 10. Quality Control

Quantitative measurement quality objectives (MQOs) are established in Element 6, *Quality Objectives*. The results for quality control (QC) samples are used to evaluate whether the measurement system is functioning properly and whether the MQOs have been met. QC requirements should be specified for both laboratory and field measurements, although more QC can generally be implemented for analyses done in a controlled laboratory environment. Recent versions of most analytical methods specify that control limits be based on historical lab performance, while some specify fixed values for QC limits. An important consideration stated by Crumbling (2001) is that "QC acceptance criteria should be very specific and should be designed such that if the QC acceptance criteria are consistently met, the project MQOs will be achieved."

**Prepare a table listing the types and frequency of field and laboratory QC samples required for the study.**

An example of a completed table is given in Appendix H.

The following discussion is intended to assist you in preparing the table and understanding the different types of QC samples that can be specified.

## Analytical QC

Many analytical methods include a section on QC procedures. The project manager should be familiar with the terminology and theory of analytical QC so as to be able to discuss them with lab staff. The Ecology QA Officer and program and lab QA Coordinators may be able to help with this communication.

Analytical QC procedures involve the use of four basic types of QC samples. QC samples are analyzed within a batch of client samples to provide an indication of the performance of the entire analytical system. Therefore, QC samples go through all sample preparation, clean up, measurement, and data reduction steps in the procedure. In some cases, the laboratory may perform additional tests that check only one part of the analytical system.

Note that the analysis of calibration standards is not considered part of QC, since all methods must include calibration whether or not QC samples are analyzed. A discussion of calibration is included in Appendix I.

### Check standards

Check standards are QC samples of known concentration prepared independently of the calibration standards. They are sometimes called laboratory control samples (LCS) or spiked blanks. Results are used to verify that analytical precision is in control and that the level of bias due to calibration is acceptable. If the results for the check standards do not fall within established control limits, the measurement system should be re-calibrated.

In some analytical methods, sample results may be qualified when associated check standard results are not within acceptable limits.

Check standards are usually prepared in deionized water, though any uncontaminated medium can be used. Their concentration should be in the range of interest for the samples, and at least one check standard should be analyzed with each batch of 20 samples or fewer.

Reference materials that more closely match the matrix of environmental samples may be used as check standards for your project. Some proficiency testing (PT) samples from commercial vendors can be stored and used as check standards once the true values are known. The acceptance limits for the results of analyses of these commercial samples should not be those set by the vendor but should be established in the lab by replicate analyses of the PT sample. An exception is when reference materials are sent to the laboratory for analysis as blinds. Ecology's Laboratory Accreditation Section can help identify suppliers of PT samples and certified reference materials.

**Analytical duplicates**

The laboratory analyzes duplicate aliquots of one or more samples within each batch. Results are used to estimate analytical precision for that matrix at that concentration.

**The project manager may specify which samples are to be analyzed in duplicate.**

If the samples selected for duplicate analyses do not contain measurable amounts of the analyte of interest, the results provide no information on precision. Also, if the lab selects samples from another study with significantly different levels of the analyte or different matrices, the estimate of precision may not be applicable to your samples.

One of the field duplicates is a good choice for an analytical duplicate since you may then estimate total and analytical variability from results for the same sample. There is no advantage to "randomly" selecting samples for duplicate analysis.

**Matrix spikes**

A matrix spike is an aliquot of a sample to which a known amount of analyte is added at the start of the procedure. Matrix spike recoveries may provide an indication of bias due to interference from components of the sample matrix.

Since the percent recovery is calculated from the difference between the analytical results for the spiked and unspiked samples, its precision may be relatively poor. If the spike is too high relative to the sample concentration, any interference effect at the sample concentration level could be masked. And if too low, random error would make it difficult to accurately estimate the recovery. The aim should be to spike at a concentration approximately equal to the concentration in the sample before spiking.

The project manager may indicate to the laboratory which samples might be most appropriate for use as matrix spikes and, if necessary, provide larger samples for this purpose.

In some cases, many replicate spikes would need to be analyzed in order to distinguish bias from the effects of random error on the recoveries. Thus, matrix spike results are not used to correct sample results and should only be used in conjunction with other QC data to qualify them.

While the primary use of matrix spikes is to indicate the presence of bias, duplicate spike results can be used to estimate analytical precision at the concentration of the spiked samples.

**The project manager may instruct the laboratory to spike certain samples since matrix spikes are not automatically included in all analytical methods.**

If the laboratory does not receive instructions, they may choose not to do any analyses of spiked samples or may select samples from other projects for spiking. Matrix spikes prepared from other types of samples or matrices provide no information on bias due to the matrices in your samples.

Some methods for organics analyses specify that all samples, including QC samples, be spiked with surrogate compounds at the start of the procedure. Because surrogate compounds are not expected to be present in the samples, they give analytical responses that can be distinguished from those of the analytes of interest. Surrogate recoveries provide an estimate of accuracy for the entire analytical procedure. The standard deviations of surrogate results provide an estimate of analytical precision, while the mean percent recoveries indicate whether or not the sample results are biased.

**Laboratory blanks**

Blanks are prepared and analyzed in the laboratory to document the response of the measurement system to a sample containing effectively none of the analyte of interest. They should not be confused with field blanks that are analyzed to determine if there is contamination during sampling. Depending on the analytical method, the analyst will analyze one or more blanks with each batch of samples and compare the results to established acceptance limits.

A positive blank response can be due to a variety of factors related to the procedure, equipment, or reagents. Unusually high blank responses indicate laboratory contamination. The blank response becomes very important when the analyte concentration is near the detection limit. Blank responses are sometimes used to correct the sample responses and to determine the limit of detection.

## Field QC

The project manager is responsible for selecting QC procedures to be used in the field. Field QC samples may be sent to the laboratory as blinds (i.e., identified the same way as normal samples) to ensure that they are not treated differently during analysis.

**Replicates**

Replicates are two (duplicates) or more samples collected, or measurements made, at the same time and place. Replicate results provide a way to estimate the total random variability (precision) of individual results. If conditions in the medium being measured or sampled are changing faster than the procedure can be repeated, then the precision calculated from replicate results will include that variability as well. Appendix G describes the calculation of precision from replicate results.

Replicate results that are "non-detects" cannot be used to estimate precision. Since there is no advantage to randomly selecting samples for replication, use all available information and professional judgment to select samples or measurements likely to yield positive results.

Samples are sometimes split in the field and sent to separate laboratories for analysis. This has been common practice in compliance situations. However, you should be aware of the limitations of this practice, since there is no way to determine which result is correct when they do not agree. No laboratory, however good their reputation, can be considered correct by definition. If the project manager doubts the lab's ability to meet the MQOs, those concerns should be resolved through analyses of representative samples and reference materials or proficiency testing samples before any commitment is made for analysis of study samples.

**Field blanks**

Field blanks are samples of "clean" material which are exposed to conditions in the field. They should be analyzed like any other sample. The results for field blanks may indicate the presence of contamination due to sample collection and handling procedures (in the field or during transport to the laboratory) or to conditions in the field, such as boat or vehicle exhaust. Plan to clearly identify field blanks so that they are not selected for analytical duplicates or matrix spikes.

Field blanks are used when there is reason to expect problems with contamination or to meet programmatic or contractual requirements to demonstrate absence of contamination**.** The use of good operational procedures in the field and thorough training of field staff reduces the risk of contamination.

Several types of field blanks are described below. The pure water or other "clean" material used to prepare them must be obtained from the laboratory or other reliable supplier.

- A *transport blank* is a container of pure water, which is prepared at the lab and carried unopened to the field and back with the other sample containers to check for possible contamination in the containers or for cross-contamination during transportation and storage of the samples.

- A *transfer blank* is prepared by filling a sample container with pure water during routine sample collection to check for possible contamination from the surroundings. The transfer blank will also detect contamination from the containers or from cross-contamination during transportation and storage of the samples.

- A *rinsate (equipment) blank* is prepared by exposing clean material to the sampling equipment after the equipment has been used in the field and cleaned. The results provide a check on the effectiveness of the cleaning procedures. The rinsate blank may also detect contamination from the surroundings, from containers, or from cross-contamination during transportation and storage of the samples and is therefore the most comprehensive type of field blank.

- A *filter blank* is a special case of a rinsate blank prepared by filtering pure water through the filtration apparatus after routine cleaning. The filter blank may detect contamination from the filter or other part of the filtration apparatus.

Ideally, the results for your field blanks will be "not detected." If the results are positives, you will need to take them into account when reporting sample results and determining whether your MQOs have been met.

**Check standards**

Check standards and spiked samples usually are not prepared in the field due to the hazards of working with concentrated solutions of contaminants under field conditions.

In some projects, it may be useful to acquire check standards to be sent to the laboratory for analysis along with the environmental samples. These can be PT samples or certified reference materials, and the laboratory results are compared with the acceptance limits of the provider.

**Describe the field QC procedures to be used for the study.**

Specify the number of each type of QC sample to be included in the study. For field blanks, specify also the source of "clean" material (e.g., pure water) that will be used.

## Corrective Actions

QC results may indicate problems with data during the course of the project. The lab will follow prescribed procedures to resolve the problems. Options for corrective action might include:

- Retrieving missing information
- Re-calibrating the measurement system
- Re-analyzing samples (must be done within holding time requirements)
- Modifying the analytical procedures
- Collecting additional samples or taking additional field measurements
- Qualifying results

**Describe in your project plan any additional procedures to be followed to correct or compensate for QC problems if they occur.**

# 11. Data Management Procedures

Data management addresses the path of data from recording in the field or laboratory to final use and archiving. Experience has shown that roughly half of the errors in results reported for proficiency testing (PT) samples have been due to mistakes in recording results, calculations, or transcription.

**Describe the procedures for recording and reporting data acquired in the field.**

Include procedures for detecting and correcting errors and for compiling and analyzing the data, including software requirements.

**Describe requirements for the data package from the laboratory.**

Documentation should always include a case narrative discussing any problems with the analyses, corrective actions taken, changes to the referenced method, and an explanation of data qualifiers.

The lab data package should also include all QC results associated with your data. This information is needed to evaluate the accuracy of the data and to determine whether the MQOs were met. This should include results for all blanks, surrogate compounds, and check standards included in the sample batch, as well as results for analytical duplicates and matrix spikes prepared from your samples.

**List requirements for electronic transfer of data from the field or lab to your database.**

Provide or reference information necessary to enter the data in your information management system. The Environmental Information Management (EIM) system is the major environmental data repository for Ecology. Information on the EIM system is available on Ecology's internet web site listed in Appendix J.

**Describe procedures for obtaining data from existing databases and literature files.**

List acceptance criteria for these data in terms of precision, bias, sensitivity, representativeness, comparability, and completeness. Discuss any qualifiers associated with the data.

