The Volunteer Monitor's Guide To

Quality Assurance Project Plans
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Dear Reader:

Across the country, volunteers are monitoring the condition of streams, rivers, lakes, reservoirs, estuaries, coastal waters, wetlands, and wells. The number and variety of these projects are continually on the rise. So, too, is the complexity of the monitoring volunteers conduct and the uses of the data they collect.

One of the most difficult issues facing volunteer environmental monitoring programs today is data credibility. Potential data users are often skeptical about volunteer data -- they may have doubts about the goals and objectives of the project, about how volunteers were trained, about how samples were collected, handled and stored, or about how data were analyzed and reports written. A key tool in breaking down this barrier of skepticism is the quality assurance project plan.

The quality assurance project plan, or QAPP, is a document that outlines the procedures that those who conduct a monitoring project will take to ensure that the data they collect and analyze meets project requirements. It is an invaluable planning and operating tool that outlines the project’s methods of data collection, storage and analysis. It serves not only to convince skeptical data users about the quality of the project’s findings, but also to record methods, goals and project implementation steps for current and future volunteers and for those who may wish to use the project’s data over time.

Developing a QAPP is a dynamic, interactive process that should ideally involve quality assurance experts, potential data users, and members of the volunteer monitoring project team. It is not an easy process. This document is designed to encourage and facilitate the development of volunteer QAPPs by clearly presenting explanations and examples. Readers are urged to consult, as well, the additional resources listed in the appendices to this document, and to contact their state or U.S. Environmental Protection Agency (EPA) Regional quality assurance staff for specific information or guidance on their projects.

Sincerely,

Geoffrey H. Grubbs, Director
Assessment and Watershed Protection Division
Acknowledgements

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Original illustrations by Dave Skibiak and Emily Faalasli of Tetra Tech, Inc., and Elizabeth Yuster of the Maryland Volunteer Watershed Monitoring Association.

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EXECUTIVE SUMMARY

The Quality Assurance Project Plan, or QAPP, is a written document that outlines the procedures a monitoring project will use to ensure that the samples participants collect and analyze, the data they store and manage, and the reports they write are of high enough quality to meet project needs.

U.S. Environmental Protection Agency-funded monitoring programs must have an EPA-approved QAPP before sample collection begins. However, even programs that do not receive EPA money should consider developing a QAPP, especially if data might be used by state, federal, or local resource managers. A QAPP helps the data user and monitoring project leaders ensure that the collected data meet their needs and that the quality control steps needed to verify this are built into the project from the beginning.

Volunteer monitoring programs have long recognized the importance of well-designed monitoring projects; written field, lab, and data management protocols; trained volunteers; and effective presentation of results. Relatively few programs, however, have tackled the task of preparing a comprehensive QAPP that documents these important elements.

This document is designed to help volunteer program coordinators develop such a QAPP.

Steps to Developing a QAPP

Developing a QAPP is a dynamic, interactive process that should ideally involve state and EPA regional QA experts,
potential data users, and key members of the volunteer monitoring project. There are 11 steps a volunteer monitoring project coordinator might take to prepare a QAPP. These are:

Step 1:  *Establish a small team* whose members will serve as advisors in helping you develop the QAPP by offering feedback and guidance throughout the entire process.

**A QAPP helps the data user and monitoring project leaders ensure that the data collected meet their needs.**

Step 2:  *Determine the goals & objectives of your project*—why it’s needed, who will use the data, and how the data will be used.

Step 3:  *Collect background information* to help you in designing your project.

Step 4:  *Refine your project’s goals* once you’ve collected more information.

Step 5:  *Design your project’s sampling, analytical & data requirements*—essentially, what, how, when, and where you’ll be monitoring.

Step 6:  *Develop an implementation plan* that lays out project logistics.

Step 7:  *Draft your standard operating procedures (SOPs) & QAPP.*

Step 8:  *Solicit feedback on your draft SOPs & QAPP* from state or EPA regional QA contacts and potential data users.
Step 9: Revise your QAPP based on review comments and submit it for approval.

Step 10: Once your QAPP is approved, begin your monitoring program.

Step 11: Evaluate and refine your project over time, and reflect any major changes in a revised QAPP.

Basic QA/QC Concepts

It is important to understand the terminology of quality assurance and quality control in order to develop a QAPP. Key definitions include:

**Precision** -- the degree of agreement among repeated measurements of the same characteristic. It may be determined by calculating the standard deviation, or relative percent difference, among samples taken from the same place at the same time.

**Accuracy** -- measures how close your results are to a true or expected value and can be determined by comparing your analysis of a standard or reference sample to its actual value.

**Representativeness** -- the extent to which measurements actually represent the true environmental condition or population at the time a sample was collected.

**Completeness** -- the comparison between the amount of valid, or usable, data you originally planned to collect, versus how much you collected.

**Comparability** -- the extent to which data can be compared between sample locations or periods of time within a project, or between projects.

Elements of a QAPP

According to EPA guidance, 24 distinct elements can be included in a QAPP, although not all elements may be necessary for all programs. Which elements you end up including in your QAPP depends on your project's goals, objectives, scope, data uses, and on the guidance you receive from your state or
EPA regional quality assurance contacts. The 24 elements are grouped into four overall categories and are listed below:

**Project Management** (elements 1-9)

1. Title and Approval Page
2. Table of Contents
3. Distribution List
4. Project/Task Organization
5. Problem Identification/ Background
6. Project/Task Description
7. Data Quality Objectives for Measurement Data
8. Training Requirements/Certification
9. Documentation and Records

**Measurement/Data Acquisition** (elements 10-19)

10. Sampling Process Design
11. Sampling Methods Requirements
12. Sample Handling and Custody Requirements
13. Analytical Methods Requirements
14. Quality Control Requirements
15. Instrument/Equipment Testing, Inspection, and Maintenance Requirements
16. Instrument Calibration and Frequency
17. Inspection/Acceptance Requirements for Supplies
18. Data Acquisition Requirements
19. Data Management

**Assessment and Oversight** (elements 20-21)

20. Assessment and Response Actions
21. Reports

**Data Validation and Usability** (elements 22-24)

22. Data Review, Validation, and Verification Requirements
23. Validation and Verification Methods
24. Reconciliation with Data Quality Objectives
Chapter 1: INTRODUCTION

Across the country, volunteers are monitoring the condition of streams, rivers, lakes, reservoirs, estuaries, coastal waters, wetlands, and wells. The number and variety of these projects is continually on the rise; so, too, is the complexity of the monitoring they conduct and the uses of the data they collect.

Most volunteer monitoring projects evaluate the chemical, physical, or biological condition of waters in a given watershed. They may address different kinds of waters—e.g., streams with associated embayments—and they may conduct several types of monitoring activities. Some projects may address only one type of monitoring in one type of waterbody, e.g., nutrient sampling in estuaries. More comprehensive projects may take basic chemical measurements of conditions such as dissolved oxygen levels, pH, or salinity, evaluate the physical condition of streamside habitat, and evaluate the biological condition of aquatic insects or vegetation.

Not only do volunteer projects monitor many different parameters and types of waters, they are also organized and supported in many different ways. Volunteer monitoring projects may be associated with state, interstate, local, or federal agencies, with environmental organizations or universities, or may be entirely independent. Financial support may come from government grants, partnerships with business, endowments, independent fundraising efforts, corporate donations, membership dues, or a combination of any and all of these sources. Most volunteer projects are fairly small and have very small budgets--based on EPA's latest Directory of Volunteer Environmental Monitoring Programs, 4th Edition, we know that the median program size is 25 volunteers, and the median annual budget is under $5,000. However, there are also volunteer programs with over 1,000 volunteers and those with annual budgets of more than $50,000.

### Top 20 Parameters Assessed by Volunteer Monitors

- Water temperature
- pH
- Dissolved Oxygen
- Macroinvertebrates
- Debris clean-up
- Habitat assessments
- Nitrogen
- Phosphorus
- Turbidity
- Coliform bacteria
- Secchi depth
- Aquatic vegetation
- Flow
- Birds/Wildlife
- Fish
- Watershed mapping
- Rainfall
- Photographic surveys
- Salinity
- Sediment assessments

Source: Directory of Volunteer Environmental Monitoring Programs, 4th Edition
Although the goals and objectives of volunteer projects vary greatly, virtually all volunteers hope to educate themselves and others about water quality problems and thereby promote a sense of stewardship for the environment. Many projects, in fact, establish these as their goals. These projects might be called primarily education oriented.

Other projects seek a more active role in the management of local water resources, and therefore strive to collect data that can be used in making water quality management decisions. Common uses of volunteer data include local planning decisions, such as identifying where to route a highway; local priority setting, such as determining which county lakes require restoration; screening for potential pollution problems, which might then be investigated more thoroughly by water quality agencies; and providing data for state water quality reports, which might then be used for statewide or national priority setting. Projects doing this type of monitoring might be called primarily data oriented. Data oriented volunteer projects, in particular, must continuously wrestle with the issue of credibility. They must prove to skeptics that their volunteers collect good-quality data that is:

- consistent over time and within projects and group members
- collected and analyzed using standardized and acceptable techniques
- comparable to data collected in other assessments using the same methods

These projects must adopt protocols that are straightforward enough for volunteers to master and yet sophisticated enough to generate data of value to resource managers.

