Quality Assurance Project Plan for the Great Salt Lake Baseline Sampling Plan

PREPARED *BY:*

STATE OF UTAH,
DEPARTMENT OF ENVIRONMENTAL QUALITY,
DIVISION OF WATER QUALITY (UDWQ)

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TITLE AND APPROVAL

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UDWQ Standards Coordinator:	Chris Bittner	Date
UDWQ Project Manager:	Jodi Gardberg	Date

DISTRIBUTION LIST

The following individuals will receive a copy of the Quality Assurance Program Plan (QAPP) along with any subsequent revisions. The QAPP will also be available online and will be distributed to all entities collecting, handling and analyzing Great Salt Lake data for UDWQ.

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ABBREVIATIONS

Abbreviation	Word
°C	degrees Celsius
CCV	Continuing Calibration Verification
COC	Chain of Custody
CRM	Certified Reference Material
DCHD	Davis County Health Department
DQO	Data Quality Objective
DQR	Data Quality Report
EDD	Electronic Data Deliverable
EPA	U.S. Environmental Protection Agency
FM	Field Manager
FSP	Field Sampling Plan
HCl	hydrochloric acid
HDPE	high-density polyethylene
HNO_3	Nitric acid
GSL	Great Salt Lake
GSLBSP	Great Salt Lake Baseline Sampling Plan
ICV	Initial Calibration Verification
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LCL	lower control limit
LIMS	Laboratory Information Management System

Abbreviation	Word
MB	method blank
MDL	method detection limit
mL	milliliter
MS	matrix spike
MSD	matrix spike duplicate
NA	Not applicable
NELAC	National Environmental Laboratory Accreditation Conference
PARCC	Precision, accuracy, representativeness, comparability, completeness
PE	performance evaluation
PM	Project manager
QA	quality assurance
QAO	Quality Assurance Officer
QAPP	quality assurance project plan
QC	quality control
%R	percent recovery
RF	response factor
RL	reporting limit
RPD	relative percent difference
RSD	relative standard deviation
RT	retention time
SOP	standard operating procedure
µg/L	micrograms per liter
UDWQ	Utah Division of Water Quality
USGS	United States Geological Survey

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PROJECT MANAGEMENT

Introduction

This Quality Assurance Project Plan (QAPP) presents the quality assurance (QA) and quality control (QC) requirements to ensure that the environmental data collected as part of the Utah Department of Environmental Quality, Division of Water Quality's (UDWQ's) baseline sampling program for the Great Salt Lake (GSL) will be of the appropriate quality to achieve each task objective. Specific protocols for sample handling and storage, chain of custody, laboratory analyses, data handling, and data evaluation are discussed.

The elements included in this QAPP are consistent with those specified in the United States Environmental Protection Agency (EPA) *Requirements for Quality Assurance Project Plans, EPA QA/R-5* (EPA, 2001). The QAPP is intended for use by all who provide services associated with GSL environmental data collection, and it supplements the work plans and any other site-specific documents. Although the QAPP attempts to cover the data collection effort, it may not address future changes in sampling and analytical needs. If the need for such changes arises, the QAPP and the relevant documents will be updated and submitted to those with project oversight for approval. The objectives of the GSL baseline sampling program (GSLBSP) QAPP are as follows:

- Ensure that data collection and measurement procedures are standardized among all participants.
- Define staff roles and responsibilities.
- Monitor the performance of the various measurement systems being used to maintain statistical control and provide rapid feedback, so that corrective measures, if needed, can be taken before data quality is compromised.
- Periodically assess the performance of these measurement systems and their components.
- Verify that reported data are sufficiently precise, accurate, representative, complete, and comparable, so that they are suitable for their intended use.

Problem Definition

Monitoring the water quality of Great Salt Lake, and thus the development and implementation of a baseline sampling plan, is a critical responsibility of UDWQ and a critical element in UDWQ's strategy to protect the water quality of GSL. This plan will provide for the routine collection of environmental samples and reporting of concentrations of potential pollutants of concern in the water, brine shrimp, and bird eggs that are indicative of the water quality of the open waters of GSL. The activities described in this document will enable UDWQ to determine long-term water quality trends, quantify water quality problems, establish water quality goals, assess beneficial use support, and determine the effectiveness of pollution control programs.