# 12. Audits and Reports

A process is needed to ensure that the QA Project Plan is implemented correctly, that the quality of the data is acceptable, and that corrective actions are implemented in a timely manner.

## Audits

Two types of useful audits are:

- *Technical Systems Audit* – a qualitative audit of conformance to the QA Project Plan. The audit is conducted soon after work has commenced, so that corrective actions can be implemented early in the project.
- *Proficiency Testing* – the quantitative determination of an analyte in a blind standard to evaluate the proficiency of the analyst or laboratory.

**Describe any audits that will be conducted during the project.**

Discuss the purpose and scope of each audit and identify the auditors. Provide the schedule and describe how the results will be reported.

## Reports

Project plans for large or repetitive projects should describe a mechanism for periodic reports to management on the performance of measurement systems and on data quality. These reports may include:

- Assessment of data accuracy and completeness
- Results of proficiency testing and/or technical systems audits
- Significant QA problems and corrective actions taken
- Any other information requested by management

**List the reports required for the project and identify staff responsible for preparing them.**

The final report for each project should include a QA section that describes data quality. The final report should undergo peer review, a scientific review of the report by staff with appropriate expertise who are not directly connected with the project. Peer reviews ensure that project activities were technically sound and properly documented. Guidelines for technical document review are provided on the Ecology intranet site listed in Appendix J.

# 13. Data Verification and Validation

Assessment is the process by which data are examined and evaluated to varying levels of detail and specificity. It includes verification, validation, and data quality assessment. This element covers the steps of data verification and validation. The data quality assessment step, covered in Element 14, is done on data that have been verified and validated (i.e., data of known and documented quality).

Data verification involves examining the data for errors or omissions as well as examining the results for compliance with QC acceptance criteria. Laboratory results are reviewed and verified by qualified and experienced lab staff. Their findings are documented in the case narrative. Field results should also be verified, preferably before leaving the site where the measurements were made.

Once the measurement results have been recorded, they are verified to ensure that:

- Data are consistent, correct, and complete, with no errors or omissions
- Results for QC samples described in Element 10, *Quality Control*, accompany the sample results
- Established criteria for QC results were met
- Data qualifiers are properly assigned where necessary
- Data specified in Element 7, *Sampling Process Design*, were obtained
- Methods and protocols specified in the QA Project Plan were followed

**Describe the procedures for verifying results for measurements done in the laboratory and in the field, and assign responsibility for verification.**

Data validation is an analyte-specific and sample-specific process that extends the evaluation of data beyond data verification to determine the analytical quality of a specific data set. It involves a detailed examination of the data package using professional judgment to determine whether the MQOs for precision, bias, and sensitivity have been met. Validation is the responsibility of the project manager, who may wish to arrange for a qualified specialist to conduct the validation and document it in a technical report. Sometimes validation can be streamlined by validating only a specific percentage of all data sets unless a problem is identified; this may include a caveat that all critical samples identified will undergo full data validation.

The results of QC sample analyses can often be compared directly to the MQOs to determine whether they have been met. For projects that follow the WRC approach described in Appendix F, an experimental design for preliminary estimation of precision and bias, and the use of control charts, provide an excellent way to determine if MQOs have been met.

**Describe the procedures to be used for data validation.**

# 14. Data Quality (Usability) Assessment

After the data have been verified and validated, Data Quality Assessment (DQA) or Usability Assessment is done. If the MQOs have been met, the quality of the data should be useable for meeting project objectives. If the MQOs have not been met for data (i.e., data have been qualified), you need to determine if they are still useable. You also need to determine if the quantity of data is sufficient to meet project objectives. This includes an assessment of whether the requirements for representativeness and comparability have been met. If you set an MQO for completeness, compare the number of valid measurements completed with those established by the MQO. And you need to evaluate whether the implementation of the sampling design gave the information expected for meeting project objectives.

DQA is built on a fundamental premise: data quality is meaningful only when it relates to the *intended* use of the data. DQA determines whether the study questions can be answered and the necessary decisions made with the desired confidence.

While it may not be possible during the planning phase to anticipate everything you will need to do when analyzing the data, it pays to include in your project plan as much detail as possible about how you will assess the usability of the data and what graphical and statistical tools you will use to determine if the project objectives have been met.

**State how you will assess the data to determine if they are of the right type, quality, and quantity to support the project objectives.**

**Summarize the methods you will use in the analysis and presentation of the data.**

**Describe any statistical calculations and graphical representations you plan on doing.**

This may involve statistical tests and verification of the assumptions of the statistical tests (e.g., tests of hypotheses, tests for outliers, tests for trends), as well as scientific evaluation of the information.

**Describe how the data will be presented (e.g., tables or charts) to illustrate trends, relationships and anomalies, and how you will handle data below the lower reporting limit or detection limit.**

**State how you will evaluate the data to determine if the sampling design has been adequate and if it needs any modification for future use.**

It is important to evaluate whether the sampling design can be used over a wide range of possible outcomes.

**Finally, indicate who will be responsible for analyzing the data and how the results of the data analysis will be documented.**

If you have used either the DQO Process or PAC Process for systematic planning, you can use the DQA Process to determine whether the objectives of the project have been met. While the DQA Process was developed to evaluate data from the DQO Process, it can be adapted to the PAC Process or other systematic planning process.

The DQA Process involves the following steps:

1. Review the project objectives and sampling design
2. Conduct a preliminary data review
3. Select the statistical method
4. Verify the assumptions of the statistical method
5. Draw conclusions from the data

EPA document QA/G-9, *Guidance for Data Quality Assessment*, provides background information and statistical tools for performing each of the steps in the DQA Process. EPA has plans to split this document into a statistical guidance document and a guide for managers.

In the DQO Process, quality objectives are specified at both the level of the decision and the level of the measurements needed to support the decision or study question, while in the PAC Process, quality objectives are only specified at the level of the measurements. Thus, data analysis is generally more involved for the DQO Process.

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# EPA Quality System Documents

www.epa.gov/quality/qa_docs.html

| | |
|---|---|
| EPA QA/G-1 | *Guidance for Developing Quality Systems for Environmental Programs* |
| EPA QA/R-2 | *EPA Requirements for Quality Management Plans* |
| EPA QA/G-3 | *Guidance on Assessing Quality Systems* |
| EPA QA/G-4 | *Guidance for the Data Quality Objectives Process* |
| EPA QA/G-4D | *Decision Error Feasibility Trials (DEFT) Software* |
| EPA QA/G-4HW | *Data Quality Objectives Process for Hazardous Waste Site Investigations* |
| EPA QA/R-5 | *EPA Requirements for Quality Assurance Project Plans* |
| EPA QA/G-5 | *Guidance for Quality Assurance Project Plans* |
| EPA QA/G-5G | *Guidance for Geospatial Data Quality Assurance Project Plans* |
| EPA QA/G-5M | *Guidance for Quality Assurance Project Plans for Modeling* |
| EPA QA/G-5S | *Guidance on Choosing a Sampling Design for Environmental Data Collection* |
| EPA QA/G-6 | *Guidance for Preparation of Standard Operating Procedures* |
| EPA QA/G-7 | *Guidance on Technical Audits and Related Assessments for Environmental Data Operations* |
| EPA QA/G-8 | *Guidance on Environmental Data Verification and Data Validation* |
| EPA QA/G-9 | *Guidance for Data Quality Assessment: Practical Methods for Data Analysis* |
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FR, 40CFR58, Subpart G, Appendix B - Quality Assurance Requirements for Prevention of Significant Deterioration (PSD) Air Monitoring. Federal Register.

FR, 40CFR60. Appendix E - Quality Assurance Requirements for Continuous Emission Monitoring Systems (CEMS), to be submitted as a proposed regulation to amend 40 CFR 60. Federal Register.

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Barcelona, M.J., J.P. Gibb, and R.A. Miller, 1983. A Guide to the Selection of Materials for Monitoring Well Construction and Ground Water Sampling, Illinois State Water Survey, Champaign, IL. www.sws.uiuc.edu

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Appendix K -- added December 2016

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# Quality Assurance Project Plan

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For Water Quality Impairment Studies, insert: **Federal Clean Water Act 1996 303(d) Listings Addressed in this Study.** See Section 3.3.

---

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# Quality Assurance Project Plan

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**Instructions for Figures and Tables**

- Place figures and tables in the text right after they're first mentioned in the text.
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# 2.0 Abstract

In less than 300 words, identify the purpose of the project and describe why it matters (why the audience should care). Also list the main objectives and how the objectives will be approached and accomplished.
xxxx

# 3.0 Background

## 3.1 Introduction and problem statement

Provide historical and scientific perspective on the project and explain why the project is needed.
xxxx

## 3.2 Study area and surroundings

Provide a general description of the study area. Include relevant features such as climate, geology, topography, hydrologic regime, unique features of the landscape, ecosystem vegetation and biota, key ecological functions, and human uses. Figure 1 should reflect these descriptions.
xxxx

Insert figure here and modify figure caption below as needed.

Figure 1. Map of larger study area.

xxxx

### 3.2.1 History of study area

Describe past and present land use as well as local issues important to this project.
xxxx

### 3.2.2 Summary of previous studies and existing data

Summarize when and how the focus of the study was first identified as an issue. List previous investigations and summarize the findings for each.
xxxx

### 3.2.3 Parameters of interest and potential sources

List environmental pollutants or contaminants of interest. Identify concerns related to each (e.g., potential toxicity, bioaccumulation of PCBs, endangered species / human health effects) along with known and possible sources. If the project doesn't involve pollutants or contaminants, summarize the other environmental parameters of interest (e.g., streambank width, flow, shade).
xxxx

### 3.2.4 Regulatory criteria or standards

If study objectives include assessing regulatory compliance status, identify all applicable governing regulations, list the relevant standards or criteria, and define how compliance will be determined. Assessing compliance status may indicate a need to set decision quality criteria for the data to be obtained (see section 6.1).

xxxx

## 3.3 Water quality impairment studies

**If this QAPP does not describe some type of WQ impairment study, delete this section.**

If this is a WQ impairment study, import relevant boilerplate language from an active web link. Refer readers to Figure 2 or insert another figure to help readers visualize the study area.

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Figure 2. Study area for the water body parameter Water Quality Impairment Study.

xxxx

## 3.4 Effectiveness monitoring studies

**If this is not an Effectiveness Monitoring (EM) study, delete this section.**

If this is an EM study, insert Effectiveness Monitoring Standard Language.
Refer readers to Figure 3 or insert another figure to help readers visualize the study area.

Insert figure here and modify caption below as needed.