This delicate and difficult path cannot be successfully navigated without a quality assurance plan that details a
project's standard operating procedures in the field and lab, outlines project organization, and addresses issues such as training requirements, instrument calibration, and internal checks on how data are collected, analyzed, and reported. Just how detailed such a plan needs to be depends to a large extent on the goals of the volunteer monitoring project.

**What Is a Quality Assurance Project Plan?**

A Quality Assurance Project Plan, or QAPP, is a written document outlining the procedures a monitoring project will use to ensure the data it collects and analyzes meets project requirements. The U.S. Environmental Protection Agency (EPA) has issued interim guidance that establishes up to 24 distinct elements of a QAPP (see Appendix C: References). Together, these elements of a QAPP comprise a project's quality assurance system. As we will discuss below, not all 24 elements need be addressed in every QAPP.

By law, any EPA-funded monitoring project must have an EPA-approved QAPP before it can begin collecting samples. The purpose of this requirement is to ensure that the data collected by monitoring projects are of known and suitable quality and quantity. Typical sources of EPA funding for volunteer monitoring projects include Lake Water Quality Assessment Grants (under Section 314 of the Clean Water Act) or grants under the nonpoint source pollution control program (Section 319 of the Clean Water Act). Quality assurance staff in each of EPA's 10 regional offices are available to review volunteer monitoring QAPPs and have authority to recommend approval or disapproval of QAPPs. In addition, volunteer monitoring coordinators and individual EPA project officers in the EPA Regions may be able to assist projects seeking advice on the preparation of QAPPs. (See Appendix A, Regional Quality Assurance Contacts.)

**About This Document**

The purpose of this document is to provide volunteer monitoring programs with the information they need to develop a quality...
The purpose of this document is to provide volunteer monitoring programs with the information they need to develop a quality assurance project plan. It does not suggest specific field, laboratory, or analytical techniques or procedures, and is not a "how to" manual. It is organized as follows:

Executive Summary introduces the reader to the steps involved in developing a QAPP, fundamental QA/QC concepts, and the basic elements of a QAPP.

Chapter 1: Introduction provides background on volunteer monitoring, discusses the purposes of QAPPs, and outlines the structure of this document.

Chapter 2: Developing a QAPP outlines the steps a volunteer monitoring project should take as it moves toward developing a quality assurance system, documenting its procedures in a QAPP, seeking approval of its QAPP, and updating the QAPP over time.

Chapter 3: QA/QC: Basic Concepts introduces basic quality assurance/quality control (QA/QC) concepts and definitions that are needed in developing a quality assurance system and a QAPP. Examples from a fictional project--the Volunteer Creek Monitoring Project--are used to illustrate these concepts.

Chapter 4: Elements of a QAPP presents the basic elements of a volunteer monitoring quality assurance project plan (QAPP), again with examples from the QAPP of the fictional Volunteer Creek Monitoring Project.

Appendix A: Glossary defines various terms and concepts associated with quality assurance and control.

Appendix B: EPA Regional Contacts is a list of people within EPA who can assist, and offer guidance to, volunteer monitoring programs. Each of the 10
EPA regions has a volunteer monitoring coordinator as well as QA staff. This appendix also shows which states and U.S. territories are within each of the 10 regions.

**Appendix C: References** is a list of documents and articles relevant to volunteer monitoring and quality assurance issues. All EPA volunteer monitoring documents are available by contacting the National Volunteer Monitoring Coordinator at USEPA. The address is given in the appendix.

**Appendix D: Abbreviated QAPP Form** is an example of the layout and structure of a quality assurance project plan. Some programs may wish to adapt this form to fit their plan.

This document is not intended as a stand-alone reference document. Volunteer monitoring programs are strongly urged to consult the references listed in Appendix C for further information on quality assurance/quality control and the Quality Assurance Project Plan process.
The purpose of this chapter is to discuss the steps a volunteer monitoring program might take in preparing a quality assurance project plan (QAPP). If your plan does not need to be approved by EPA (that is, you are not receiving EPA grant or contract money to conduct your monitoring), you need not submit your QAPP for EPA approval. In that case, consult your data users, such as the state or county water quality agency, regarding their QAPP requirements.

Developing a QAPP is a dynamic, interactive process. Seek as much feedback as possible from those who have gone before you in the QAPP development process. You will be investing a substantial amount of time and energy, but don’t be discouraged. The person who writes the QAPP is usually the one who ends up with the most technical expertise and monitoring insights. Your efforts will pay off in a living document that helps current and future volunteers, staff, and data users understand exactly how your project works.

**STEP 1**

**Establish a small QAPP team**

It will be helpful to pull together a small team of two or three people who can help you develop the QAPP. Include representatives from groups participating in the monitoring project who have technical expertise in different areas of the project.

Take the time to establish contact with your state, local or EPA Quality Assurance Officer, or other experienced volunteer organizations. Remember, if you are getting any EPA funding through a grant or contract, EPA must approve your QAPP. However, even if EPA approval isn’t needed, you can consult with

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**Steps to Developing a QAPP**

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EPA QA representatives if you need advice. Let them know a bit about your project, and find out if they have any resources that might help you out (such as a copy of an approved volunteer monitoring QAPP, or specific regional guidance on preparing plans). Also ask your QA contact if he or she would be willing to review your draft plan.

**STEP 2**

**Determine the goals and objectives of your project**

Why are you developing this monitoring project? Who will use its information, and how will it be used? What will be the basis for judging the usability of the data collected? If you don't have answers to these questions, you may flounder when it comes time to put your QAPP down on paper.

Project goals could include, for example:

- identifying trends in a lake to determine if nuisance vegetation problems are on the rise
- monitoring in conjunction with the county health department to be sure a beach is safe for swimmers
- teaching local elementary schoolers about stream macroinvertebrates
- monitoring the effectiveness of a stream restoration project

Write down your goal. The more specific your project's goal, the easier it will be to design a QAPP. Identify the objectives of your project--that is, the specific statements of how you will achieve your goal. For example, if your project's goal is to identify trends in a lake plagued by nuisance vegetation, your objectives might be to collect three years of data on weed beds, algae, and nutrients, and to develop yearly reports for nearby lake residents.
Knowing the use of the collected data will help you determine the right kind of data to collect, and the level of effort necessary to collect, analyze, store, and report it. Volunteer monitoring data can be used to screen for problems, educate youth and the community, supplement state agency data, help set statewide priorities for pollution control, and a myriad of other uses. Each use of volunteer data has potentially different requirements.

Your project should be designed to meet the needs of your data users. Data users can include the volunteers themselves, state water quality analysts, local planning agencies, parks staff, or many others. You will also probably need to strike a balance between data quality and available resources.

**STEP 3**

**Collect background information**

As you learn more about the area you are choosing to monitor, you will be better able to design an effective monitoring project. Begin by contacting programs and agencies that might already monitor in your area. Talk to the state water quality agency, the county and/or city environmental office, local universities, and neighboring volunteer monitoring programs. Ask about their sampling locations, what parameters they monitor and what methods they use.

If they are already monitoring in your chosen area, find out if they will share their data, and identify what gaps exist that your project could fill. If no monitoring is ongoing, find out what kind of data your local or state agencies could use (if one of your goals is that these agencies use your data), where they would prefer you locate your sampling sites, and what monitoring methods they recommend. Government agencies are not likely to use your data unless it fills a gap in their monitoring network and was collected using approved protocols.

A watershed survey can help you set the foundation for your monitoring project design. This is simply a practical investigation of how the watershed works, its history, and its stressors. For information on conducting a watershed survey, consult *Volunteer Stream Monitoring: A Methods Manual* (Draft, April 1995, EPA 841-D-95-001).
STEP 4

Refine your project

Once you've collected background information for your project and coordinated with potential data users, you may find it necessary to refine your original project goals and objectives. You may have found, for example, that the county already regularly monitors weed and algae growth in your lake. In that case, your project might better examine nutrient inputs from tributaries, lake water clarity, or other parameters.

Don't hesitate to reevaluate your project goals and objectives. Now is the best possible time to do so: before you've invested time, money, and effort in equipment purchases, training, grant proposals and quality assurance plan development.

STEP 5

Design your project’s sampling, analytical, and data requirements

Once you feel comfortable with your project's goals and objectives, and have gathered as much background information as possible on the area you will be monitoring, it is time to focus on the details of your project. Convene a planning committee consisting of the project coordinator, key volunteers, scientific advisors, and data users, along with your QAPP team. This committee should address the following questions:

› What parameters or conditions will you monitor, and which are most important to your needs? Which are of secondary importance?