Project Background

The importance of the complex and unique Great Salt Lake (GSL) to migratory birds, recreation, brine shrimp, and mineral industries and its significance to the ecology and economy of the region is well documented (Colwell and Jehl, 1994; United States Geological Survey [USGS], 1995; Jehl, 1998; Aldrich and Paul, 2002; Isaacson et al., 2002; GSLCMP. 2010; Great Salt Lake Advisory Council, 2011). Millions of birds use the lake every year as they migrate from breeding grounds as far north

as the Arctic to wintering areas as far south as Argentina. Recreational opportunities abound on and around the lake, which attracts thousands of visitors annually to enjoy sailing, hiking, hunting, and watching the diverse bird life. GSL is also home to the mineral and brine shrimp industries, which annually contribute 700 million dollars to Utah's economy (Bioeconomics, Inc., 2012). GSL produces a significant portion of the world's supply of brine shrimp cysts and is internationally renowned for cyst quality as feed for the aquaculture and ornamental fish industry.

These same complex and unique characteristics also make it challenging for UDWQ to develop numeric water quality criteria, monitor the lake's water quality, and assess the lake's beneficial uses. Numeric criteria that are broadly applied to other water bodies are generally not applicable to the lake because it's unique ecology, biogeochemistry, and hydrology. To date, there is one numeric water quality standard for GSL and it is 12.5 milligrams of selenium per kilogram (mg/kg) bird tissue based on the complete egg/embryo of aquatic-dependent birds that use the waters of Gilbert Bay (Utah Administrative Code UAC R317-2-14). In addition, the lack of published high quality data and scientific uncertainty about the fate and transport of potential pollutants in the lake and its associated food web further complicate the assessment efforts.

What was first considered a relatively simple ecosystem composed of algae, brine shrimp, brine flies, and bird life is now understood to be quite complex and dynamic. UDWQ needed a baseline sampling program for GSL and associated QAPP that will:

- Establish a public, long-term database of the lake's water quality that will enable UDWQ to determine long-term water quality trends, quantify water quality problems, establish water quality goals, assess beneficial use support, and determine the effectiveness of pollution control programs
- Confirm appropriate sampling and analytical techniques of various matrices and target potential pollutants of concern in the lake
- Support the development of numeric water quality criteria and the assessment of GSL's beneficial uses
- Facilitate a collaborative approach with partner agencies

Study Site Description

Figure 1 shows the study area for the GSLBSP. It includes the "open waters of Great Salt Lake" defined as Gilbert Bay (Class 5A), Gunnison Bay (Class 5B), Farmington Bay (Class 5D), and Bear River Bay (Class 5C) and is generally bounded by the shoreline as defined by the current lake water level but an area no greater than as represented by the lake's bed elevation of 4,208 feet per UDWQ's segmentation of the waters of GSL (UAC R317-2-6). The Union Pacific Railroad Causeway separates Gilbert Bay from Gunnison Bay and Bear River Bay. The Antelope Island Causeway at the northern end of Antelope Island and the Island Dike Road at the southern end of Antelope Island separate Gilbert Bay from Farmington Bay.