Figure 3. Study area for the Effectiveness Monitoring study.

xxxx

# 4.0 Project Description

Tell the "story" of the project. Define the problem and summarize the anticipated study outcomes. Address the following five plan elements.
xxxx

## 4.1 Project goals

State the major reasons for conducting the project. Examples include:

- To identify where fecal coliform or nutrient pollution is greatest in a given watershed
- To characterize the level of toxic contaminants in a water body
- To determine if annual discharge from Smith Creek has increased due to changing land use
- To bring a water body into compliance with water quality standards by using a model and historic data to predict the magnitude of pollution sources and the effects of source reduction

xxxx

## 4.2 Project objectives

Describe specific activities you want to accomplish. Examples include:

- To collect ## water and ## sediment samples from a specific area of Puget Sound
- To analyze PCBs in ## tissue samples of freshwater fish collected from Smith Creek
- To analyze historic precipitation and stream-gage data to establish a flow-rating curve
- To simulate effects of new construction (e.g., roadway, stormwater retention pond) on stream flows and water quality

xxxx

## 4.3 Information needed and sources

Summarize the types and sources of existing data to be assembled, and all new data to be collected, that will address project objectives. Projects that involve analysis of existing environmental information, including many GIS layers, should summarize the data needed. For environmental modeling projects, data need can be described in overview here, with details provided in Section 7.3.
xxxx

## 4.4 Tasks required

List tasks, the specific activities planned to address each objective or obtain the needed information. For example, if one objective is to measure summer dissolved oxygen in Smith Creek, then a corresponding task might be to deploy continuous DO monitoring instrumentation at one site in Reach X and collect weekly grab samples from multiple depths at the same location.
xxxx

## 4.5 Systematic planning process used

Preparing the QAPP is adequate systematic planning for most projects. However, for very complex or specialized projects, consider including description of a formalized systematic planning process.

xxxx

# 5.0 Organization and Schedule

## 5.1 Key individuals and their responsibilities

Describe who will be involved in the project, what their responsibilities will be, their relevant expertise and training, and a timeline for completing milestones for the overall project. This information is usually presented in table format (see below).

Table 1. Organization of project staff and responsibilities.
(If this QAPP won't be an Ecology publication, modify table as needed.)

| Staff<br>(All EAP except client) | Title | Responsibilities |
|---|---|---|
| Name<br>Program<br>xx Regional Office<br>Phone: xxx-xxx-xxxx | EAP Client | Clarifies scope of the project. Provides internal review of the QAPP and approves the final QAPP. |
| Name<br>xx Unit<br>xx Section<br>Phone: xxx-xxx-xxxx | Project Manager | Writes the QAPP. Oversees field sampling and transportation of samples to the laboratory. Conducts QA review of data, analyzes and interprets data, and enters data into EIM. Writes the draft report and final report. |
| Name<br>xx Unit<br>xx Section<br>Phone: xxx-xxx-xxxx | Principal Investigator | (If the Project Manager is also the Principal Investigator, add "Principal Investigator" in column 2 above – then delete this row from the table. If the Principal Investigator is not the Project Manager, list PI responsibilities here.) |
| Name<br>xx Unit<br>xx Section<br>Phone: xxx-xxx-xxxx | Field Assistant | Helps collect samples and records field information. |
| Name<br>xx Unit<br>xx Section<br>Phone: xxx-xxx-xxxx | Unit Supervisor for the Project Manager | Provides internal review of the QAPP, approves the budget, and approves the final QAPP. |
| Name<br>xx Section<br>Phone: xxx-xxx-xxxx | Section Manager for the Project Manager | Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP. |
| Name<br>xx Section<br>Phone: xxx-xxx-xxxx | Section Manager for the Study Area | (This may or may not be the author's section manager)<br>Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP. |
| Joel Bird<br>Manchester Environmental Laboratory<br>Phone: 360-871-8801 | Director | Reviews and approves the final QAPP. |
| Contract Laboratory | Project Manager | Reviews draft QAPP, coordinates with MEL QA Coordinator |
| William R. Kammin<br>Phone: 360-407-6964 | Ecology Quality Assurance Officer | Reviews and approves the draft QAPP and the final QAPP. |

EAP: Environmental Assessment Program
EIM: Environmental Information Management database
QAPP: Quality Assurance Project Plan

## 5.2 Special training and certifications

Describe relevant experience, training, and certifications of key project personnel. Examples include: certifications for using field measurement devices and field sampling SOPs, experience collecting specific types of field samples, training related to conducting complex GIS analysis, and experience evaluating and using environmental models.

xxxx

## 5.3 Organization chart

Include this if the study involves multiple organizations or many individuals with differing roles. Otherwise, enter "Not Applicable - See Table 1".

xxxx

## 5.4 Proposed project schedule

List key activities (e.g., Tasks) and estimated time when those activities will occur. Include start and end dates for field and lab work, data analysis, modeling milestones and publication dates.

xxxx

Table 2. Proposed schedule for completing field and laboratory work, data entry into EIM, and reports.
(If this QAPP won't be an Ecology publication, modify table as needed.)

| **Field and laboratory work** | **Due date** | **Lead staff** |
|---|---|---|
| Field work completed | month year | name |
| Laboratory analyses completed | month year | |
| **Environmental Information System (EIM) database** | | |
| EIM Study ID (see Publication Information for how to set up your EIM ID.) | ID number | |
| Product | Due date | Lead staff |
| EIM data loaded [1] | month year | name |
| EIM data entry review [2] | month year | name |
| EIM complete [3] | month year | name |
| **Final report** | | |
| Author lead / Support staff | lead name / support staff names | |
| Schedule | | |
| Draft due to supervisor | month year | |
| Draft due to client/peer reviewer | month year | |
| Draft due to external reviewer(s) | month year | |
| Final (all reviews done) due to publications coordinator (Joan) | month year | |
| Final report due on web | month year | |

[1] All data entered into EIM by the lead person for this task.
[2] Data verified to be entered correctly by a different person; any data entry issues identified. Allow one month.
[3] All data entry issues identified in the previous step are fixed (usually by the original entry person); EIM Data Entry Review Form signed off and submitted to Melissa McCall (who then enters the "EIM Completed" date into Activity Tracker). Allow one month for this step. Normally the final EIM completion date is no later than the final report publication date.

## 5.5 Budget and funding

Describe the funding sources for the project. For simpler projects, a short paragraph describing funding sources and budget may be all that is needed. For larger-scale and more complex projects, include a table showing budgets for more specific cost categories (e.g., salary and benefits) or project tasks (e.g., sampling, lab analyses) or contracted services (e.g., aerial surveys, data validation, and other specialized services). Table 3 is an example.
xxxx

Table 3. Project budget and funding.
(Modify this example table as needed.)

| **xxxx** | | | | | **xxxx** |
|---|---|---|---|---|---|
| Salary, benefits, and indirect/overhead | | | | | |
| Equipment | | | | | |
| Travel and other | | | | | |
| Contracts | | | | | |
| Laboratory | | | | | |
| **Parameter** | **Number of Samples** | **Number of QA Samples** | **Total Number of Samples** | **Cost Per Sample** | **Lab Subtotal** |
| Screening Samples | | | | | |
| PCB Congeners | | | | | |
| Dieldrin | | | | | |
| TOC | | | | | |
| TSS | | | | | |
| Source Identification Samples | | | | | |
| PCB Aroclors | | | | | |
| Dieldrin | | | | | |
| TOC | | | | | |
| Grain Size | | | | | |
| | | | | Screening Survey Subtotal | |
| | | | | Source ID Subtotal | |
| | | | | Lab Grand Total | |

xxxx

# 6.0 Quality Objectives

## 6.1 Data quality objectives [1]

EPA describes a seven-step Data Quality Objectives (DQO) process [EPA, 2006 (EPA QA/G-4, Publication EPA/240/B-06/001)]. Most of the steps are addressed by other sections of this QAPP template (e.g., defining the problem, identifying the type of data needed, describing the analytical approach, and designing data collection efforts). But the sixth step "establishes acceptable quantitative criteria on the quality and quantity of the data to be collected, relative to the ultimate use of the data. These criteria are known as performance or acceptance criteria, or DQOs."

Here is an example of the brief narrative that might appear in this section:

> The main DQO for this project is to collect a minimum of 50 water samples representative of Smith Creek and have them analyzed, using standard methods, to obtain total copper concentration data that meet Measurement Quality Objectives that are described below and that are comparable to previous study results.

xxxx

## 6.2 Measurement quality objectives

Identify measurement quality objectives (MQOs) for the data to be collected. MQOs usually take the form of data quality indicators: precision, bias, sensitivity, representativeness, comparability and completeness. Analytical method descriptions, standard operating procedures (SOPs), and participating laboratories can help fine-tune the target MQOs for these indicators. Projects not involving laboratory analyses, e.g., habitat assessments, will often still benefit from setting MQOs to help ensure that results can be used for their intended purpose. See Ecology QAPP Guidance for more detailed information.

xxxx

### 6.2.1 Targets for precision, bias, and sensitivity

For example:

> The MQOs for project results, expressed in terms of acceptable precision, bias, and sensitivity, are described in this section and summarized in Table 4 below.

xxxx

[1] DQO can also refer to ***Decision*** Quality Objectives. The need to identify Decision Quality Objectives during the planning phase of a project is less common. For projects that do lead to important decisions, DQOs are often expressed as tolerable limits on the probability or chance (risk) of the collected data leading to an erroneous decision. And for projects that intend to estimate present or future conditions, DQOs are often expressed in terms of acceptable uncertainty (e.g., width of an uncertainty band or interval) associated with a point estimate at a desired level of statistical confidence.

Table 4. Measurement quality objectives (e.g., for laboratory analyses of water samples). (Modify this example table as needed.)

| MQO → | Precision | | Bias | | | Sensitivity |
|---|---|---|---|---|---|---|
| Parameter | Duplicate Samples | Matrix Spike-Duplicates | Verification Standards (LCS,CRM,CCV) | Matrix Spikes | Surrogate Standards* | MDL or Lowest Conc. of Interest |
| | Relative Percent Difference (% RPD) | | Recovery Limits (%) | | | Concentration Units |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

*Surrogate recoveries are compound specific.