› How good does your monitoring data need to be?

› How will you pick your sampling sites, and how will you identify them over time?

› What methods or protocols will you use for sampling and analyzing samples?

› When will you conduct the monitoring?

› How will you manage your data and ensure your data are credible?
As a general rule, it is a good idea to start small and build to a more ambitious project as your volunteers and staff grow more experienced.

**STEP 6**

*Develop an implementation plan*

You’ve done the hard part once you’ve developed your monitoring project design. The next step is to decide the particulars -- the logistics, if you will. These are, essentially, the whos and whens of your project.

Determine *who* will carry out individual tasks such as volunteer training, data management, report generation, assuring lab and field quality assurance, and recruiting volunteers. If you send your samples to an outside lab, choose the lab and specify why you chose it.

Set up schedules for *when* you will recruit and train volunteers, conduct sampling and lab work, produce reports, and report back to volunteers or the community.

**STEP 7**

*Draft your standard operating procedures and QAPP*

Now it’s time to actually write your standard operating procedures and develop a draft QAPP. Your standard operating procedures (SOPs) are the details on all the methods you expect your volunteers to use and can serve as the project handbook you give your volunteers. Remember, there are many SOPs already available for sampling and analytical procedures. Where possible, adapt your procedures from existing methods and modify them as needed to fit your project objectives. Be sure to reference and cite any existing methods and documents you use in your project.

You should append your standard operating procedures to your QAPP and refer to them throughout the QAPP document. Use the elements described in Chapter 4 as your guide in developing a draft QAPP. Your written plan can be elaborate or simple, depending on your project goals.
STEP 8

Solicit feedback on your draft SOPs and QAPP

Draft QAPP in hand, your next step is to run the draft by people "in the know." These are, primarily, state and EPA Regional volunteer monitoring coordinators and Quality Assurance Officers, EPA project officers, and any other agency data users (such as a representative from the county planning office or Natural Resource Conservation Service, if you are collecting data you hope they will use). Ask for their feedback and suggestions. Expect their review to take up to two or three months (times will vary).

Based on the comments you receive from the review of your draft plan, you may have to revise your QAPP. While you are waiting for comments, you should probably try out your procedures with volunteers on a trial basis, to see if they really work. Don't plan to use the data at this early stage, however; you will probably be finding quirks in your plan, and the data will not be accepted by your data users until the QAPP is approved and accepted.

You may find that some of your QA contacts resist the idea of reviewing your draft plan. This is because they are often quite overburdened. Don't give up; after a reasonable time has elapsed since you submitted your plan, call back and inquire if you should submit the draft elsewhere for review. Solicit all the comments you can, from as many sources as possible.

STEP 9

Revise your QAPP and submit it for final approval

Based on the comments you receive from the review of your draft plan, you may have to revise your QAPP. This could involve simply being more specific about existing methods and quality control procedures in the plan, or actually modifying your procedures to meet agency requirements. Once you have revised or fine-tuned your QAPP, submit it to the proper agency for formal approval.

Final review/approval can take a couple of months. During this time, you may be asked to incorporate additional comments, although this is less likely if you had previously asked the approving official to review your draft.

Note: If you are developing a QAPP simply to document your methods and are not working in cooperation with a state, local, or federal agency, you need not submit a QAPP for review and approval.
**STEP 10**

Once the QAPP is approved, begin your monitoring project

Once you've received EPA and/or state approval of your QAPP, your monitoring project can begin. Follow the procedures described in your QAPP to train volunteers and staff, conduct sampling, analyze samples, compile results, and develop any reports.

**STEP 11**

Evaluate and refine your project over time

As time goes on, you may decide to improve on sampling techniques, site selection, lab procedures or any of the other elements of your monitoring project design. Project evaluation should occur during the course of your project rather than after the project or a sampling season is completed.

If you make any substantive changes in your QAPP, document them and seek EPA/state approval for the changes. A phone call to your QA official can help you determine if the changes require a new QAPP. Also, always be prepared for formal audits or QC inquiries from data users during the course of your project.
As coordinator of a volunteer monitoring program, you are probably involved in many aspects of project planning, sample collection, laboratory analysis, data review, and data assessment. You should be considering quality assurance and quality control activities in every one of these steps.

Quality assurance (QA) refers to the overall management system which includes the organization, planning, data collection, quality control, documentation, evaluation, and reporting activities of your group. QA provides the information you need to ascertain the quality of your data and whether it meets the requirements of your project. QA ensures that your data will meet defined standards of quality with a stated level of confidence.

Quality control (QC) refers to the routine technical activities whose purpose is, essentially, error control. Since errors can occur in either the field, the laboratory or in the office, QC must be part of each of these functions. QC should include both internal and external measures (see side box).

Together, QA and QC help you produce data of known quality, enhance the credibility of your group in reporting monitoring results, and ultimately save time and money. However, a good QA/QC program is only successful if everyone consents to follow it and if all project components are available in writing. The Quality Assurance Project Plan (QAPP) is the written record of your QA/QC program.

This chapter is designed to introduce you to the terminology of quality assurance/quality control. The key terms we will be addressing are: precision, accuracy (sometimes referred to as bias), representativeness, completeness, comparability, and sensitivity. You will...
Measures of precision, accuracy, representativeness, completeness, comparability, and sensitivity help us evaluate sources of variability and error and thereby increase confidence in our data.

Because all projects have different goals, data users and uses, capabilities, and methods, this document cannot tell you what levels of precision, accuracy, representativeness, completeness, comparability, and sensitivity are acceptable for your individual project. You will need to consult your advisory panel (in particular, your data users), the laboratory you deal with, and peer reviewers to determine acceptance criteria for your monitoring project.

**Precision**

Precision is the degree of agreement among repeated measurements of the same characteristic on the same sample or on separate samples collected as close as possible in time and place. It tells you how consistent and reproducible your field or laboratory methods are by showing you how close your measurements are to each other. It does not mean that the sample results actually reflect the "true" value, but rather that your sampling and analysis are giving consistent results under similar conditions.

Typically, precision is monitored through the use of replicate samples or...
measurements. Replicate samples are two or more samples taken from the same place at the same time.

When you have many replicate samples, determine precision by calculating the **standard deviation(s)** of the samples. The standard deviation indicates the range of variation in the measurements you've taken. Many of today's calculators perform the standard deviation calculation.

The **relative standard deviation** (RSD), or coefficient of variation, expresses the standard deviation as a percentage. This is generally easier for others to understand. The smaller the relative standard deviation (or standard deviation), the more precise your measurements.

When you have only two replicate samples, determine precision by calculating the **relative percent difference (RPD)** of the two samples. Again, the smaller the relative percent difference, the more precise your measurements.

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**Example:**

The Volunteer Creek Monitoring Project wants to determine the precision of its temperature assessment procedure. They have taken 4 replicate samples:

- Replicate 1 ($X_1$) = 21.1°C
- Replicate 2 ($X_2$) = 21.1°C
- Replicate 3 ($X_3$) = 20.5°C
- Replicate 4 ($X_4$) = 20.0°C

To determine the **Standard Deviation (s)**, use the following formula:

$$s = \sqrt{\frac{1}{n} \sum_{i=1}^{n} (X_i - \bar{X})^2}$$

where $X_i$ = measured value of the replicate, $\bar{X}$ = mean of replicate measurements, $n$ = number of replicates, $\Sigma$ = the sum of the calculations for each measurement value—in this case, $X_1$ through $X_4$.

First, figure out the mean, or average of the sample measurements. Mean = ($X_1 + X_2 + X_3 + X_4$) / 4. In this example, the mean is equal to 20.68°C.

Then, for each sample measurement ($X_1$ through $X_4$), calculate the next part of the formula. For $X_1$ and $X_2$, the calculation would look like this:

$$\frac{21.1 - 20.68}{2} = 0.21 \times 0.0588 = 0.0108$$

For $X_3$ the calculation would be 0.0108; and for $X_4$ it would be 0.1541.

Finally, add together the calculations for each measurement and find the square root of the sum: $0.0588 + 0.0588 + 0.0108 + 0.1541 = 0.2825$. The square root of 0.2825 is 0.5315.

So, the standard deviation for temperature is 0.532 (rounded off).

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**Example:**

If the Volunteer Creek project had only two replicates (21.1°C and 20.5°C) they would use **Relative Percent Difference (RPD)** to determine precision.

$$RPD = \frac{(X_1 - X_2) \times 100}{(X_1 + X_2) ÷ 2}$$

where $X_1$ = the larger of the two values and $X_2$ = the smaller of the two values. In this example, $X_1 = 21.1°C$ and $X_2 = 20.5°C$.

$$RPD = \frac{(21.1 - 20.5) \times 100}{(21.1 + 20.5) ÷ 2} = \frac{60.00}{20.8} = 2.88$$

So, in this example, the RPD between our sample measurements is 2.88%.
Accuracy

Accuracy is a measure of confidence in a measurement. The smaller the difference between the measurement of a parameter and its "true" or expected value, the more accurate the measurement. The more precise or reproducible the result, the more reliable or accurate the result.