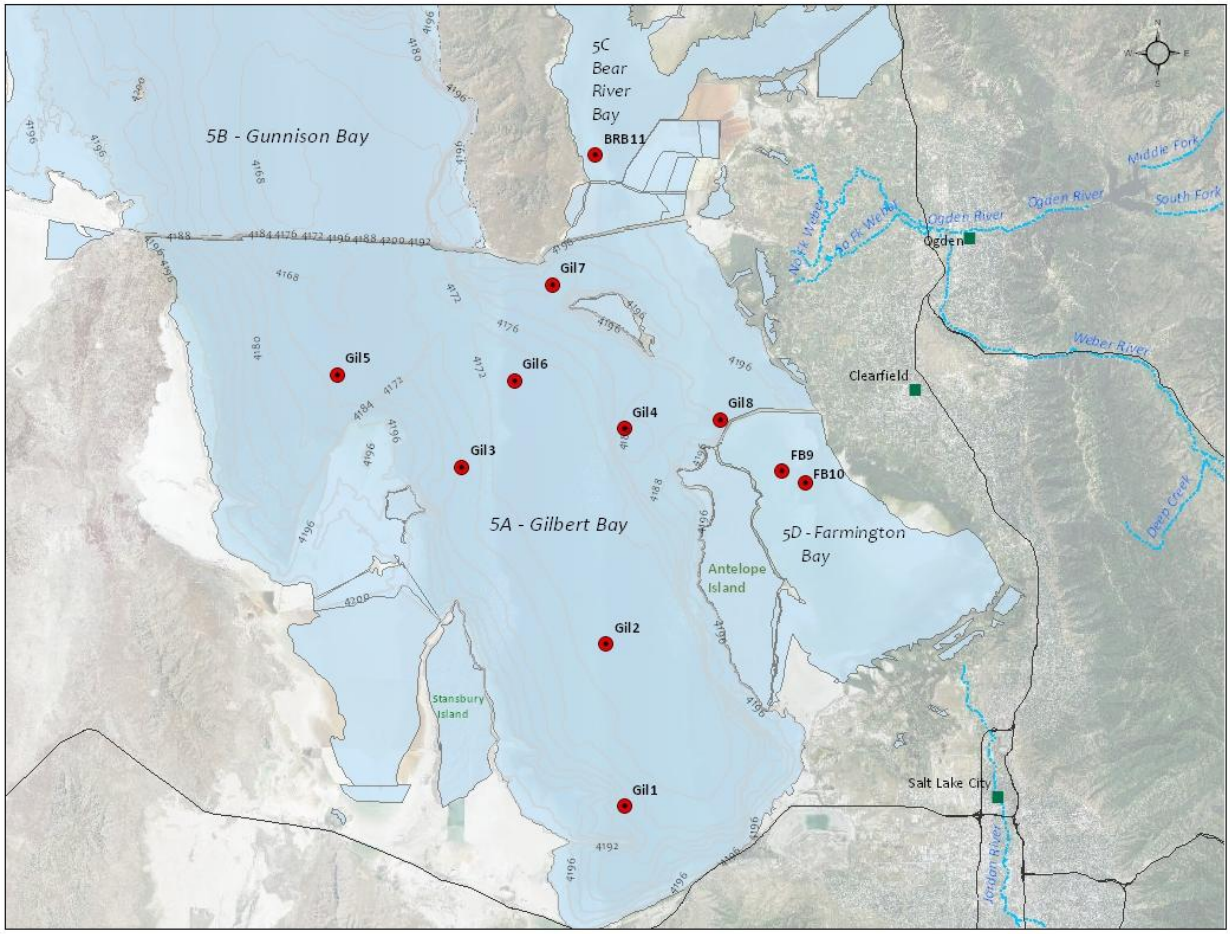

FIGURE 1 GREAT SALT LAKE SITE MAP WITH SAMPLING LOCATIONS

Project Organization

UDWQ and its partners comprise the project team for the GSLBSP as outlined in Table1. The organizational chart for implementation of the GSLBSP is shown in Figure 2

TABLE 1 PROJECT TEAM AND RESPONSIBILITIES

Name	Project Responsibilities	Contact Information
Jodi Gardberg, UDWQ	Project Manager	195 North 1950 West, P.O. Box 144870 Salt Lake City, Utah 84114-4870 Phone: 801-536-4372 jgardberg@utah.gov
James Harris, UDWQ	Quality Assurance Officer and Field Manager for Bear River Bay	195 North 1950 West, P.O. Box 144870 Salt Lake City, Utah 84114-4870 Phone: 801-536-4360 jamesharris@utah.gov
Chris Bittner, UDWQ	Technical Advisor	195 North 1950 West, P.O. Box 144870 Salt Lake City, Utah 84114-4870