#### 6.2.1.1 Precision

Precision is a measure of variability between results of replicate measurements that is due to random error. It is usually assessed using duplicate field measurements or laboratory analysis of duplicate samples. In this section, describe how field measurements will be made in duplicate or how duplicate samples will be collected/created for chemical analysis (field duplicates, field splits of a single field sample, laboratory splits, matrix spike duplicates, and/or extract duplicates). List targets for acceptable precision between duplicate results, in terms of relative percent difference (RPD), in Table 4. Express acceptable precision among three or more replicate sample results as relative standard deviation (RSD).
xxxx

#### 6.2.1.2 Bias

Bias is the difference between the population mean and the true value. Bias is usually addressed by calibrating field and laboratory instruments, and by analyzing lab control samples, matrix spikes, and/or standard reference materials. List targets for bias in terms of acceptable % recovery of a known quantity, listed in Table 4.
xxxx

#### 6.2.1.3 Sensitivity

Sensitivity is a measure of the capability of a method to detect a substance. It is commonly described as a detection limit. In a regulatory setting, the method detection limit (MDL) [2] is often used to describe sensitivity. List targets for acceptable sensitivity of all field and lab measurements in Table 4. Studies not involving environmental pollutants or contaminants may still benefit from setting MQOs for sensitivity. Examples include minimum stream depth /

[2] The lowest quantity of a physical or chemical parameter that is detectable (above background noise) by each field instrument or laboratory method.

minimum measurable flow, minimum area of specific habitat definable using new aerial photographic survey images.
xxxx

### 6.2.2 Targets for comparability, representativeness, and completeness

#### 6.2.2.1 Comparability

List the standardized operating procedures (SOPs) that will be followed for sampling, analysis, and data reduction and to ensure comparability between projects. Also, list standardized sampling techniques and methods to be used to ensure comparability. Project results may need to be comparable to those generated by other projects that took place in the same study area. The QAPP might need to provide detailed procedures for analyzing existing environmental data or for modeling environmental conditions that are comparable to other existing studies.
xxxx

#### 6.2.2.2 Representativeness

Describe how environmental samples to be collected are representative of existing conditions. If they are not, the resulting data gathered will either be rejected or of limited use. Show how the sampling strategy and number of collected samples also contribute to representativeness. Show representativeness through consideration of factors such as seasonality, time of day, flow conditions, sampling location(s), and weather. Representativeness also influences the data used in environmental models.
xxxx

#### 6.2.2.3 Completeness

Propose a percentage of observations, measurements, and samples (taken and analyzed acceptably) for your study to be a success. 95% is often used as a measure for this plan element.
xxxx

## 6.3 Acceptance criteria for quality of existing data

If known, describe the quality of existing data available for the study area. If not known, describe the criteria that will be used to assess quality and usability of the existing data, whether the project will also collect new environmental data, analyze the data (only), or use the data for modeling. It may be possible to cite a programmatic QAPP or other document that already contains this information.

Identify data gaps and describe how the study may fill those gaps and improve the quality of available information.
xxxx

## 6.4 Model quality objectives

If the project does not involve environmental modeling, then Enter “NA”. Otherwise, describe the quality of modeling results desired to meet the objectives of the project. Quality objectives for modeling results may be a combination of quantitative and qualitative.

Define the quantitative objectives needed for the project. Examples include target values for bias, error, goodness-of-fit, and other measures of uncertainty, that are comparable to ones achieved by similar modeling studies. For some projects, it may be critical to meet firm quantitative objectives. For other projects, quantitative objectives may be used as initial benchmarks in a broader evaluation of model quality. Ecology has summarized quantitative model quality results from various water quality modeling projects (Ecology, 2014). The process of evaluating whether these quality objectives are met, and the consequences of not meeting them, should be described in Section 13.1.

Managers of modeling projects may also set qualitative or narrative quality objectives. Examples include:

- Peak flows should match the timing and magnitude of those observed from 2010 to 2015.
- Model outputs are not overly sensitive to uncertainty associated with input parameters or values.

Past modeling project plans also offer examples of narrative quality objectives.
xxxx

# 7.0 Study Design

## 7.1 Study boundaries

Define the specific area of focus when the project involves measuring parameters in the field, collecting samples for analysis by a laboratory, or other field activities should. This might be something as simple as "WRIA 1" or a very complex area designated using a GPS coordinate system and GIS [3]. Consider showing the study area in a figure that is more specific than what is presented in Figure 1a.

Insert figure here and modify caption below as needed.

Figure 4. Map showing boundary of project study area.
or
Refer to Figures 1 - 3, as appropriate.

For projects involving analysis of historic data, GIS analysis, or modeling environmental conditions, descriptions of study design will be different. For these types of projects, describe study design including topics such as: how existing data will be chosen for analysis and the proposed statistical approach; how GIS data layers will be analyzed; the process for choosing the final model(s) from existing alternatives and examples of the model simulations that will be conducted.
xxxx

## 7.2 Field data collection

Show the proposed and perhaps alternate measurement and sampling locations.
xxxx

### 7.2.1 Sampling locations and frequency

Describe all sampling strategies chosen for the project and explain why they will be appropriate. Examples of sampling strategies include random, stratified random, subjective, before-after-control-impact (BACI), nested paired. List all target sampling locations and potential alternate locations as accurately as possible. If locations cannot be identified in advance of sampling, then describe the factors that will be used to choose locations when in the field. Also describe as accurately as possible how often and when samples will be collected, or how the timing of sample collection will be determined (e.g., within 4 hours of storm > 0.1" of precipitation).
xxxx

### 7.2.2 Field parameters and laboratory analytes to be measured

List all environmental parameters to be observed/counted, measured, or analyzed.

[3] Water Resource Inventory Areas (WRIAs) for the study area can be found at:
WRIAs: www.ecy.wa.gov/services/gis/maps/state/ecyreg-a.pdf

xxxx

## 7.3 Modeling and analysis design

Enter "NA" if the project does not involve these activities.
xxxx

### 7.3.1 Analytical framework

Describe the conceptual framework of the model and the type of model needed. Examples include empirical vs. mechanistic, static vs. dynamic, simulation vs. optimization, deterministic vs. stochastic, and lumped vs. distributed. Project managers analyzing existing environmental data should describe the analytical tools they will use, such as GIS, statistics, and computational models, and how these tools support the project objectives.

If developing a new model, describe key elements of its design. If the project will use a specific model or modeling software package that has already been chosen, briefly justify the choice. If an existing model will be used but has yet to be chosen, describe the criteria that will be used to choose from among the established alternatives.

Describe in detail the hardware and software needed for the planned modeling.
xxxx

### 7.3.2 Model setup and data needs

Describe the temporal and geographic scale of the study. Include an initial estimate of the spatial and temporal resolution (geographic features that affect model reach/grid size and design of the data collection network; temporal features or needs affecting model output time-step) that supports project objectives at an appropriate level of certainty.

Describe the level of model process complexity appropriate to meet project objectives. Identify, to the extent possible, the various simulations that will be run or the specific scenarios that will be tested using the model. Specify state variables required by the model framework that are significant and will require data. List the data and parameters needed as model inputs and the data needed for model quality assessment or refer to a previous section (Section 4.3 or 6.3).
xxxx

## 7.4 Assumptions in relation to objectives and study area

Discuss any assumptions that affect your study design. This is important for projects generating new environmental data, for projects analyzing existing data, and for environmental modeling.
xxxx

## 7.5 Possible challenges and contingencies

Ensure that the study design supports the objectives of the project. Assess the proposed design in light of any challenges the study location may present in terms of access, physical hazards, chemical hazards, and other environmental factors.

xxxx

### 7.5.1 Logistical problems

Describe potential problems associated with logistics. Examples might include: access to private property (uncertain access to safe sampling sites); timing field work for optimal tidal conditions; precipitation and high-flow/low-flow sampling issues (adequate flow and water depth, threshold defining storm event), and other seasonal considerations. Also describe contingencies or measures to be taken that may prevent or reduce the likelihood of such problems.

xxxx

### 7.5.2 Practical constraints

Describe issues such as availability of resources (human and budgetary), difficulties obtaining historic data for novel analyses, and access to hardware or software required to run preferred models. Also, summarize how investigators will prevent or minimize the impact of such problems.

xxxx

### 7.5.3 Schedule limitations

Describe how problems and constraints listed in the previous sections may impact the proposed study schedule. Include discussion of other things that may impact schedule, including the time required for QAPP review and approval and the preparedness of external parties involved in the project.

xxxx

# 8.0 Field Procedures

## 8.1 Invasive species evaluation

Assess the possibility of invasive species contamination of both protective gear and sampling equipment, including boats, rafts, and other water-borne devices. Ecology's SOP EAP070 addresses invasive species transport and contamination. This document is at Ecology QA Website.
xxxx

## 8.2 Measurement and sampling procedures

Standard Operating Procedures (SOPs) are required for field sampling and field analyses. Ecology's QA Website contains over 80 SOPs that address specific sampling and field analytical techniques. Identify and reference SOPs that accurately reflect field, laboratory, and other procedural details of the project. Include relevant SOPs for projects that involve complex data analyses or modeling (to ensure repeatability of project outcomes). Develop a new SOP, if no existing one fits your particular situation.
xxxx

## 8.3 Containers, preservation methods, holding times

Refer to the example Table 5 and describe appropriate containers, preservation techniques, and holding times as per 40CFR 136.
xxxx

Table 5. Sample containers, preservation, and holding times.
(Modify this example table as needed)

| Parameter | Matrix | Minimum Quantity Required | Container | Preservative | Holding Time |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

## 8.4 Equipment decontamination

Explain your procedure for decontamination that may be necessary when sampling substances that contain high levels of contaminants, bacterial contamination, or organic materials that stick to the sampling devices. Refer to Ecology's SOP EAP090, *Decontamination of Sampling Equipment for Use in Collecting Toxic Chemical Samples*.
xxxx

## 8.5 Sample ID

Provide a specific protocol for establishing sample IDs. If such a protocol is lacking, adopt one (e.g., from an analytical laboratory) or develop and describe a new one.
xxxx

## 8.6 Chain-of-custody

Maintaining environmental samples under chain-of-custody is standard practice. If standard procedures and forms are not available, adopt them, for example, from an analytical laboratory or develop and describe new ones here. More details on chain-of-custody are available in the Ecology QAPP Guidance.
xxxx

## 8.7 Field log requirements

A field log is an important component of many projects. It is used to record irreplaceable information, such as:

- Name and location of project
- Field personnel
- Sequence of events
- **Any changes or deviations from the QAPP**
- Environmental conditions
- Date, time, location, ID, and description of each sample
- Field instrument calibration procedures
- Field measurement results
- Identity of QC samples collected
- Unusual circumstances that might affect interpretation of results

Use field logs that are bound, waterproof notebooks with pre-numbered pages. Use permanent, waterproof ink for all entries. Make corrections with single line strikethroughs; initial and date corrections. Do not use correction fluid such as Wite-Out. Electronic field logs may be used if they demonstrate equivalent security to a waterproof, bound notebook.
xxxx

## 8.8 Other activities

These may include:

- Briefings and trainings for field staff
- Periodic maintenance for field instrumentation
- Procedures and equipment for homogenizing non-aqueous matrices
- Procedure for lab notification regarding sampling and other topics

xxxx

# 9.0 Laboratory Procedures

## 9.1 Lab procedures table

Include Table 6 which contains the following information for each analysis to be performed:

- Analyte or parameter name. The element, compound, physical property, chemical property, or organism that is being analyzed or determined. Examples include temperature, pH, sodium, PCBs, or *E. coli*.
- Matrix. The type of substance being analyzed. Typical matrices include water, air, soil and sediment, hazardous waste, and tissues of biota.
- Number of samples. Use a table to list the number of samples, by matrix, that will be analyzed for each parameter.
- Expected range of results. List ranges derived based on results of previous studies, if available and relevant.
- Analytical method. List the analytical method that will be used for each analyte. Generally speaking, these must be EPA-approved methods.
- Sensitivity/Method Detection Limit (MDL). Identify the method that will be used to detect low levels of each analyte. Obtain MDL values from published methods or from the laboratory performing the analysis.