Measurement accuracy can be determined by comparing a sample that has a known value, such as a standard reference material or a performance evaluation sample, to a volunteer's measurement of that sample (see note below). Increasingly, however, some scientists, especially those involved with statistical analysis of measurement data, have begun to use the term "bias" to reflect this error in the measurement system and to use "accuracy" as indicating both the degree of precision and bias (see "bullseye" figure at left). For the purpose of this document, the term "accuracy" will be used.

If you are concerned that other components of a sample matrix (e.g., soil or sludge) may be interfering with analysis of a parameter, one way to measure accuracy is to add a known concentration of the parameter to a portion of the sample. This is called a spiked sample. The difference between the original measurement of the parameter in the sample and the measurement of the spiked sample should equal (or be close to) the added amount. The difference indicates your ability to obtain an accurate measurement.

For many parameters such as secchi depth and macroinvertebrate abundance, no standard reference or performance evaluation samples exist. In these cases, the trainer's results may be considered the reference value to

PRECISION, BIAS, AND ACCURACY

Accuracy is a measure of confidence in a measurement. The smaller the difference between the measurement of a parameter and its "true" or expected value, the more accurate the measurement. The more precise or reproducible the result, the more reliable or accurate the result.

Measurement accuracy can be determined by comparing a sample that has a known value, such as a standard reference material or a performance evaluation sample, to a volunteer's measurement of that sample (see note below). Increasingly, however, some scientists, especially those involved with statistical analysis of measurement data, have begun to use the term "bias" to reflect this error in the measurement system and to use "accuracy" as indicating both the degree of precision and bias (see "bullseye" figure at left). For the purpose of this document, the term "accuracy" will be used.

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For many parameters such as secchi depth and macroinvertebrate abundance, no standard reference or performance evaluation samples exist. In these cases, the trainer's results may be considered the reference value to

ACCURACY

Attendance at QC training sessions is required for Volunteer Creek monitors. In the field, monitors use a Jones Wide-Range pH Kit, which covers a full range of expected pH values. During a recent training session, the monitors recorded the following results when testing a pH standard buffer solution of 7.0 units.

<p>| | | | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>7.5</td>
<td>7.2</td>
<td>6.5</td>
<td>7.0</td>
</tr>
<tr>
<td>7.4</td>
<td>6.8</td>
<td>7.2</td>
<td>7.4</td>
</tr>
<tr>
<td>6.7</td>
<td>7.3</td>
<td>6.8</td>
<td>7.2</td>
</tr>
</tbody>
</table>

Accuracy = average value - true value

The average of these measurements is equal to 7.08 units. Since we know that the reference or "true" value is 7.0 units, the difference between the average pH value is off or biased by + 0.08 units. This level of accuracy is satisfactory for the data quality objectives of the project.
which the volunteer's results are compared. This process will help evaluate if the volunteer measurements are biased as compared to the trainer's.

If you are monitoring biological conditions by collecting and identifying specimens, maintaining a voucher collection is a good way to determine if your identification procedures are accurate. The voucher collection is a preserved archive of the organisms your volunteers have collected and identified. An expert taxonomist can then provide a "true" value by checking the identification in the voucher collection.

It is important to note that the relationship between a voucher collection and accurate identification cannot be expressed numerically in your QAPP. Rather, the QAPP document should indicate that you have a voucher collection and describe how it is used to evaluate consistent accurate identification in your program.

Note: Standard reference material (in the form of solids or solutions with a certified known concentration of pollutant) can be obtained from a variety of companies, including the National Institute of Standard and Technologies, that sell quality control, proficiency, or scientific reference materials.

Representativeness

Representativeness is the extent to which measurements actually depict the true environmental condition or population you are evaluating. A number of factors may affect the representativeness of your data. For instance, are your sampling locations indicative of the waterbody? Data collected just below a pipe outfall is not representative of an entire stream. Minimizing the effects of variation is critical in the development of your sampling design.

Completeness

Completeness is a measure of the number of samples you must take to be able to use the information, as compared to the number of samples you originally planned to take. Since there are many reasons why your volunteers may not collect as many samples as planned, as a general rule you should try to take more samples than you determine you actually need. This issue should be discussed within your QAPP team and by peer reviewers before field activities begin.
To calculate percent completeness, divide the number of measurements that have been judged valid by the total number of measurements you originally planned to take and then multiply by 100.

Remember, completeness requirements can be lowered if extra samples are factored into the project. The extra samples in turn, increase the likelihood of more representative data.

**Comparability**

Comparability is the extent to which data from one study can be compared directly to either past data from the current project or data from another study. For example, you may wish to compare two seasons of summer data from your project or compare your summer data set to one collected 10 years ago by state biologists.

Using standardized sampling and analytical methods, units of reporting, and site selection procedures helps ensure comparability. However, it is important to keep in mind that some types of monitoring rely heavily on best professional judgement and that standard methods may not always exist.

**Detection Limit**

The term detection limit can apply to monitoring and analytical instruments as well as to methods. In general, detection limit is defined as the lowest concentration of a given pollutant your methods or equipment can detect and report as greater than zero. Readings that fall below the detection limit are too unreliable to use in your data set. Furthermore, as readings approach the detection limit (that is, as they go from higher, easier-to-detect concentrations to lower, harder-to-detect concentrations) they become less and less reliable. Manufacturers generally provide detection limit information with high-grade monitoring equipment such as meters.

**Measurement Range**

The measurement range is the range of reliable measurements of an instrument or measuring device. Preassembled kits usually come with information indicating
the measurement range that applies. For example, you might purchase a kit that is capable of detecting pH falling between 6.1 and 8.1. However, pH can theoretically range from 0.0 to 14.00. If acidic conditions (below 6) are a problem in the waters you are monitoring, you will need to use a kit or meter that is sensitive to the lower pH ranges.

**Quality Control (QC) Samples**

Contamination is a common source of error in both sampling and analytical procedures. QC samples help you identify when and how contamination might occur. For most projects, there is no set number of field or laboratory QC samples which must be taken. The general rule is that 10% of samples should be QC samples. This means that if 20 samples are collected, at least one additional sample must be added as a QC sample. The laboratory must also run its own QC samples. For a new monitoring project or for a new analytical procedure, it is a good idea to increase the number of QC samples (up to 20%) until you have full confidence in the procedures you are using.

When the project is over, determine data quality by evaluating the results of all the QC samples and determining precision and accuracy. For QC samples that are not blind to the lab, require the lab to calculate and report precision and accuracy results. Lab reported precision and accuracy results can then be checked during data validation.

The decision to accept data, reject it, or accept only a portion of it is should be made after analysis of all QC data. Various types of QC samples are described in the box on the next page.
A field blank is a “clean” sample, produced in the field, used to detect analytical problems during the whole process (sampling, transport, and lab analysis). To create a field blank, take a clean sampling container with "clean" water (i.e., distilled or deionized water that does not contain any of the substance you are analyzing for) to the sampling site. Other sampling containers will be filled with water from the site. Except for the type of water in them, the field blank and all site samples should be handled and treated in the same way. For example, if your method calls for the addition of a preservative, this should be added to the field blank in the same manner as in the other samples. When the field blank is analyzed, it should read as analyte-free or, at a minimum, the reading should be a factor of 5 below all sample results.

An equipment or rinsate blank is a “clean” sample used to check the cleanliness of sample collection equipment. This type of blank is used to evaluate if there is carryover contamination from reuse of the same sampling equipment. A sample of distilled water is collected in a sample container using regular collection equipment and analyzed as a sample.

A split sample is one sample that is divided equally into two or more sample containers and then analyzed by different analysts or labs. Split samples are used to measure precision. Samples should be thoroughly mixed before they are divided. Large errors can occur if the analyte is not equally distributed into the two containers. A sample can be split in the field, called a field split, or in the laboratory, a lab split. The lab split measures analytical precision while the field split measures both analytical and field sampling precision. In addition, a sample split in the field and submitted to the laboratory without informing the laboratory represents a blind sample. Split samples can also be submitted to two different laboratories for analysis to measure the variability in results between laboratories independently using the same analytical procedures.

Replicate samples are obtained when two or more samples are taken from the same site, at the same time, using the same method, and independently analyzed in the same manner. When only two samples are taken, they are sometimes referred to as duplicate samples. These types of samples are representative of the same environmental condition. Replicates (or duplicates) can be used to detect both the natural variability in the environment and that caused by field sampling methods.

