APPENDIX 4

A CLOSER LOOK AT QUALITY CONTROL AND EVALUATION

QUALITY CONTROL is the part of your quality assurance system that relates to your sampling and analysis procedures. It consists of the specific internal and external measures you take to measure accuracy and precision. Internal measures are samples that are collected and analyzed by project field volunteers, staff and lab (see p. A4-2). External measures are samples collected and analyzed by non-volunteer field staff or "quality control" labs (see p. A4-3). General categories of quality control samples are:

Duplicates: Two or more samples from the same site, or sub-samples from the same sample, are collected and/or analyzed in the field or lab.

Splits: A sample is split into two sub-samples at the lab or in the field. One sub-sample is analyzed at the project lab and the other is analyzed at an outside lab and the results compared. Alternatively, both can be analyzed at the project lab to evaluate reliability, precision and reproducibility of project lab results. In the case of field analysis, one subsample is analyzed in the field and the other is analyzed in a lab and the results compared.

Knowns and Unknowns: Outside lab-prepared samples with pre-determined concentrations either known or unknown to the project lab.

Spike Samples: Adding a known amount and concentration of the indicator being measured to part of a sample should increase the concentration by a predictable amount.

EVALUATION is that part of your system that involves calculating the accuracy and precision of your quality control samples and comparing them to your data quality objectives. Common statistical tools used to calculate accuracy and precision include:

Standard Deviation: Used to compare how closely three or more values are clustered around the average value. It is expressed as a ± from the average value. When used with duplicate samples, standard deviation measures precision -- the lower the standard deviation, the more precise the results.

Coefficient of Variation: The standard deviation as a percentage of the average. When used with duplicate samples, the Coefficient of Variation measures precision -- the lower the percentage, the more precise the results.

Relative Percent Difference: used to compare how close the result from a water sample is to the true result. It is expressed as either a positive difference (the sample result is higher than the true value) or negative difference (the sample result is lower than the true value). When used with duplicate samples, the Relative Percent Difference measures precision -- the lower the Relative Percent Difference, the more precise the results. It can also measure accuracy, when one of your results is the true value, such as the quality control lab results for a split sample, or the actual concentration of a known or unknown sample.

Percent Recovery: the percentage of the substance added to a standard sample that is detected. It is the difference between the concentration detected in the spiked sample and that detected in the un-spiked sample, divided by the concentration of the substance added to the spiked sample X 100. Percent Recovery measures accuracy -- the higher the percent recovery, the greater the accuracy.

In the following sections, we'll briefly review some common internal and external quality control measures and how the results are evaluated. For a fuller explanation of quality control and evaluation, and for recommendations about which measures are appropriate for the survey(s) you've selected, consult Chapter 5.

Common INTERNAL Quality Control Samples and How They Are Evaluated

These are types of samples that are collected and analyzed by project field volunteers, staff and labs. Note that some are specific to particular indicators.

Field Blanks: A field blank is de-ionized water that is poured into a sample container in the field as if it were a stream or lake sample. This type of blank helps to determine if there is an environment / atmosphere contamination.

Evaluation of Results: The results should be "zero."

Trip Blank: A trip blank is appropriate "blank" water placed in a sample container (with appropriate preservation) prior to going to collect samples. This type of blank helps to determine if there is any in-transit contamination of results. The result should be "zero" contamination.

Negative and Positive Plates (for bacteria): *Negative plates* result when the buffered rinse water (the sterile water used to rinse down the sides of the filter funnel during filtration) has been filtered the same way as a sample. *Positive plates* result when water known to contain bacteria (such as wastewater treatment plant influent) is filtered the same way as a sample.

Evaluation of Results: The results for negative plates should be "zero." The results for positive plates should be "too numerous to count."

Field Duplicates: A field duplicate is a duplicate stream or lake sample collected and analyzed. This is used to evaluate precision.

Evaluation of Results: The results for two samples should be compared using the relative percent difference between them. The results for three or more samples should be compared using the standard deviation among them. In either case, results are compared with your data quality objectives.

Lab Duplicates: A lab duplicate is a sample that is split into two or more sub-samples at the lab. Each sub-sample is then analyzed and the results compared. This is used to evaluate precision.

Evaluation of Results: The results for two samples should be compared using the relative percent difference between them. The results for three or more samples should be compared using the standard deviation among them. In either case, results are compared with your data quality objectives.

Calibration Blank: A calibration blank is de-ionized water processed like any of the samples and used to "zero" the instrument.

Evaluation of Results: The results of periodic checks should be "zero."

Calibration Standards: Calibration standards are used to calibrate a meter. They consist of one or more "standard concentrations" (made up in the lab to specified concentrations) of the indicator being measured).

Evaluation of Results: The meter should read the expected concentration.

Spike Samples: A sample is split into two sub-samples in the lab. One is analyzed according to the specified procedure. The other is treated by adding a known amount and concentration of the indicator being measured, then running the specified procedure. This should increase the concentration in the spiked sample relative to the unspiked sample by a predictable amount. This is used to evaluate accuracy.

Evaluation of Results: The percent of the indicator "recovered" by comparing the spiked to the unspiked sample is determined. Results are compared with your data quality objectives.

Common EXTERNAL Quality Control Samples and How They Are Evaluated

These are types of samples collected and analyzed by non-volunteer field staff and a lab (also known as a "quality control lab"). The results are compared with those obtained by your project lab. Note that some are specific to particular indicators.

External Field Duplicates: An external field duplicate is a duplicate stream or lake sample collected and processed by an independent (e.g. professional) sampler or team. It is used to estimate total (sampling and laboratory) analysis accuracy.

Evaluation of Results: The results for two samples should be compared using the relative percent difference between them. Results are compared with your data quality objectives.