Information required for this table may be provided by the lab that will perform the analyses, and it is available in these publications:

- 40 CFR 136.3, Table II
- SW-846 Methods, Section 6.0
- EPA/600/R-93/100, *Methods for the Determination of Inorganic Substances in Environmental Samples*, August, 1993

Table 6. Measurement methods (laboratory).
(Modify this example table as needed)

| Analyte | Sample Matrix | Samples (Number/ Arrival Date) | Expected Range of Results | Detection or Reporting Limit | Sample Prep Method | Analytical (Instrumental) Method |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

A similar table should be constructed for field testing that will occur in support of this project.
xxxx

## 9.2 Sample preparation method(s)

It is rare to analyze samples without some form of preparation and extraction. List each preparation and extraction technique. It is especially important to provide details of any unusual or nonstandard technique.

xxxx

## 9.3 Special method requirements

Some analytical laboratories have special requirements. Record these in the QAPP to communicate them effectively to the laboratory. Typical causes for special method modifications include: analysis of very low or very high concentrations of analytes, analysis of analytes with high levels of interference, and use of non-standard methods.

xxxx

## 9.4 Laboratories accredited for methods

You must use an accredited laboratory to analyze your samples. That laboratory must also be accredited for the specific method that you are using for analysis. Ecology only accredits methods published by EPA, Standard Methods, or ASTM. This is an Ecology legal requirement, and exceptions for it are difficult to obtain. If your technical work involves the use of non-standard methods or analytes, a waiver process is available. Contact the Ecology Lab Accreditation Unit for more information.

xxxx

# 10.0 Quality Control Procedures

Describe the quality control procedures that will help identify problems or issues associated with data collection, data analysis, or modeling while the project is underway (e.g., before it is too late to address them). These may include having experts accompany field staff on sampling campaigns, holding weekly staff meetings, or reviewing interim work products or model outputs.
xxxx

## 10.1 Table of field and laboratory quality control

Identify the QC samples that will be measured in the field, analyzed in the lab or otherwise evaluated. You may do this with a table similar to Table 7. Ecology's QA Glossary defines various types of QC samples, including:

- Blanks (lab, field, and other)
- Duplicates (lab and field)
- Lab Control Samples (LCS)
- Matrix Spikes
- Standard Reference Materials (SRM)
- "Blind" SRMs submitted to the laboratory
- Surrogates

xxxx

Table 7. Quality control samples, types, and frequency.
(Modify table as appropriate for the project)

| Parameter | Field | | Laboratory | | | |
|---|---|---|---|---|---|---|
| | Blanks | Replicates | Check Standards | Method Blanks | Analytical Duplicates | Matrix Spikes |
| | | | | | | |
| | | | | | | |
| | | | | | | |

Each type of QC sample listed above will have MQOs associated with it (Section 6.2) that will be used to evaluate the quality and usability of the results.
xxxx

## 10.2 Corrective action processes

This section should describe actions that will be taken if activities are found to be inconsistent with the QAPP, if analysis or modeling results do not meet MQOs or performance expectations, or if some other unforeseen problem arises. Such actions may include:

- Collecting new samples using the method described in the approved QAPP
- Reanalysis of lab samples that do not meet QC criteria (analytical methods often state what to do when QC criteria are not met)
- Convening project personnel and technical experts to decide on the next steps that need to be taken to improve model performance

xxxx

# 11.0 Management Procedures

## 11.1 Data recording and reporting requirements

Describe field data that will be transferred to Ecology's EIM database (sometimes EPA's STORET or other acceptable database). Also describe procedures for recording lab results and transferring them to the same database. Summarize how data entry errors will be detected and corrected.

xxxx

## 11.2 Laboratory data package requirements

Describe how the analytical lab will provide results. Labs usually provide a cover narrative with attached detailed results presented in a standard package when work has been completed. Labs should be required to provide all relevant quality control data.

xxxx

## 11.3 Electronic transfer requirements

Require laboratories to submit data electronically, in a readily-usable format, to minimize data entry problems and facilitate data analysis. Most laboratories will comply, with the data at least available in Microsoft Excel and text formats.

xxxx

## 11.4 EIM/STORET data upload procedures

Projects funded by or submitting data to Ecology must submit the data formatted for entry into Ecology's EIM data system. EPA-funded projects usually require data to be entered into that agency's STORET data system. It *may* be possible to do this by transferring the data from EIM.

xxxx

## 11.5 Model information management

Describe how modeling information will be managed. This should include: the volume of input and output data expected; input and output data storage needs; version control and; mapping post-processed model outputs to the appropriate version of the model. Enter "NA" if this project does not involve modeling or analysis of existing data.

xxxx

# 12.0 Audits and Reports

## 12.1 Field, laboratory, and other audits

Describe the number, frequency, type, and schedule for any audits that are planned. For projects that have controversial implications, or are large, complex, and costly, the QAPP should describe conducting one or more field, "bench", or telephone audits before project completion. Audits can also be appropriate for projects that only involve complex data analysis and/or modeling. You may also describe audits in which the analytical laboratory routinely participates. Simpler projects may not warrant audits.

xxxx

## 12.2 Responsible personnel

Identify who will conduct the audits and what the auditors will examine.

xxxx

## 12.3 Frequency and distribution of reports

Determine and describe report frequencies. For a project extending over a long period of time, it may be useful to generate interim reports or report the data more frequently than just at the end of the project. Often some form of short technical communication is used for this reporting. An e-mail message or technical memo may be adequate to cover the required information transfer. Propose an outline for the final report.

xxxx

## 12.4 Responsibility for reports

Identify all authors of the final report.

xxxx

# 13.0 Data Verification

EPA defines data verification as "the process of evaluating the completeness, correctness, and conformance/compliance of a specific data set against the method, procedural, or contractual requirements."

## 13.1 Field data verification, requirements, and responsibilities

Describe the process by which field data are verified (e.g., examined in detail to ensure that quality criteria such as MQOs have been met). Data verification should be performed by a qualified person different from the field staff who generated the data.
xxxx

## 13.2 Laboratory data verification

Describe the process for verifying quality of lab analytical data (see EPA definition above).
xxxx

## 13.3 Validation requirements, if necessary

Data validation defined as "an analyte-specific and sample-specific process that extends the evaluation of data beyond method, procedural, or contractual compliance (i.e., data verification) to determine the analytical quality of a specific data set". Validation requires a qualified individual, independent of the data generation process, to use raw instrument records and bench sheets to assess the quality of the data. For the majority of projects that do not warrant this added difficulty and expense, this section is "Not Applicable".
xxxx

## 13.4 Model quality assessment

Enter "NA" if this project does not involve modeling or analysis of existing data.
xxxx

### 13.4.1 Calibration and validation

Use subsections below to describe how the model will be calibrated and verified/validated. Detail the procedures that will be used to assess goodness-of-fit between model outputs (predictions) and field data. If an independent data set will be used to corroborate calibrated model results (often called "verification" or "validation"), describe that procedure also. Calibration and validation procedures usually involve estimating precision and bias.
xxxx

#### 13.4.1.1 Precision

Model precision is usually assessed by comparing the "absolute distance" between modeled results and field measurements representing a similar time and location (positive and negative differences will be treated the same). Examples of metrics for precision include relative percent

difference (RPD), relative standard deviation (RSD), and the root mean square error (RMSE) between paired modeled and observed results.
xxxx

#### 13.4.1.2 Bias

Bias is also usually assessed by comparing modeled results to field measurements from a similar time and location. However, bias is indicated by the average shift between the two (positive and negative differences "cancel out") which helps determine how much precision deviates from being equally balanced. Metrics for bias include the mean error (average of paired observed-modeled values) or the percent error (average of paired observed-modeled values divided by observed value), using actual values and not absolute values.
xxxx

#### 13.4.1.3 Representativeness

Describe how model results will be assessed to determine how representative they are of the population of interest and the model-specified population boundaries. Describe how the model approach combined with input and calibration data collection methods contribute to representativeness. Show representativeness through consideration of factors such as seasonality, time of day, flow conditions, and weather.
xxxx

#### 13.4.1.4 Qualitative assessment

Describe any qualitative methods that will be used for goodness-of-fit, such as graphical evaluation. Include the criteria used, e.g., important patterns such as diurnal variation or daily maximum values.
xxxx

### 13.4.2 Analysis of sensitivity and uncertainty

Describe the analytical procedures that will be used to assess sensitivity of the model to input values for different parameters. Also describe how uncertainty associated with the various modeled outputs will be calculated.
xxxx

# 14.0 Data Quality (Usability) Assessment

## 14.1 Process for determining project objectives were met

Describe the process for evaluating whether the project outcomes have met the original objectives. In general, this will be the case if the data were collected consistent with the study design [4], methods, and procedures described in the final approved QAPP, and if enough of the data are deemed usable after verification (e.g., quality objectives detailed in the QAPP have been met). Also describe causes for rejecting data, as well as how data that do not meet MQOs will be qualified.

A similar process should be described for projects involving modeling or analysis of existing data. For example, describe how investigators will evaluate overall model quality, e.g., by comparing RSD, RMSE, other goodness-of-fit statistics, and uncertainty values to the model quality objectives listed in Section 6.4. Also describe how the final assessment of model quality may affect usability or applicability of the model.
xxxx

## 14.2 Treatment of non-detects

Describe how non-detect project results will be handled. This is a complex topic. If uncertain about how to address non-detect data, determine whether there is available guidance. If not, consult a statistician.
xxxx

## 14.3 Data analysis and presentation methods

Include procedures for compiling and analyzing the data, including any software requirements. Discuss, in general terms, any statistical treatment or specialized statistics you plan to use for interpretation of data or determining trends.