Spiked samples are samples to which a known concentration of the analyte of interest has been added. Spiked samples are used to measure accuracy. If this is done in the field, the results reflect the effects of preservation, shipping, laboratory preparation, and analysis. If done in the laboratory, they reflect the effects of the analysis from the point when the compound is added, e.g. just prior to the measurement step. Percent recovery of the spike material is used to calculate analytical accuracy.
Chapter 4: Elements of a QAPP

This chapter discusses the 24 elements of a Quality Assurance Project Plan, as outlined in EPA quality assurance guidance, *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations* (EPA QA/R-5, August 1994). It is very likely that not all elements will apply to your project. This is an issue that should be discussed with your QAPP team and any group who will be approving the QAPP. If your project does not require all 24 elements, indicate in your QAPP which elements you will not be including. This will make review and approval of your QAPP faster and easier.

Throughout this chapter, brief examples are included. The examples are drawn from a fictional monitoring project—the *Volunteer Creek Monitoring Project*. They are not intended to be comprehensive, but rather simply to help illustrate the type of information that might be included in the elements of a QAPP. For more information, you may wish to contact other volunteer monitoring programs with approved QAPPs.

1. **Title and Approval Page**

Your title page should include the following:

- title and date of the QAPP
- names of the organizations involved in the project
- names, titles, signatures, and document signature dates of all appropriate approving officials such as project manager, project QA officer, and, if the project is funded by EPA, the EPA project manager and QA officer.

<table>
<thead>
<tr>
<th>Elements of a QAPP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Management (elements 1-9)</strong></td>
</tr>
<tr>
<td>1. Title and Approval Page</td>
</tr>
<tr>
<td>2. Table of Contents</td>
</tr>
<tr>
<td>3. Distribution List</td>
</tr>
<tr>
<td>4. Project/Task Organization</td>
</tr>
<tr>
<td>5. Problem Identification/ Background</td>
</tr>
<tr>
<td>6. Project/Task Description</td>
</tr>
<tr>
<td>7. Data Quality Objectives for Measurement Data</td>
</tr>
<tr>
<td>8. Training Requirements/ Certification</td>
</tr>
<tr>
<td>9. Documentation and Records</td>
</tr>
<tr>
<td><strong>Measurement/Data Acquisition (elements 10-19)</strong></td>
</tr>
<tr>
<td>10. Sampling Process Design</td>
</tr>
<tr>
<td>11. Sampling Methods Requirements</td>
</tr>
<tr>
<td>12. Sample Handling and Custody Requirements</td>
</tr>
<tr>
<td>13. Analytical Methods Requirements</td>
</tr>
<tr>
<td>14. Quality Control Requirements</td>
</tr>
<tr>
<td>15. Instrument/Equipment Testing, Inspection, and Maintenance Requirements</td>
</tr>
<tr>
<td>16. Instrument Calibration and Frequency</td>
</tr>
<tr>
<td>17. Inspection/Acceptance Requirements for Supplies</td>
</tr>
<tr>
<td>18. Data Acquisition Requirements</td>
</tr>
<tr>
<td>19. Data Management</td>
</tr>
<tr>
<td><strong>Assessment and Oversight (elements 20-21)</strong></td>
</tr>
<tr>
<td>20. Assessment and Response Actions</td>
</tr>
<tr>
<td>21. Reports</td>
</tr>
<tr>
<td><strong>Data Validation and Usability (elements 22-24)</strong></td>
</tr>
<tr>
<td>22. Data Review, Validation, and Verification Requirements</td>
</tr>
<tr>
<td>23. Validation and Verification Methods</td>
</tr>
<tr>
<td>24. Reconciliation with Data Quality Objectives</td>
</tr>
</tbody>
</table>
Table of Contents
A Table of Contents should include section headings with appropriate page numbers and a list of figures and tables.

Distribution List
List the individuals and organizations that will receive a copy of your approved QAPP and any subsequent revisions. Include representatives of all groups involved in your monitoring effort.

Project/Task Organization
Identify all key personnel and organizations that are involved in your program, including data users. List their specific roles and responsibilities. In many monitoring projects, one individual may have several responsibilities. An organizational chart is a good way to graphically display the roles of key players.

Element 4
Project/Task Organization
In addition to the project officers shown, the Volunteer Creek Monitoring Project also has an Advisory Panel consisting of representatives from EPA, the state Department of Environmental Conservation (DEC), and the County Department of Public Works (DPW). Each of the leaders shown serves on the Advisory Panel. Major responsibilities of all personnel are detailed in the Volunteer Creek SOPs, attached to this document. The primary data users are the state DEC and the County DPW.
Problem Definition / Background

In a narrative, briefly state the problem your monitoring project is designed to address. Include any background information such as previous studies that indicate why this project is needed. Identify how your data will be used and who will use it.

Project/Task Description

In general terms, describe the work your volunteers will perform and where it will take place. Identify what kinds of samples will be taken, what kinds of conditions they will measure, which are critical, and which are of secondary importance. Indicate how you will evaluate your results— that is, how you will be making sense out of what you find. For example, you may be comparing your water quality readings to State or EPA standards, or comparing your macroinvertebrate evaluations to State-established reference conditions or historical information.
Include an overall project timetable that outlines beginning and ending dates for the entire project as well as for specific activities within the project. The timetable should include information about sampling frequency, lab schedules, and reporting cycles.

**Element 6**

**Project/Task Description**

From January through March 1996, the Watershed Association will conduct initial volunteer recruitment and training in conjunction with the county and state. A second recruitment drive as well as training and retraining sessions will be held from August to October.

Monthly water sampling of temperature, pH, turbidity, and dissolved oxygen will occur throughout the calendar year at each of 20 sites. At the same sites, macroinvertebrate and habitat assessments will be conducted in March, July, and October. In order to characterize the stream and to create a baseline of data, each of these evaluations is a critical component of the overall study. For informational and educational purposes, volunteers will also record characteristics such as water odor and color during each assessment. Macroinvertebrate taxonomy will take place in April, August, and November at the state university biology laboratory.

Following each assessment, all data will be entered into the computerized management system and analyzed. Interim report of findings will be produced and distributed in May and September. A final, year-end report will be produced and distributed in January 1997.

<table>
<thead>
<tr>
<th>MAJOR TASK CATEGORIES</th>
<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>volunteer recruitment, training, and re-training</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>monthly pH, temp., turbidity, &amp; dissolved oxygen sampling</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>seasonal macroinvertebrate &amp; habitat assessments</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>lab analysis</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>data processing, analysis &amp; reporting</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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</tr>
</tbody>
</table>

**Data Quality Objectives for Measurement Data**

Data Quality Objectives (DQOs) are the quantitative and qualitative terms you use to describe how good your data need to be to meet your project's objectives. DQOs for measurement data (referred to here as data quality indicators) are precision, accuracy, representativeness, completeness, comparability, and measurement range. Provide information on these indicators, in quantitative terms if possible. See Chapter 3 for a further discussion of these terms.

Since it is important to develop a QAPP prior to monitoring, it may not be possible to include actual numbers for some of the data quality measurements.
within the first version of the document. You will need, however, to discuss your goals or objectives for data quality and the methods you will use to make actual determinations after monitoring has begun. You must also discuss at what point changes will be made if project specifications are not achieved. Data quality indicators should be given for each parameter you are measuring, in each "matrix" (i.e., substance you are sampling from, such as water or sediment). The easiest way to present quantitative information is in a table.

In some types of monitoring, particularly macroinvertebrate monitoring and habitat assessment, some data quality indicators cannot be quantitatively expressed. In that case, you can fulfill this requirement of the QAPP by citing and describing the method used and by providing as many of the data quality indicators as possible (e.g., completeness, representativeness, and comparability) in narrative form.

**Precision** is the degree of agreement among repeated measurements of the same characteristic, or parameter, and gives information about the consistency of your methods.

**Accuracy** is a measure of confidence that describes how close a measurement is to its “true” value.

---

### Data Quality Objectives for Measurement Data

**Precision, Accuracy, Measurement Range**

The following table illustrates the precision, accuracy and measurement range for the Volunteer Creek pH, temperature, turbidity, and dissolved oxygen assessments.

<table>
<thead>
<tr>
<th>Matrix</th>
<th>Parameter</th>
<th>Precision</th>
<th>Accuracy</th>
<th>MR*</th>
</tr>
</thead>
<tbody>
<tr>
<td>water</td>
<td>pH</td>
<td>±20%</td>
<td>±0.5</td>
<td>3 to 10.5 units</td>
</tr>
<tr>
<td>water</td>
<td>temperature</td>
<td>±20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>water</td>
<td>dissolved oxygen</td>
<td>±20%</td>
<td>±0.3mg/L</td>
<td>1 to 20 mg/L</td>
</tr>
<tr>
<td>water</td>
<td>turbidity</td>
<td>±20%</td>
<td>±0.2mg/L</td>
<td>0 to 1000 NTU</td>
</tr>
</tbody>
</table>

* MR = measurement range

**Representativeness**

In the Volunteer Creek project's assessment, representativeness depends largely on randomized sampling. The creek is a high-gradient stream with a predominance of riffle habitats. Monitoring sites selected for this study are indicative of that habitat type and the program uses sampling techniques developed for high-gradient streams. In addition, for the macroinvertebrate collection, volunteers sample at three locations within the riffle and then composite (combine) the samples so as to be more generally reflective of the entire riffle habitat.