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Jeff Ostermiller, UDWQ	Technical Advisor	195 North 1950 West, P.O. Box 144870 Salt Lake City, Utah 84114-4870 Phone: 801-536-4370 jostermiller@utah.gov
Tom Marston and Ryan Rowland, United States Geological Survey, Utah Water Science Center	Field Managers for Gilbert Bay	2929 Orton Circle West Vally City, Utah 84119 Phone: (801) 908-5000 rrowland@usgs.gov tmarston@usgs.gov
Angie Jones and Dee Jette, Davis County Health Department, Environmental Services Division	Field Managers for Farmington Bay	22 South State Street Clearfield, Utah 84105 Phone: (801) 525-5100 ajones@daviscountyutah.gov deejette@daviscountyutah.gov
John Cavitt, Weber State University	Field Manager for co-located bird eggs, sediment, water and macroinvertebrate sample collection	Department of Zoology Weber State University 2505 University Circle Ogden, UT 84408-2505 Phone: (801) 626-7445 jcavitt@weber.edu
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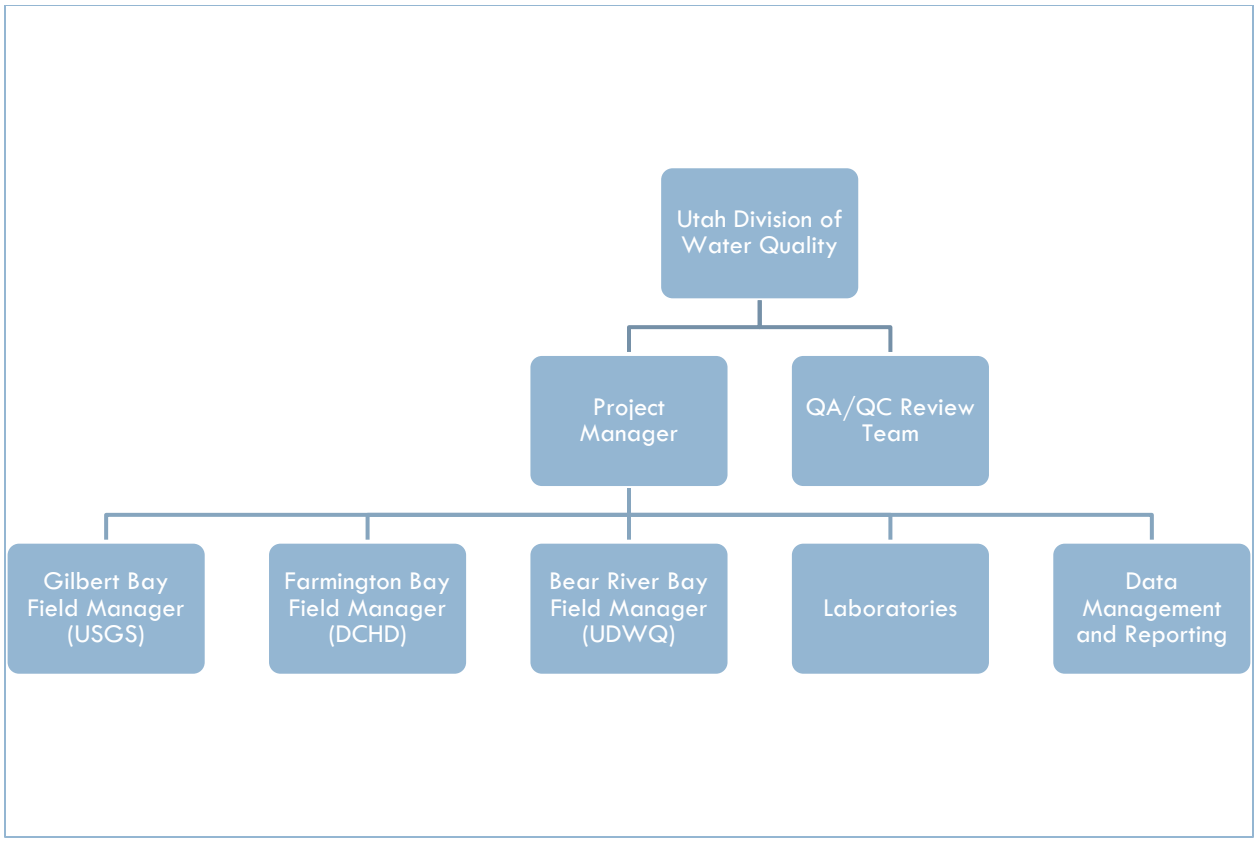