An important element of the project might be statistical analysis to detect relationships and trends in the data or to compare results with those of other projects. Use guidance for these techniques in Ecology QAPP Guidance.
xxxx

## 14.4 Sampling design evaluation

Evaluate the anticipated effectiveness of the sampling design to be used. For example, does the design yield enough statistical power to draw the desired conclusions? Revise as necessary.
xxxx

## 14.5 Documentation of assessment

Describe how the data usability assessment will be documented.
xxxx

[4] And there is no reason to question the study design assumptions xx

# 15.0 References

Almost every QAPP will refer to studies, reports, SOPs, and scientific literature. Include these references in this section. Spell out all journal names.

Delete any of the following references that aren't cited in this QAPP.


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Sullivan, L., 2007. Standard Operating Procedure for Estimating Streamflow, Version 1.0. Washington State Department of Ecology, Olympia, WA. SOP Number EAP024. www.ecy.wa.gov/programs/eap/quality.html

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WAC 173-201A. Water Quality Standards for Surface Waters in the State of Washington Washington State Department of Ecology, Olympia, WA. www.ecy.wa.gov/laws-rules/ecywac.html

Ward, W.J., 2007. Collection, Processing, and Analysis of Stream Samples, Version 1.3. Washington State Department of Ecology, Olympia, WA. SOP Number EAP034. www.ecy.wa.gov/programs/eap/quality.html

# 16.0 Appendices

In addition to Appendix A, appendices might include:

- SOPs
- MSDS and safety information
- Historical data
- Examples of forms to be used in the project

# Appendix A.  xx (Title)

In Appendix A, number figures and tables as:

- Figure A-1, Figure A-2, etc.
- Table A-1, Table A-2, etc.

Don’t add captions to figures and tables in the appendices.

Don’t delete the next appendix (Glossaries…), and be sure it’s your last appendix.

xxxx

# Appendix xx. Glossaries, Acronyms, and Abbreviations

## Glossary of General Terms

Author, delete any terms that don't apply to this QAPP and also add other terms, as needed.

Don't add any terms already included in the *Quality Assurance Glossary* that follows this *Glossary of General Terms*.

**Ambient:** Background or away from point sources of contamination. Surrounding environmental condition.

**Anthropogenic:** Human-caused.

**Bankfull stage:** Formally defined as the stream level that "corresponds to the discharge at which channel maintenance is most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels (Dunne and Leopold, 1978).

**Baseflow:** The component of total streamflow that originates from direct groundwater discharges to a stream.

**Char:** Fish of genus *Salvelinus* distinguished from trout and salmon by the absence of teeth in the roof of the mouth, presence of light-colored spots on a dark background, absence of spots on the dorsal fin, small scales, and differences in the structure of their skeleton. (Trout and salmon have dark spots on a lighter background.)

**Chronic critical effluent concentration:** The maximum concentration of effluent during critical conditions at the boundary of the mixing zone assigned in accordance with WAC 173-201A-100. The boundary may be based on distance or a percentage of flow. Where no mixing zone is allowed, the chronic critical effluent concentration shall be 100% effluent.

**Clean Water Act:** A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

**Conductivity:** A measure of water's ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water.

**Critical condition:** When the physical, chemical, and biological characteristics of the receiving water environment interact with the effluent to produce the greatest potential adverse impact on aquatic biota and existing or designated water uses. For steady-state discharges to riverine systems, the critical condition may be assumed to be equal to the 7Q10 flow event unless determined otherwise by the department.

**Designated uses:** Those uses specified in Chapter 173-201A WAC (Water Quality Standards for Surface Waters of the State of Washington) for each water body or segment, regardless of whether or not the uses are currently attained.

**Diel:** Of, or pertaining to, a 24-hour period.

**Dissolved oxygen (DO):** A measure of the amount of oxygen dissolved in water.

**Dilution factor:** The relative proportion of effluent to stream (receiving water) flows occurring at the edge of a mixing zone during critical discharge conditions as authorized in accordance with the state's mixing zone regulations at WAC 173-201A-100. http://apps.leg.wa.gov/WAC/default.aspx?cite=173-201A-020

**Diurnal:** Of, or pertaining to, a day or each day; daily. (1) Occurring during the daytime only, as different from nocturnal or crepuscular, or (2) Daily; related to actions which are completed in the course of a calendar day, and which typically recur every calendar day (e.g., diurnal temperature rises during the day, and falls during the night).

**Effective shade:** The fraction of incoming solar shortwave radiation that is blocked from reaching the surface of a stream or other defined area.

**Effluent:** An outflowing of water from a natural body of water or from a human-made structure. For example, the treated outflow from a wastewater treatment plant.

**Enterococci:** A subgroup of the fecal streptococci that includes *S. faecalis*, *S. faecium*, *S. gallinarum*, and *S. avium*. The enterococci are differentiated from other streptococci by their ability to grow in 6.5% sodium chloride, at pH 9.6, and at 10 degrees C and 45 degrees C.

**Eutrophic:** Nutrient rich and high in productivity resulting from human activities such as fertilizer runoff and leaky septic systems.

**Existing uses:** Those uses actually attained in fresh and marine waters on or after November 28, 1975, whether or not they are designated uses. Introduced species that are not native to Washington, and put-and-take fisheries comprised of non-self-replicating introduced native species, do not need to receive full support as an existing use.

**Extraordinary primary contact:** Waters providing extraordinary protection against waterborne disease or that serve as tributaries to extraordinary quality shellfish harvesting areas.

**Fecal coliform (FC):** That portion of the coliform group of bacteria which is present in intestinal tracts and feces of warm-blooded animals as detected by the product of acid or gas from lactose in a suitable culture medium within 24 hours at 44.5 plus or minus 0.2 degrees Celsius. Fecal coliform bacteria are "indicator" organisms that suggest the possible presence of disease-causing organisms. Concentrations are measured in colony forming units per 100 milliliters of water (cfu/100 mL).

**Fish Tissue Equivalent Concentration (FTEC):** The FTEC is a tissue contaminant concentration used by Ecology to determine whether the designated uses of fishing and drinking from surface waters are being met. The FTEC is an interpretation of Washington's water quality

criterion for a specific chemical for the protection of human health: the National Toxics Rule (40 CFR 131.36). Fish tissue sample concentrations that are lower than the FTEC suggest that the uses of fishing and drinking from surface waters are being met for that specific contaminant. Where an FTEC is not met (i.e., concentration of a chemical in fish tissue is greater than the FTEC), that water body is then placed into Category 5 during Washington's periodic Water Quality Assessment (http://www.ecy.wa.gov/programs/Wq/303d/index.html). Category 5 listings become part of Washington's 303(d) list during the assessment process. The FTEC is calculated by multiplying the contaminant-specific Bio-Concentration Factor (BCF) times the contaminant-specific Water Quality Criterion found in the National Toxics Rule.

**Geometric mean:** A mathematical expression of the central tendency (an average) of multiple sample values. A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if a straight average (arithmetic mean) were calculated. This is helpful when analyzing bacteria concentrations, because levels may vary anywhere from 10 to 10,000 fold over a given period. The calculation is performed by either: (1) taking the nth root of a product of n factors, or (2) taking the antilogarithm of the arithmetic mean of the logarithms of the individual values.

**Hyporheic:** The area beneath and adjacent to a stream where surface water and groundwater intermix.

**Load allocation:** The portion of a receiving water's loading capacity attributed to one or more of its existing or future sources of nonpoint pollution or to natural background sources.

**Loading capacity:** The greatest amount of a substance that a water body can receive and still meet water quality standards.

**Margin of safety:** Required component of TMDLs that accounts for uncertainty about the relationship between pollutant loads and quality of the receiving water body.

**Municipal separate storm sewer systems (MS4):** A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels, or storm drains): (1) owned or operated by a state, city, town, borough, county, parish, district, association, or other public body having jurisdiction over disposal of wastes, stormwater, or other wastes and (2) designed or used for collecting or conveying stormwater; (3) which is not a combined sewer; and (4) which is not part of a Publicly Owned Treatment Works (POTW) as defined in the Code of Federal Regulations at 40 CFR 122.2.

**National Pollutant Discharge Elimination System (NPDES):** National program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements under the Clean Water Act. The NPDES program regulates discharges from wastewater treatment plants, large factories, and other facilities that use, process, and discharge water back into lakes, streams, rivers, bays, and oceans.

**Near-stream disturbance zone (NSDZ):** The active channel area without riparian vegetation that includes features such as gravel bars.

**Nonpoint source:** Pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but not limited to atmospheric deposition, surface-water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the NPDES program. Generally, any unconfined and diffuse source of contamination. Legally, any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act.

**Nutrient:** Substance such as carbon, nitrogen, and phosphorus used by organisms to live and grow. Too many nutrients in the water can promote algal blooms and rob the water of oxygen vital to aquatic organisms.

**Pathogen:** Disease-causing microorganisms such as bacteria, protozoa, viruses.

**pH:** A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

**Phase I stormwater permit:** The first phase of stormwater regulation required under the federal Clean Water Act. The permit is issued to medium and large municipal separate storm sewer systems (MS4s) and construction sites of five or more acres.

**Phase II stormwater permit:** The second phase of stormwater regulation required under the federal Clean Water Act. The permit is issued to smaller municipal separate storm sewer systems (MS4s) and construction sites over one acre.

**Point source:** Source of pollution that discharges at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites where more than 5 acres of land have been cleared.

**Pollution:** Contamination or other alteration of the physical, chemical, or biological properties of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

**Primary contact recreation:** Activities where a person would have direct contact with water to the point of complete submergence including, but not limited to, skin diving, swimming, and water skiing.

**Reach:** A specific portion or segment of a stream.

**Riparian:** Relating to the banks along a natural course of water.

**Salmonid:** Fish that belong to the family *Salmonidae*. Any species of salmon, trout, or char.

**Sediment:** Soil and organic matter that is covered with water (for example, river or lake bottom).

**Stormwater:** The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

**Streamflow:** Discharge of water in a surface stream (river or creek).

**Surface waters of the state:** Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and water courses within the jurisdiction of Washington State.

**Synoptic survey:** Data collected simultaneously or over a short period of time.

**System potential:** The design condition used for TMDL analysis.

**System-potential channel morphology:** The more stable configuration that would occur with less human disturbance.

S**ystem-potential mature riparian vegetation:** Vegetation which can grow and reproduce on a site, given climate, elevation, soil properties, plant biology, and hydrologic processes.

**System-potential riparian microclimate:** The best estimate of air temperature reductions that are expected under mature riparian vegetation. System-potential riparian microclimate can also include expected changes to wind speed and relative humidity.

**System-potential temperature:** An approximation of the temperatures that would occur under natural conditions. System potential is our best understanding of natural conditions that can be supported by available analytical methods. The simulation of the system-potential condition uses best estimates of *mature riparian vegetation, system-potential channel morphology, and system-potential riparian microclimate* that would occur absent any human alteration.