**Comparability**

One of the ways that the Volunteer Creek program ensures comparability is to follow the monitoring protocol established by the State for assessment and analysis. Volunteers also use standardized taxonomic keys to identify macroinvertebrates to the family level.

**Completeness**

There are no legal or compliance uses anticipated for the Volunteer Creek data. In addition, there is no fraction of the planned data that must be collected in order to fulfill a statistical criteria. It is expected that samples will be collected from at least 90% of the sites unless unanticipated weather conditions prevent sampling.
**Measurement Range** is the range of reliable readings of an instrument or measuring device, as specified by the manufacturer.

**Representativeness** is the extent to which measurements actually represent the true environmental condition.

**Comparability** is the degree to which data can be compared directly to similar studies. Using standardized sampling, analytical methods, and units of reporting helps to ensure comparability.

**Completeness** is the comparison between the amount of data you planned to collect versus how much usable data you collected, expressed as a percentage.

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**Training Requirements / Certification**

Identify any specialized training or certification requirements your volunteers will need to successfully complete their tasks. Discuss how you will provide such training, who will be conducting the training, and how you will evaluate volunteer performance.

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**Element 8
Training Requirements / Certification**

Volunteer Creek monitors participate in a two-day field training course conducted by state and local water quality personnel. On the first day, volunteers are instructed how to calibrate equipment and perform physical and chemical tests and analyses. The second day is devoted to macroinvertebrate and habitat sampling. Volunteers for the taxonomy lab receive a separate day of training. All participants are required to attend an annual refresher course as well.

Performance is evaluated in the field and the lab. During initial and renewal training sessions, volunteers perform a simultaneous dip-in determination of pH, temperature, and dissolved oxygen. Volunteers also determine turbidity levels of water samples using meters at the lab. In addition, during training, participants conduct macroinvertebrate sampling in small groups with trainers. To evaluate volunteer skill in the taxonomy lab, volunteers are trained and re-trained using previously identified samples from earlier assessments.
**DOCUMENTATION AND RECORDS**

Identify the field and laboratory information and records you need for this project. These records may include raw data, QC checks, field data sheets, laboratory forms, and voucher collections. Include information on how long, and where, records will be maintained. Copies of all forms to be used in the project should be attached to the QAPP.

Each Volunteer Creek field sampling sheet must be completed on-site at the time sampling occurs. Volunteers record site number, location, the date and time the sample was collected, and the name of each team member. Contact information for the team captain or monitor responsible for returning field sheets and macroinvertebrate samples to the watershed association office is also included on each field sheet.

Volunteers make a copy of each field sheet and keep the copy with their records. The original is returned to the Volunteer Creek Watershed Association office along with the macroinvertebrate sample (if taken). Field sheets are archived for three years. After macroinvertebrate samples have been identified, laboratory record sheets are maintained in the watershed association office for three years. Hard copies of all data as well as computer back-up disks are maintained by the Association. A macroinvertebrate voucher collection is maintained by the state university biology lab for five years.

<table>
<thead>
<tr>
<th>VOLUNTEER CREEK MONITORING PROJECT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Site #: _____</strong></td>
</tr>
<tr>
<td>**Date: / / **</td>
</tr>
<tr>
<td><strong>Team Captain:</strong></td>
</tr>
<tr>
<td><strong>Address:</strong></td>
</tr>
<tr>
<td><strong>Other Monitoring Team Members:</strong></td>
</tr>
</tbody>
</table>

Chapter 4: Elements of a QAPP
Volunteer Creek monitoring sites are sampled monthly for pH, temperature, turbidity, and dissolved oxygen. In March, July and October, a macroinvertebrate and habitat assessment is conducted at each site. Monitoring sites are identified by a number and a location.

If possible, volunteers are asked to wait at least 10 days after a heavy rain or snowfall before sampling. If this is not possible, they are instructed to contact the Field Leader so that this information can be noted immediately. In addition, if volunteers cannot conduct the scheduled sampling, they are instructed to contact the Field Leader as soon as possible, so that an alternative monitor can be found. Volunteers are instructed to work in teams of at least two people. Three team members are recommended for the macroinvertebrate sampling. If a scheduled team cannot conduct the sampling together, the team captain is instructed to contact the Field Leader so that arrangements can be made for a substitute.

Prior to final site selection, permission to access the stream is obtained from all property owners. If for some reason access to the site is a problem, the team captain is instructed to contact the Field Leader. All constraints and safety plans are detailed in the Volunteer Creek SOPs.

Four, or 20%, of the sampling sites surround Volunteer Creek Boulevard, which is being widened to accommodate growing residential and commercial development. They are located as follows:

- Site #1 adjacent to the new townhome development in the Happy Lakes Community
- Site #2 downstream of the confluence with Urban Creek
- Site #3 at the crossing of Volunteer Creek Boulevard
- Site #4 within Volunteer Park, adjacent to the picnic area
Sampling Methods Requirements

Describe your sampling methods. Include information on parameters to be sampled, how samples will be taken, equipment used, and containers used, sample preservation methods used, and holding times (time between taking samples and analyzing them). If samples are composited (i.e., mixed), describe how this will be done. Describe procedures for decontamination and equipment cleaning. (For example, kick nets need to be thoroughly rinsed and examined for clinging organisms between sampling events.) Most of this information can be presented in a table or you may also cite any SOPs that contain this information.

 ELEMENT 11
Sampling Methods Requirements

The Volunteer Creek SOP, attached to this document, contains detailed information on all sampling protocols and equipment. The table below summarizes a portion of this information.

<table>
<thead>
<tr>
<th>Matrix</th>
<th>Parameter</th>
<th>Sampling Equipment</th>
<th>Sample Holding Container</th>
<th>Method Sample Preservative</th>
<th>Maximum Holding Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>water</td>
<td>pH</td>
<td>Jones pH color comparator kits</td>
<td>screw top, glass sample bottle</td>
<td>none</td>
<td>immediately</td>
</tr>
<tr>
<td>water</td>
<td>temperature</td>
<td>Smith armored thermometer</td>
<td>none, measurement taken instream</td>
<td>none</td>
<td>immediately</td>
</tr>
<tr>
<td>water</td>
<td>dissolved oxygen</td>
<td>Jones DO kit</td>
<td>screw top, glass sample bottle</td>
<td>none</td>
<td>immediately</td>
</tr>
<tr>
<td>water</td>
<td>turbidity</td>
<td>Jones turbidity meter</td>
<td>screw top glass sample bottle</td>
<td>store on ice</td>
<td>48 hours</td>
</tr>
<tr>
<td>substrate</td>
<td>macroinvertebrates</td>
<td>3' X 3' kicknet; 500 micron mesh</td>
<td>1 liter plastic wide-mouth bottle</td>
<td>90% ethyl alcohol</td>
<td>6 weeks</td>
</tr>
</tbody>
</table>
Sample Handling and Custody Requirements

Sample handling procedures apply to projects that bring samples from the field to the lab for analysis, identification, or storage.

These samples should be properly labeled in the field. At a minimum, the sample identification label should include sample location, sample number, date and time of collection, sample type, sampler's name, and method used to preserve sample.

Describe the procedures used to keep track of samples that will be delivered or shipped to a laboratory for analysis. Include any chain-of-custody forms and written procedures field crews and lab personnel should follow when collecting, transferring, storing, analyzing, and disposing of samples.

All macroinvertebrate samples collected as part of the Volunteer Creek project are labeled in the field. The chain-of-custody for these samples is as follows: In the field, samples are the responsibility of, and stay with, the team captain. Once samples have been collected, they are returned, by the monitoring team captain, to the Volunteer Creek Watershed Association office for temporary storage. The date and time of arrival is recorded by the Field Leader who is then responsible for transporting samples to the university laboratory for analysis. The date and time of arrival is also recorded at the lab by the Laboratory Leader. After samples are analyzed, laboratory information is added to the label. Samples are then stored and maintained in the university's biological lab for a minimum of three years. A chain-of-custody form is used to record all transport and storage information.
**Analytical Methods Requirements**

List the analytical methods and equipment needed for the analysis of each parameter, either in the field or the lab. If your program uses standard methods, cite these. If your program's methods differ from the standard or are not readily available in a standard reference, describe the analytical methods or cite and attach the program's SOPs.

**Quality Control Requirements**

List the number and types of field and laboratory quality control samples your volunteers will take. (See Chapter 3 for a discussion of quality control samples.) This information can be presented in a table. If you use an outside laboratory, cite or attach the lab's QA/QC plan.