FIGURE 2 ORGANIZATIONAL CHART

Project Manager

The UDWQ Project Manager (PM) for the GSLBSP is Jodi Gardberg, the UDWQ Great Salt Lake Water Quality Coordinator. Her responsibilities include the following:

- Develop and implement the program.
- Technical oversight of all monitoring and sampling.
- Schedule, financial status, technical status, and contract management.
- Overall project quality assurance.
- Interface with appropriate UDWQ and partner agency staff, field managers (FMs), and laboratories.
- After a quality assurance review by the UDWQ QA/QC review team, the PM and the QA/QC review team will identify appropriate corrective action(s) to be initiated if quality assurance problems or deficiencies require special action are discovered.
- Maintain overall management and control of all analytical and field data that will be used for decision-making and project reporting purposes.
- Coordinate with the FMs and the laboratories to facilitate data transfer into the project database.
- Coordinate the output of data from the database to the data users (e.g., technical staff, stakeholders) and provide quality control for all data outputs.
- Maintain adherence to QA/QC requirements specified in this QAPP

- Maintain the official approved QAPP
- Manage project tasks associated with the coordination of sample collection and analysis with the FMs; act as the liaison between the FMs and laboratories.
- Manage sample tracking, sample analysis, and data reporting from each laboratory.
- Coordinate or perform validation of the analytical data.
- Communicate QA/QC issues to the FMs.

Field Managers

Water and brine shrimp tissue samples will be collected from Gilbert Bay, GSL by personnel from the United States Geological Survey (USGS), Utah Water Science Center. Hydrologists, Ryan Rowland and Tom Marston will serve as the Field Managers (FMs). Samples from Farmington Bay, GSL will be collected by personnel from the Davis County Health Department Environmental Service Division. The Quality Assurance Officer, Angie Jones will serve as the FM. Samples from Bear River Bay, GSL will be collected by UDWQ personnel and James Harris will be the FM. Co-located egg, water, sediment and macroinvertebrate samples will be collected by John Cavitt of Weber State University who also serves as the FM.

The FMs responsibilities include:

- Coordinating field schedules.
- Coordinating field personnel at the project site.
- Maintaining communication with the laboratories regarding sampling needs and coordinating delivery of samples to the laboratories.
- Managing tasks associated with sampling; general quality assurance, oversight of field personnel in sampling activities, coordination of sample collection, and coordinating sample submittal to the analytical lab.
- Collecting and reviewing all field task-related documents and archiving the documents in the project file.

Quality Assurance/Quality Control (QA/QC) Review Team

The UDWQ QA/QC review team is composed of UDWQ personnel that are independent from data generation activities and include the following:

- As the Quality Assurance Officer (QAO), James Harris will be responsible for reviewing and approving this QAPP as well as subsequent revisions. Mr. Harris is the point of contact for all data quality assurance matters with UDWQ and is the representative to DEQ's Quality Assurance Council. He also serves as the Monitoring Section Manager and oversees the monitoring staff and field activities for the Division.
- As Technical advisors for this QAPP, Chris Bittner and Jeff Ostermiller will provide technical input on the sampling design and analytical methodologies as well as data verification and validation.

Data Quality Objectives

The EPA's seven-step Data Quality Objectives (DQOs) process (EPA, 2006) was used to guide the requirements and design rationale for the GSLBSP. The DQOs define the type, quantity, and quality

of data and establish performance and acceptance criteria to ensure that data collected support the goals of the study.

Table 2 details the DQOs for this sampling plan including the need, goals, data input, study boundaries, decision rules, and performance and acceptance criteria.

The GSLBSP was designed to collect the data necessary to answer the following questions:

- What pollutants are of potential concern for GSL?
- What are the concentration of those pollutants in GSL's water or the tissue of brine shrimp and the eggs of nesting birds?
- How do these concentrations vary spatially and temporally?

The purpose is to sample a set of key water quality parameters in GSL to determine long-term water quality trends, quantify water quality problems, establish water quality goals, assess beneficial use support, and determine the effectiveness of pollution control programs. Implementation of this plan is the foundation to proactively fulfilling UDWQ's responsibilities for GSL.