**Thalweg:** The deepest and fastest moving portion of a stream.

**Total Maximum Daily Load (TMDL):** A distribution of a substance in a water body designed to protect it from not meeting (exceeding) water quality standards. A TMDL is equal to the sum of all of the following: (1) individual waste load allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a margin of safety to allow for uncertainty in the waste load determination. A reserve for future growth is also generally provided.

**Total suspended solids (TSS):** Portion of solids retained by a filter.

**Turbidity:** A measure of water clarity. High levels of turbidity can have a negative impact on aquatic life.

**Waste load allocation:** The portion of a receiving water's loading capacity allocated to existing or future point sources of pollution. Waste load allocations constitute one type of water quality-based effluent limitation.

**Watershed:** A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

**1-DMax or 1-day maximum temperature:** The highest water temperature reached on any given day. This measure can be obtained using calibrated maximum/minimum thermometers or continuous monitoring probes having sampling intervals of thirty minutes or less.

**303(d) list:** Section 303(d) of the federal Clean Water Act, requiring Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality-limited estuaries, lakes, and streams that fall short of state surface water quality standards and are not expected to improve within the next two years.

**7-DADMax or 7-day average of the daily maximum temperatures:** The arithmetic average of seven consecutive measures of daily maximum temperatures. The 7-DADMax for any individual day is calculated by averaging that day's daily maximum temperature with the daily maximum temperatures of the three days before and the three days after that date.

**7Q2 flow:** A typical low-flow condition. The 7Q2 is a statistical estimate of the lowest 7-day average flow that can be expected to occur once every other year on average. The 7Q2 flow is commonly used to represent the average low-flow condition in a water body and is typically calculated from long-term flow data collected in each basin. For temperature TMDL work, the 7Q2 is usually calculated for the months of July and August as these typically represent the critical months for temperature in our state.

**7Q10 flow:** A critical low-flow condition. The 7Q10 is a statistical estimate of the lowest 7-day average flow that can be expected to occur once every ten years on average. The 7Q10 flow is commonly used to represent the critical flow condition in a water body and is typically calculated from long-term flow data collected in each basin. For temperature TMDL work, the 7Q10 is usually calculated for the months of July and August as these typically represent the critical months for temperature in our state.

**$90^{th}$ percentile:** An estimated portion of a sample population based on a statistical determination of distribution characteristics. The $90^{th}$ percentile value is a statistically derived estimate of the division between 90% of samples, which should be less than the value, and 10% of samples, which are expected to exceed the value.

## Acronyms and Abbreviations

Author, delete any of the following that aren't used in this QAPP.

Add any acronyms/abbreviations/units used in this QAPP that aren't already on this list.

| | |
|---|---|
| BMP | Best management practice |
| DO | (see Glossary above) |
| DOC | Dissolved organic carbon |
| e.g. | For example |
| Ecology | Washington State Department of Ecology |
| EIM | Environmental Information Management database |
| EPA | U.S. Environmental Protection Agency |
| et al. | And others |
| FC | (see Glossary above) |
| GIS | Geographic Information System software |
| GPS | Global Positioning System |
| i.e. | In other words |
| MEL | Manchester Environmental Laboratory |
| MQO | Measurement quality objective |
| NAF | New Approximation Flow |
| NPDES | (See Glossary above) |
| NSDZ | Near-stream disturbance zones |
| NTR | National Toxics Rule |
| PBDE | polybrominated diphenyl ethers |
| PBT | persistent, bioaccumulative, and toxic substance |
| PCB | polychlorinated biphenyls |
| QA | Quality assurance |
| QC | Quality control |
| RM | River mile |
| RPD | Relative percent difference |
| RSD | Relative standard deviation |
| SOP | Standard operating procedures |
| SRM | Standard reference materials |
| TIR | Thermal infrared radiation |
| TMDL | (See Glossary above) |
| TOC | Total organic carbon |
| TSS | (See Glossary above) |
| USFS | United States Forest Service |
| USGS | United States Geological Survey |
| WAC | Washington Administrative Code |
| WDFW | Washington Department of Fish and Wildlife |
| WQA | Water Quality Assessment |
| WRIA | Water Resource Inventory Area |
| WSTMP | Washington State Toxics Monitoring Program |
| WWTP | Wastewater treatment plant |

*Units of Measurement*

| | |
|---|---|
| °C | degrees centigrade |
| cfs | cubic feet per second |
| cfu | colony forming units |
| cms | cubic meters per second, a unit of flow |
| dw | dry weight |
| ft | feet |
| g | gram, a unit of mass |
| kcfs | 1000 cubic feet per second |
| kg | kilograms, a unit of mass equal to 1,000 grams |
| kg/d | kilograms per day |
| km | kilometer, a unit of length equal to 1,000 meters |
| l/s | liters per second (0.03531 cubic foot per second) |
| m | meter |
| mm | millimeter |
| mg | milligram |
| mgd | million gallons per day |
| mg/d | milligrams per day |
| mg/Kg | milligrams per kilogram (parts per million) |
| mg/L | milligrams per liter (parts per million) |
| mg/L/hr | milligrams per liter per hour |
| mL | milliliter |
| mmol | millimole or one-thousandth of a mole |
| mole | an International System of Units (IS) unit of matter |
| ng/g | nanograms per gram (parts per billion) |
| ng/Kg | nanograms per kilogram (parts per trillion) |
| ng/L | nanograms per liter (parts per trillion) |
| NTU | nephelometric turbidity units |
| pg/g | picograms per gram (parts per trillion) |
| pg/L | picograms per liter (parts per quadrillion) |
| psu | practical salinity units |
| s.u. | standard units |
| ug/g | micrograms per gram (parts per million) |
| ug/Kg | micrograms per kilogram (parts per billion) |
| ug/L | micrograms per liter (parts per billion) |
| um | micrometer |
| uM | micromolar (a chemistry unit) |
| umhos/cm | micromhos per centimeter |
| uS/cm | microsiemens per centimeter, a unit of conductivity |
| ww | wet weight |

## Quality Assurance Glossary

Leave all terms in this glossary intact.

**Accreditation:** A certification process for laboratories, designed to evaluate and document a lab's ability to perform analytical methods and produce acceptable data. For Ecology, it is "Formal recognition by (Ecology)…that an environmental laboratory is capable of producing accurate analytical data." [WAC 173-50-040] (Kammin, 2010)

**Accuracy:** The degree to which a measured value agrees with the true value of the measured property. USEPA recommends that this term not be used, and that the terms precision and bias be used to convey the information associated with the term accuracy. (USGS, 1998)

**Analyte:** An element, ion, compound, or chemical moiety (pH, alkalinity) which is to be determined. The definition can be expanded to include organisms, e.g., fecal coliform, Klebsiella. (Kammin, 2010)

**Bias:** The difference between the population mean and the true value. Bias usually describes a systematic difference reproducible over time, and is characteristic of both the measurement system, and the analyte(s) being measured. Bias is a commonly used data quality indicator (DQI). (Kammin, 2010; Ecology, 2004)

**Blank:** A synthetic sample, free of the analyte(s) of interest. For example, in water analysis, pure water is used for the blank. In chemical analysis, a blank is used to estimate the analytical response to all factors other than the analyte in the sample. In general, blanks are used to assess possible contamination or inadvertent introduction of analyte during various stages of the sampling and analytical process. (USGS, 1998)

**Calibration:** The process of establishing the relationship between the response of a measurement system and the concentration of the parameter being measured. (Ecology, 2004)

**Check standard:** A substance or reference material obtained from a source independent from the source of the calibration standard; used to assess bias for an analytical method. This is an obsolete term, and its use is highly discouraged. See Calibration Verification Standards, Lab Control Samples (LCS), Certified Reference Materials (CRM), and/or spiked blanks. These are all check standards, but should be referred to by their actual designator, e.g., CRM, LCS. (Kammin, 2010; Ecology, 2004)

**Comparability:** The degree to which different methods, data sets and/or decisions agree or can be represented as similar; a data quality indicator. (USEPA, 1997)

**Completeness:** The amount of valid data obtained from a project compared to the planned amount. Usually expressed as a percentage. A data quality indicator. (USEPA, 1997)

**Continuing Calibration Verification Standard (CCV):** A QC sample analyzed with samples to check for acceptable bias in the measurement system. The CCV is usually a midpoint calibration standard that is re-run at an established frequency during the course of an analytical run. (Kammin, 2010)

**Control chart:** A graphical representation of quality control results demonstrating the performance of an aspect of a measurement system. (Kammin, 2010; Ecology 2004)

**Control limits:** Statistical warning and action limits calculated based on control charts. Warning limits are generally set at +/- 2 standard deviations from the mean, action limits at +/- 3 standard deviations from the mean. (Kammin, 2010)

**Data integrity:** A qualitative DQI that evaluates the extent to which a data set contains data that is misrepresented, falsified, or deliberately misleading. (Kammin, 2010)

**Data Quality Indicators (DQI):** Commonly used measures of acceptability for environmental data. The principal DQIs are precision, bias, representativeness, comparability, completeness, sensitivity, and integrity. (USEPA, 2006)

**Data Quality Objectives (DQO):** Qualitative and quantitative statements derived from systematic planning processes that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions.
(USEPA, 2006)

**Data set:** A grouping of samples organized by date, time, analyte, etc. (Kammin, 2010)

**Data validation:** An analyte-specific and sample-specific process that extends the evaluation of data beyond data verification to determine the usability of a specific data set. It involves a detailed examination of the data package, using both professional judgment, and objective criteria, to determine whether the MQOs for precision, bias, and sensitivity have been met. It may also include an assessment of completeness, representativeness, comparability and integrity, as these criteria relate to the usability of the data set. Ecology considers four key criteria to determine if data validation has actually occurred. These are:

- Use of raw or instrument data for evaluation.
- Use of third-party assessors.
- Data set is complex.
- Use of EPA Functional Guidelines or equivalent for review.

Examples of data types commonly validated would be:

- Gas Chromatography (GC).
- Gas Chromatography-Mass Spectrometry (GC-MS).
- Inductively Coupled Plasma (ICP).

The end result of a formal validation process is a determination of usability that assigns qualifiers to indicate usability status for every measurement result. These qualifiers include:

- No qualifier, data is usable for intended purposes.
- J (or a J variant), data is estimated, may be usable, may be biased high or low.
- REJ, data is rejected, cannot be used for intended purposes (Kammin, 2010; Ecology, 2004).