QC checks for biological monitoring programs can be described narratively, and, if appropriate, should include discussion of replicate sample collection, cross checks by different field crews, periodic sorting checks of lab samples, and maintenance of voucher and reference collections. Describe what actions you will take if the QC samples reveal a sampling or analytical problem.
**Element 15**

**Instrument/Equipment Testing, Inspection, and Maintenance Requirements**

Describe your plan for routine inspection and preventive maintenance of field and lab equipment and facilities. Identify what equipment will be routinely inspected, and what spare parts and replacement equipment will be on hand to keep field and lab operations running smoothly. Include an equipment maintenance schedule, if appropriate.

**Element 16**

**Instrument Calibration and Frequency**

Identify how you will calibrate sampling and analytical instruments. Include information on how frequently instruments will be calibrated, and the types of standards or certified equipment that will be used to calibrate sampling instruments. Indicate how you will maintain calibration.

---

The Volunteer Creek project’s turbidity meters will be calibrated, prior to each sampling event, according to the manufacturer’s instructions and using the manufacturer’s turbidity standards. Calibration results are recorded in a log book and maintained by the Lab Manager. Calibration procedures and standards are contained in the SOP manual, available upon request.
records and ensure that records can be traced to each instrument. Instrument calibration procedures for biological monitoring programs should include routine procedures that ensure that equipment is clean and in working order.

17 Inspection and Acceptance Requirements for Supplies
Describe how you determine if supplies such as sample bottles, nets, and reagents are adequate for your program's needs.

18 Data Acquisition Requirements
Identify any types of data your project uses that are not obtained through your monitoring activities. Examples of these types of data include historical information, information from topographical maps or aerial photos, or reports from other monitoring groups. Discuss any limits on the use of this data resulting from uncertainty about its quality.
**19 Data Management**

Trace the path your data take, from field collection and lab analysis to data storage and use. Discuss how you check for accuracy and completeness of field and lab forms, and how you minimize and correct errors in calculations, data entry to forms and databases, and report writing. Provide examples of forms and checklists. Identify the computer hardware and software you use to manage your data.

**20 Assessments and Response Actions**

Discuss how you evaluate field, lab, and data management activities, organizations (such as contract labs) and individuals in the course of your project. These can include evaluations of volunteer performance (for example, through field visits by staff or in laboratory refresher sessions); audits of systems such as equipment and analytical procedures; and audits of data quality (e.g., comparing actual data results with project quality objectives).

Include information on how your project will correct any problems identified through these assessments. Corrective actions might include calibrating equipment more frequently, increasing the
number of regularly scheduled training sessions, or rescheduling field or lab activities.

### 21 Reports

Identify the frequency, content, and distribution of reports to data users, sponsors, and partnership organizations that detail project status, results of internal assessments and audits, and how QA problems have been resolved.


### Data Review, Validation and Verification Requirements

State how you review data and make decisions regarding accepting, rejecting, or qualifying the data. All that is needed here is a brief statement of what will be done, by whom.

### Validation and Verification Methods

Describe the procedures you use to validate and verify data. This can include, for example, comparing computer entries to field data sheets; looking for data gaps; analyzing quality control data such as chain of custody information, spikes, and equipment calibrations; checking calculations; examining raw data for outliers or nonsensical readings; and reviewing graphs, tables and charts. Include a description of how errors, if detected, will be corrected, and how results will be conveyed to data users.
Reconciliation with Data Quality Objectives

Once the data results are compiled, describe the process for determining whether the data meet project objectives. This should include calculating and comparing the project’s actual data quality indicators (precision, accuracy, completeness, representativeness, and comparability) to those you specified at the start of the project, and describing what will be done if they are not the same. Actions might include discarding data, setting limits on the use of the data, or revising the project's data quality objectives.
Appendix A: Glossary

**Accuracy.** A data quality indicator, accuracy is the extent of agreement between an observed value (sampling result) and the accepted, or true, value of the parameter being measured. High accuracy can be defined as a combination of high precision and low bias.

**Analyte.** Within a medium, such as water, an analyte is a property or substance to be measured. Examples of analytes would include pH, dissolved oxygen, bacteria, and heavy metals.

**Bias.** Often used as a data quality indicator, bias is the degree of systematic error present in the assessment or analysis process. When bias is present, the sampling result value will differ from the accepted, or true, value of the parameter being assessed.

**Blind sample.** A type of sample used for quality control purposes, a blind sample is a sample submitted to an analyst without their knowledge of its identity or composition. Blind samples are used to test the analyst’s or laboratory’s expertise in performing the sample analysis.

**Comparability.** A data quality indicator, comparability is the degree to which different methods, data sets, and/or decisions agree or are similar.

**Completeness.** A data quality indicator that is generally expressed as a percentage, completeness is the amount of valid data obtained compared to the amount of data planned.

**Data users.** The group(s) that will be applying the data results for some purpose. Data users can include the monitors themselves as well as government agencies, schools, universities, businesses, watershed organizations, and community groups.

**Data quality objectives (DQOs).** Data quality objectives are quantitative and qualitative statements describing the degree of the data’s acceptability or utility to the data user(s). They include indicators such as accuracy, precision, representativeness, comparability, and completeness. DQOs specify the quality of the data needed in order to meet the monitoring project's goals.
project's goals. The planning process for ensuring environmental data are of the type, quality, and quantity needed for decision making is called the DQO process.

**Detection limit.** Applied to both methods and equipment, detection limits are the lowest concentration of a target analyte that a given method or piece of equipment can reliably ascertain and report as greater than zero.

**Duplicate sample.** Used for quality control purposes, duplicate samples are two samples taken at the same time from, and representative of, the same site that are carried through all assessment and analytical procedures in an identical manner. Duplicate samples are used to measure natural variability as well as the precision of a method, monitor, and/or analyst. More than two duplicate samples are referred to as replicate samples.

**Environmental sample.** An environmental sample is a specimen of any material collected from an environmental source, such as water or macroinvertebrates collected from a stream, lake, or estuary.

**Equipment or rinsate blank.** Used for quality control purposes, equipment or rinsate blanks are types of field blanks used to check specifically for carryover contamination from reuse of the same sampling equipment (see field blank).

**Field blank.** Used for quality control purposes, a field blank is a “clean” sample (e.g., distilled water) that is otherwise treated the same as other samples taken from the field. Field blanks are submitted to the analyst along with all other samples and are used to detect any contaminants that may be introduced during sample collection, storage, analysis, and transport.

**Instrument detection limit.** The instrument detection limit is the lowest concentration of a given substance or analyte that can be reliably detected by analytical equipment or instruments (see detection limit).

**Matrix.** A matrix is a specific type of medium, such as surface water or sediment, in which the analyte of interest may be contained.

**Measurement Range.** The measurement range is the extent of reliable readings of an instrument or measuring device, as specified by the manufacturer.

**Method detection limit (MDL).** The MDL is the lowest concentration of a given substance or analyte that can be reliably detected by an analytical procedure (see detection limit).
**Performance evaluation (PE) samples.** Used for quality control purposes, a PE sample is a type of *blind sample*. The composition of PE samples is unknown to the analyst. PE samples are provided to evaluate the ability of the analyst or laboratory to produce analytical results within specified limits.

**Precision.** A data quality indicator, precision measures the level of agreement or variability among a set of repeated measurements, obtained under similar conditions. Precision is usually expressed as a *standard deviation* in absolute or relative terms.

**Protocols.** Protocols are detailed, written, standardized procedures for field and/or laboratory operations.

**Quality assurance (QA).** QA is an integrated management system designed to ensure that a product or service meets defined standards of quality with a stated level of confidence. QA activities involve planning quality control, quality assessment, reporting, and quality improvement.

**Quality assurance project plan (QAPP).** A QAPP is a formal written document describing the detailed *quality control* procedures that will be used to achieve a specific project’s data quality requirements.

**Quality control (QC).** QC is the overall system of technical activities designed to measure quality and limit error in a product or service. A QC program manages quality so that data meets the needs of the user as expressed in a *quality assurance project plan*.

**Relative standard deviation (RSD).** RSD is the *standard deviation* of a parameter expressed as a percentage and is used in the evaluation of *precision*.

**Relative percent difference (RPD).** RPD is an alternative to *standard deviation*, expressed as a percentage and used to determine precision when only two measurement values are available.

**Replicate samples.** See duplicate samples.

**Representativeness.** A data quality indicator, representativeness is the degree to which data accurately and precisely portray the actual or true environmental condition measured.

**Sensitivity.** Related to detection limits, sensitivity refers to the capability of a method or instrument to discriminate between measurement responses.
Standard Reference Materials (SRMs) are produced by the U. S. National Institute of Standards and Technology (NIST) and characterized for absolute content independent of any analytical method.

**Spiked samples.** Used for quality control purposes, a spiked sample is a sample to which a known concentration of the target analyte has been added. When analyzed, the difference between an environmental sample and the analyte’s concentration in a spiked sample should be equivalent to the amount added to the spiked sample.