Split Samples: A split sample is a sample that is split into two sub-samples at the lab or in the field. One sub-sample is analyzed at the project lab and the other is analyzed at the independent lab and the results compared. Where field analysis are required, one subsample is analyzed in the field and the other is analyzed in a lab and the results compared. It is used to estimate laboratory analysis accuracy.

Evaluation of Results: The results for the two samples should be compared using the relative percent difference between them. Results are compared with your data quality objectives.

Taxonomic Verification (for Benthic Macroinvertebrates): Benthic macroinvertebrate samples identified by volunteers should be preserved and archived for verification by an experienced taxonomist.

Evaluation of Results: The identifications are compared.

Knowns: The quality control lab sends samples for selected indicators, labeled with the concentrations, to the project lab for analysis. Knowns are used to evaluate accuracy.

Evaluation of Results: The results for the samples should be compared with the known concentration using the relative percent difference between them. Results are compared with your data quality objectives.

Unknowns: The quality control lab sends samples to the project lab for analysis for selected indicators. The concentrations of these samples are unknown to the project lab until after it analyzes them. Unknowns are used to evaluate accuracy.

Evaluation of Results: The results for the samples should be compared with the known concentration using the relative percent difference between them. Results are compared with your data quality objectives.

Recommended Quality Controls To Meet Data Quality Goals

In this section, we recommend various quality control measures to meet data quality goals for specified indicators. The usual rule of thumb is that 10% of your samples should be subject to some sort of quality control measures.

Table 1 lists the controls recommended to meet state and federal agency water quality assessment data quality goals.

Table 2 lists the controls recommended to meet the goals of Education and Awareness, Baseline Data Collection for Trend Analysis and Community and/or Watershed Level Assessment.

These tables are a starting point only. You will need to work with your technical committee to select the appropriate measures.

Recommended Quality Control Measures for State and Federal Water Quality Assessment

Table 1:

Internal Checks	FC/EC	DO	Turb	Secchi	T	pH	Alk
Field Blanks	√		√				√
Field Duplicates	√	√	√	√	√	√	√
Lab Duplicates	√♣		√			√	√
Positive Plates	√						
Negative Plates	√						
Spike Samples (Std. Add.)							√
Calibration Blank			√		√		√
Calibration to Reference Device					√		
Calibration Standard		√*	√			√	
External Checks							
External Field Duplicates	√		√	√	√	√	√
Split Samples	√		√			√	√
Outside Lab Analysis•	√						
Verification							
Knowns		√	√			√	√
Unknowns		√	√			√	√
Internal Checks	**Cond**	**Phos**	**Nitrog**	**Solids**	**Chlo**	**Benthics**	**Habitat**
Field Blanks	√	√	√	√	√		
Field Duplicates	√	√	√	√	√	√	√
Lab Replicates	√	√	√	√	√		
Positive Plates							
Negative Plates							
Spike Samples (Std. Add.)		√	√				
Calibration Blank	√	√	√		√		
Calibration to Reference Device							
Calibration Standard	√	√	√				
External Checks							
External Field Duplicates	√	√	√	√	√	√	√
Split Samples	√	√	√		√		
Outside Lab Analysis•		√	√	√	√		
Verification						√	
Knowns	√	√	√			√	
Unknowns	√	√	√			√	

Phos = Total / Total Dissolved Phosphorus
Solids = Total / Total Dissolved Solids
Chlo = chlorophyll a
Nitrog = all species
FC / EC = Fecal coliform / E. coli

• analysis expensive or difficult - consider analysis by a certified lab instead of the project lab
* using an oxygen-saturated sample
♣ using subsamples of different sizes

Recommended Quality Control Measures for Education and Awareness, Baseline Data Collection for Trend Assessment and/or Community Watershed Assessment

Quality control for these data quality goals does not necessarily require external checks, so these are not listed in the table. However, you may decide to carry out a few to check your accuracy and precision either for educational purposes or because a local data user requires it.

Table 2: QC

Internal Checks	FC/EC¨	T	pH	Alk	DO	Secchi	Cond	Benthics	Habitat
Field Blanks	√						√		
Field Duplicates	√	√	√	√	√	√	√	√	√
Lab Duplicates	♣		√	√	√		√		
Positive Plates	√								
Negative Plates	√								
Spike Samples (Std. Add.)				√					
Calibration To Ref. Device		√							
Calibration Blank		√					√		
Calibration Standard			√		√*		√		

¨ **FC/EC** = Fecal coliform / E. Coli

* using an oxygen-saturated sample

♣ using subsamples of different sizes

A Closer Look At Quality Assurance for Data Management

This includes measures to assure that sample containers (if used) are labeled and that the data are properly recorded on field and lab sheets and accurately transferred to a computer or summary sheet. Data management procedures are described in more detail in study design Step 9 ("How Will You Manage, Analyze and Report the Data?" on page 2-28).

Sample Containers: Sample containers should be clearly labeled with some of the same information that goes on you field and lab sheets:

- Site #
- Unique container ID # (if used)
- Date and time sample was collected
- Sampler name(s)

Field and Lab Sheets: These should be laid out clearly with the information suggested on pages 2-34 and 2-35 of this handbook (Step 9: "How Will You Manage, Analyze and Report the Data?")

Data Entry and Validation: If a computer is used, data should be entered by one person, if possible. The data entered into the computer must be checked against the raw data from the field and lab sheets to assure that it has been entered correctly. Ideally, this should be done by someone other than the person who entered the data. Other validation steps can include:

- Looking for data gaps;
- Analyzing chain of custody information;
- Checking calculations (have the right formulas been entered in the computer spreadsheet or database?); and
- Looking for conflicting, outlying or nonsensical data.