**Data verification:** Examination of a data set for errors or omissions, and assessment of the Data Quality Indicators related to that data set for compliance with acceptance criteria (MQOs). Verification is a detailed quality review of a data set. (Ecology, 2004)

**Detection limit** (limit of detection)**:** The concentration or amount of an analyte which can be determined to a specified level of certainty to be greater than zero. (Ecology, 2004)

**Duplicate samples:** Two samples taken from and representative of the same population, and carried through and steps of the sampling and analytical procedures in an identical manner. Duplicate samples are used to assess variability of all method activities including sampling and analysis. (USEPA, 1997)

**Field blank:** A blank used to obtain information on contamination introduced during sample collection, storage, and transport. (Ecology, 2004)

**Initial Calibration Verification Standard (ICV):** A QC sample prepared independently of calibration standards and analyzed along with the samples to check for acceptable bias in the measurement system. The ICV is analyzed prior to the analysis of any samples. (Kammin, 2010)

**Laboratory Control Sample (LCS):** A sample of known composition prepared using contaminant-free water or an inert solid that is spiked with analytes of interest at the midpoint of the calibration curve or at the level of concern. It is prepared and analyzed in the same batch of regular samples using the same sample preparation method, reagents, and analytical methods employed for regular samples. (USEPA, 1997)

**Matrix spike:** A QC sample prepared by adding a known amount of the target analyte(s) to an aliquot of a sample to check for bias due to interference or matrix effects. (Ecology, 2004)

**Measurement Quality Objectives** (MQOs)**:** Performance or acceptance criteria for individual data quality indicators, usually including precision, bias, sensitivity, completeness, comparability, and representativeness. (USEPA, 2006)

**Measurement result:** A value obtained by performing the procedure described in a method. (Ecology, 2004)

**Method:** A formalized group of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, data analysis), systematically presented in the order in which they are to be executed. (EPA, 1997)

**Method blank:** A blank prepared to represent the sample matrix, prepared and analyzed with a batch of samples. A method blank will contain all reagents used in the preparation of a sample, and the same preparation process is used for the method blank and samples. (Ecology, 2004; Kammin, 2010)

**Method Detection Limit (MDL):** This definition for detection was first formally advanced in 40CFR 136, October 26, 1984 edition. MDL is defined there as the minimum concentration of an analyte that, in a given matrix and with a specific method, has a 99% probability of being identified, and reported to be greater than zero. (Federal Register, October 26, 1984)

**Percent Relative Standard Deviation (%RSD):** A statistic used to evaluate precision in environmental analysis. It is determined in the following manner:

$$\%RSD = (100 * s)/x$$

where s is the sample standard deviation and x is the mean of results from more than two replicate samples. (Kammin, 2010)

**Parameter:** A specified characteristic of a population or sample. Also, an analyte or grouping of analytes. Benzene and nitrate + nitrite are all "parameters." (Kammin, 2010; Ecology, 2004)

**Population:** The hypothetical set of all possible observations of the type being investigated. (Ecology, 2004)

**Precision:** The extent of random variability among replicate measurements of the same property; a data quality indicator. (USGS, 1998)

**Quality assurance (QA):** A set of activities designed to establish and document the reliability and usability of measurement data. (Kammin, 2010)

**Quality Assurance Project Plan (QAPP):** A document that describes the objectives of a project, and the processes and activities necessary to develop data that will support those objectives. (Kammin, 2010; Ecology, 2004)

**Quality control (QC):** The routine application of measurement and statistical procedures to assess the accuracy of measurement data. (Ecology, 2004)

**Relative Percent Difference (RPD):** RPD is commonly used to evaluate precision. The following formula is used:

$$[Abs(a-b)/((a + b)/2)] * 100$$

where "Abs()" is absolute value and a and b are results for the two replicate samples. RPD can be used only with 2 values. Percent Relative Standard Deviation is (%RSD) is used if there are results for more than 2 replicate samples (Ecology, 2004).

**Replicate samples:** Two or more samples taken from the environment at the same time and place, using the same protocols. Replicates are used to estimate the random variability of the material sampled. (USGS, 1998)

**Representativeness:** The degree to which a sample reflects the population from which it is taken; a data quality indicator. (USGS, 1998)

**Sample (field):** A portion of a population (environmental entity) that is measured and assumed to represent the entire population. (USGS, 1998)

**Sample (statistical):** A finite part or subset of a statistical population. (USEPA, 1997)

**Sensitivity:** In general, denotes the rate at which the analytical response (e.g., absorbance, volume, meter reading) varies with the concentration of the parameter being determined. In a specialized sense, it has the same meaning as the detection limit. (Ecology, 2004)

**Spiked blank:** A specified amount of reagent blank fortified with a known mass of the target analyte(s); usually used to assess the recovery efficiency of the method. (USEPA, 1997)

**Spiked sample:** A sample prepared by adding a known mass of target analyte(s) to a specified amount of matrix sample for which an independent estimate of target analyte(s) concentration is available. Spiked samples can be used to determine the effect of the matrix on a method's recovery efficiency. (USEPA, 1997)

**Split sample:** A discrete sample subdivided into portions, usually duplicates (Kammin, 2010)

**Standard Operating Procedure (SOP):** A document which describes in detail a reproducible and repeatable organized activity. (Kammin, 2010)

**Surrogate:** For environmental chemistry, a surrogate is a substance with properties similar to those of the target analyte(s). Surrogates are unlikely to be native to environmental samples. They are added to environmental samples for quality control purposes, to track extraction efficiency and/or measure analyte recovery. Deuterated organic compounds are examples of surrogates commonly used in organic compound analysis. (Kammin, 2010)

**Systematic planning:** A step-wise process which develops a clear description of the goals and objectives of a project, and produces decisions on the type, quantity, and quality of data that will be needed to meet those goals and objectives. The DQO process is a specialized type of systematic planning. (USEPA, 2006)

## References for QA Glossary


Ecology, 2004. Guidance for the Preparation of Quality Assurance Project Plans for Environmental Studies. https://fortress.wa.gov/ecy/publications/SummaryPages/0403030.html

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## Revision History for this Template

| Version Date | Version Number | Summary of substantive changes | Sections | Reviser Initials |
|---|---|---|---|---|
| 10/24/2011<br>12/18/2013<br>5/29/2014<br>7/11/2014 | Document control inadequate for previous versions | | | BK, TG, and others |
| 10/07/2016 | 1.0 | Adapted first several pages for use by Ecology staff and external parties. Inserted new modeling-related headers, modified or deleted others. Clarified instructions.<br><br>Section 3: Moved ***Logistical problems***.<br>Section 4: Deleted ***Target Population;*** moved ***Practical Constraints*** and ***Study Boundaries***.<br>Section 5: Moved ***Schedule Limitations***.<br>Section 6: Changed ***Decision quality objectives*** to ***Data quality objectives;*** inserted ***Acceptance criteria for existing data***; added ***Modeling quality objectives***.<br>Section 7: Inserted ***Study boundaries***; added ***Modelling and analysis design***; created subsection with all limitations/problems.<br>Section 8: Renamed ***Field Procedures;*** moved ***Invasive species evaluation***<br>Section 9: Renamed ***Field procedures;*** condensed ***Lab procedures table*** headers.<br>Section 11: Moved ***Acceptance criteria for existing data***; added ***Model information management***.<br>Section 13: Added ***Model quality assessment.***<br>Sections 16 and 17: Deleted. | Front, Sections 3-9, 11, 13, 16-17 | TG, NM, PP, others |
| 11/9/2016 | 1.0 | QA approval for document control information | All pages | B. Kammin |
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# QAPP Checklist (Version 1.0) for Peer Reviewers

(Router for Ecology author and peer reviewer is attached at the end of this Checklist.)

Use this form for all QAPPs. It may also be used, on a case-by-case basis, for QAPP addenda.

Directions for using this form: Read, then delete, all text in brown.

| | |
|---|---|
| Title of QAPP: | |
| Author: | |
| Manager of author's section: | |
| Manager of reviewing section: | |
| Peer reviewer (determined by manager of reviewing section) | |

**Checklist for Peer Reviewer**

| Element | Acceptable as written? Y / N / NA | Comments |
|---|---|---|
| **1.0 Title Page, Table of Contents, and Distribution List** | | |
| Title, author, organization | | |
| Date prepared or revised | | |
| Approval signatures of key individuals | | |
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| Distribution List | | |
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| 3.2.2 Summary of previous studies and existing data | | |
| 3.2.3 Parameters of interest and potential sources | | |
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| 3.3 Water quality impairment studies | | |
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| | | |
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| | | |

| Element | Acceptable as written? Y / N / NA | Comments |
|---|---|---|
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| Element | Acceptable as written? Y / N / NA | Comments |
|---|---|---|
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| Quality Assurance Glossary | | |

# QAPP Router for Ecology staff

| | |
|---|---|
| Date author emailed a link to the draft QAPP and this peer review/router form to the assigned peer reviewer, the peer reviewer's unit supervisor and section manager, as well as everyone on the signature page. | |

| | |
|---|---|
| Date review is due to author. This is usually 3 weeks from date author sent draft QAPP and this form to the peer reviewer. | |

**Additional comments or significant concerns that need to be addressed in a revised QAPP:**

Both here, and in comments within the reviewed QAPP, strive to differentiate between comments/concerns that are significant and threaten study integrity vs. comments that are for the author's consideration and discretion.
xx

**Peer reviewer determination (select either 1 or 2 below):**

1. **<u>QAPP is acceptable</u> as is or with minor revisions as noted above in comments/section. No further review is required.**

Enter date when t step is completed: Date

| | |
|---|---|
| Peer reviewer emails router/review checklist (and a link to the marked-up draft QAPP if necessary) to author, with cc's to unit supervisors of the peer reviewer and author. | |

2. **<u>QAPP needs to be revised</u> and reviewed again. After revising and responding to significant concerns identified above, the author will return the QAPP to the peer reviewer.**

Enter date when each step is completed: Date

| | |
|---|---|
| Peer reviewer emails router/review checklist (and link to the marked-up draft QAPP if necessary) to author, with cc's to unit supervisors of the peer reviewer and author. | |
| Author revises QAPP per the comments above, and prepares a brief response summary indicating how the reviewer's significant concerns were addressed. | |
| Author sends a link to the revised draft QAPP and response summary to peer reviewer, with cc's to unit supervisors of the peer reviewer and author. | |
| Peer reviewer emails author when QAPP is technically adequate, with cc's to author, with cc's to unit supervisors of the peer reviewer and author. | |
| Author's supervisor signs, indicating the peer review process was followed and substantive issues resolved: _____ | |

## Revision history for this peer review/router form

| Version date | Version number | Summary of substantive changes | Sections | Reviser initials |
|---|---|---|---|---|
| 12/18/2013<br>6/23/2014 | Document control inadequate for previous versions | | | BK, TG, and others |
| 10/07/2016 | 1.0 | Modified headers to match QAPP Template Version 2.0 | Sections 3-9, 11, 13, 16-17 | T Gries |
| 11/9/2016 | 1.0 | QA approval for document control information | All pages | B Kammin |
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