**Split sample.** Used for quality control purposes, a split sample is one that has been equally divided into two or more subsamples. Splits are submitted to different analysts or laboratories and are used to measure the precision of the analytical methods.

**Standard reference materials (SRM).** An SRM is a certified material or substance with an established, known and accepted value for the analyte or property of interest. Employed in the determination of bias, SRMs are used as a gauge to correctly calibrate instruments or assess measurement methods. SRMs are produced by the U. S. National Institute of Standards and Technology (NIST) and characterized for absolute content independent of any analytical method.

**Standard deviation(s).** Used in the determination of precision, standard deviation is the most common calculation used to measure the range of variation among repeated measurements. The standard deviation of a set of measurements is expressed by the positive square root of the variance of the measurements.

**Standard operating procedures (SOPs).** An SOP is a written document detailing the prescribed and established methods used for performing project operations, analyses, or actions.

**True value.** In the determination of accuracy, observed measurement values are often compared to true, or standard, values. A true value is one that has been sufficiently well established to be used for the calibration of instruments, evaluation of assessment methods or the assignment of values to materials.

**Variance.** A statistical term used in the calculation of standard deviation, variance is the sum of the squares of the difference between the individual values of a set and the arithmetic mean of the set, divided by one less than the numbers in the set.
Each of EPA’s 10 Regional offices has a volunteer monitoring coordinator and quality assurance officers who can be of assistance to volunteer programs. Listed below are the contact names for each region, as of September 1, 1996. These contacts may change over time.

### EPA Regional Volunteer Monitoring Coordinators

<table>
<thead>
<tr>
<th>Region</th>
<th>Name</th>
<th>Contact Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Diane Switzer</td>
<td>USEPA Region I 1 1255 Courtland Street Atlanta, GA 30365 404-347-2126 (x6590)</td>
</tr>
<tr>
<td>2</td>
<td>Tom Davenport</td>
<td>USEPA Region V 77 W. Jackson Blvd. Chicago, IL 60604 312-886-7804</td>
</tr>
<tr>
<td>3</td>
<td>Diane Calesso</td>
<td>USEPA Region II 345 Courtland Street Atlanta, GA 30365 404-347-2126 (x6590)</td>
</tr>
<tr>
<td>4</td>
<td>Mike Bira</td>
<td>USEPA Region VI (6WQS) 1445 Ross Avenue 12th Floor, Suite 120 Dallas, TX 75202-2733</td>
</tr>
<tr>
<td>5</td>
<td>Chuck Kanetsky</td>
<td>USEPA Region III 841 Chestnut Bldg. Philadelphia, PA 19107 215-566-2735</td>
</tr>
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### Which EPA region are you in?

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<th>Region</th>
<th>States/Regions</th>
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<td>3</td>
<td>DE, DC, MD, PA, VA, WV</td>
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<td>4</td>
<td>AL, FL, GA, KY, MS, NC, SC, TN</td>
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<td>AR, LA, NM, OK, TX</td>
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<td>7</td>
<td>IA, KS, MO, NE</td>
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<td>CO, MT, ND, SD, UT, WY</td>
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<td>9</td>
<td>AZ, CA, NV, GU, HI, AS</td>
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<tr>
<td>10</td>
<td>AK, ID, OR, WA</td>
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</tbody>
</table>
Regional Quality Assurance Officers

Nancy Barmakian
USEPA Region I
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60 Westview Street
Lexington, MA 02173-3185
617-860-4684

Robert Runyon
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908-321-6645

Charles Jones, Jr.
USEPA (3ES00) Region III
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Diann Sims
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Claudia Walters
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Willie Harris
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Chicago, IL 60604

Jerry Pitt
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303-312-6056

Phil Johnson
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303-312-6084

Ed Liu
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Andrea Lindsay
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1200 Sixth Avenue
Seattle, WA 98101
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Drew Puffer
Gulf of Mexico Program
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Stennis Space Ctr, MS 39529-620
601-688-3913

Alice Mayio, National Volunteer Monitoring Coordinator
USEPA (4503F)
401 M Street, SW
Washington, DC 20460
202-260-7018

The Volunteer Monitor's Guide to Quality Assurance Project Plans
Appendix B: EPA Regional Contacts
Appendix C:
REFERENCES


The following presentation paper topics, specifically relevant to quality assurance and quality control issues, are contained in the proceedings documents from past national volunteer monitoring conferences:

Proceedings of Third National Citizens' Volunteer Water Monitoring Conference.
- Goal Setting and Organizing
- Study Design
- Training Monitors
- Integrated Monitoring Systems
- Enforcement and Compliance Monitoring
- Procedures for Collecting Quality Data
- Meeting Scientific Standards for Biological Monitoring
- Deciding Data Objectives
- River and Stream Monitoring Techniques
- Lake Monitoring Techniques
- Wetland Monitoring Techniques
- Estuary Monitoring Techniques
- Computer Data Management
- Data Application and Presentation

- Designing Your Water Quality Study
- Assuring Quality Data
- Defining Data Use
- Using Your Data to Evaluate Your Volunteer Monitoring Program
- Geographic Information Systems and Volunteer Monitoring Data
- Managing Your Data: Some Basic Principles
- Data Analysis for the Technically Impaired
- Macroinvertebrate Monitoring
- Bacteria Testing
- Monitoring Restoration and Pollution Prevention Activities

Both of these documents are available upon request from the EPA National Volunteer Monitoring Coordinator.


Appendix D: Abbreviated QAPP Form

What follows is an example of an optional abbreviated quality assurance project plan form. You may be able to use it as a model for your project’s QAPP. However, be sure to consult your state or EPA regional QA officers to determine if use of this form (or a modified version) is acceptable to them, and for specific information on required elements for your project.

1. Title and Approval Page

<table>
<thead>
<tr>
<th>(Project Name)</th>
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<tbody>
<tr>
<td>(Responsible Agency)</td>
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<tr>
<td>(Date)</td>
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</tbody>
</table>

Project Manager Signature
Name/Date

Project QA Officer Signature
Name/Date

USEPA Project Manager Signature
Name/Date

USEPA QA Officer Signature
Name/Date

2. Table of Contents

List sections with page numbers, figures, tables, references, and appendices (attach pages).
3. Distribution List

Names and telephone numbers of those receiving copies of this QAPP. Attach additional page, if necessary.

i. 

ii. 

iii. 

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viii. 

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4. Project/Task Organization

List key project personnel and their corresponding responsibilities.

<table>
<thead>
<tr>
<th>Name</th>
<th>Project Title/Responsibility</th>
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<tr>
<td>Advisory Panel (contact)</td>
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<td>Project Manager</td>
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<td>QA Officer</td>
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<td>Field/Sampling Leader</td>
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<td>Laboratory Manager/Leader</td>
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5. Problem Definition/Background

A. Problem Statement

_____________________________________________________________________________________
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6. Project/Task Description

   A. General Overview of Project

   B. Project Timetable

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<th>Activity</th>
<th>Projected Start Date</th>
<th>Anticipated Date of Completion</th>
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### 7. Measurement Quality Objectives

**A. Data Precision, Accuracy, Measurement Range**

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<th>Matrix</th>
<th>Parameter</th>
<th>Measurement Range</th>
<th>Accuracy</th>
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**B. Data Representativeness**


**C. Data Comparability**


**D. Data Completeness**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>No. Valid Samples Anticipated</th>
<th>No. Valid Samples Collected &amp; Analyzed</th>
<th>Percent Complete</th>
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8. Training Requirements and Certification

A. Training Logistical Arrangements

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<th>Type of Volunteer Training</th>
<th>Frequency of Training/Certification</th>
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B. Description of Training and Trainer Qualifications

9. Documentation and Records

10. Sampling Process Design

A. Rationale for Selection of Sampling Sites
B. Sample Design Logistics

<table>
<thead>
<tr>
<th>Type of Sample/Parameter</th>
<th>Number of Samples</th>
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<th>Sampling Period</th>
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<td>Chemical</td>
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11. Sampling Method Requirements

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<th>Sampling Method</th>
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12. Sample Handling and Custody Procedures

The Volunteer Monitor’s Guide to Quality Assurance Project Plans
13. Analytical Methods Requirements

14. Quality Control Requirements

   A. Field QC Checks

   B. Laboratory QC Checks

   C. Data Analysis QC Checks

15. Instrument/Equipment Testing, Inspection, and Maintenance Requirements

<table>
<thead>
<tr>
<th>Equipment Type</th>
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</table>
16. Instrument Calibration and Frequency

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<th>Equipment Type</th>
<th>Calibration Frequency</th>
<th>Standard or Calibration Instrument Used</th>
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17. Inspection/Acceptance Requirements

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18. Data Acquisition Requirements

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19. Data Management

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20. Assessment and Response Actions

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_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
21. Reports

22. Data Review, Validation, and Verification

23. Validation and Verification Methods

24. Reconciliation with DQO’s