Key parameters and potential pollutants of concern were determined based on results of previous studies conducted by UDWQ and other agencies and include those that are currently identified to be the highest priority. Standard operating procedures (SOPs) were identified that can be implemented consistently by all organizations sampling and monitoring GSL to ensure consistent quality and facilitate cross-agency use of the data

TABLE 2 DATA QUALITY OBJECTIVES FOR THE GREAT SALT LAKE BASLINE SAMPLING PLAN

Step	DQOs for Great Salt Lake Baseline Sampling Plan
Problem Statement	**Problem** Several pollutants, such as selenium, mercury, and other metals and metalloids, are known to cause adverse effects on the biological health and the beneficial uses of some water bodies and are known to exist in the waters of Great Salt Lake. Little is known about existing concentrations of these pollutants in Great Salt Lake, their temporal and spatial variability, and their fate and transport. Great Salt Lake's unique and complex water chemistry has made assessing these pollutants and tracking their long-term variability difficult and precluded the use of typical numeric water quality criteria to manage Great Salt Lake's water quality. This has resulted in a dearth of data that often results in a reactive approach to managing its water quality and makes the assessment of the water quality in Great Salt Lake extremely difficult. These uncertainties resulted in a large expenditure of resources to develop the criterion for selenium. Great Salt Lake is protected by a narrative water quality standard and currently has only one site-specific numeric water quality standard for selenium in Gilbert Bay (UAC R317-2-14). A long-term database of water quality measures (including water and biota tissue chemistry) is needed to assess long-term trends and enable UDWQ to fulfill its responsibilities. A long-term plan to monitor selenium concentrations in bird eggs is needed to assess compliance with the existing numeric criterion. Proven protocols are needed to enable the consistent collection and analysis of environmental samples from Great Salt Lake's hypersaline waters. Research is needed to better understand the idiosyncrasies of Great Salt Lake's ecosystem and how they relate to water quality. These tools are needed to better understand the ecosystem and identify reliable measures that can be used to assess its health. Project Partners It is UDWQ's objective to collaborate and coordinate with various state and federal agencies that have management responsibilities, conduct research, and monitor the condition of Great Salt Lake. The following agencies are identified as partners in completing a baseline sampling program and developing protocols for future monitoring of the health of Great Salt Lake: • Davis County Health Department (DCHD) • United States Geological Survey (USGS) • Utah Division of Wildlife Resources/Great Salt Lake Ecosystem Program (UDWR) • Utah Division of Forestry, Fire, and State Lands (FFSL) • Utah Geological Survey (UGS) • United States Fish and Wildlife Service (USFWS)

Step	DQOs for Great Salt Lake Baseline Sampling Plan
	• Environmental Protection Agency (EPA) **Available Resources** UDWQ will seek to collaborate with partner agencies to provide the resources required for the baseline sampling program. UDWQ will include funds for the proposed baseline sampling program in its annual budget. Monies for supplemental studies will be appropriated on an as-needed basis. **Relevant Deadlines** UDWQ began implementation in Spring 2011 and will continue on an annual basis. A report providing a summary and evaluation of analytical results will be included in the State of Utah's biennial 305(b) *Integrated Report.*
Goal of the Study/Decision Statements	**Key Questions** The overall question to be resolved can be stated as, "What is the overall water quality of the open waters of Great Salt Lake?" The following more specific questions will be addressed by the baseline sampling program: • What pollutants are of potential concern for GSL? • What are the concentration of those pollutants in GSL's water or the tissue of brine shrimp and the eggs of nesting birds? • How do these concentrations vary spatially and temporally? **Possible Outcomes** Information obtained from the sampling efforts is adequate to accurately quantify concentrations of pollutants in Great Salt Lake. Data are useful for management decisions, designated use support, a better understanding of Great Salt Lake's ecosystem, and guiding future research. Information obtained from the sampling efforts is not adequate to accurately quantify concentrations of identified pollutants in Great Salt Lake. Steps will be taken to improve and/or develop appropriate sampling and analytical methods for Great Salt Lake and revise the baseline sampling program as needed. Information obtained is adequate to understand the spatial and temporal variation of identified pollutants in the lake. Information obtained is not adequate to understand the spatial and temporal variation of pollutants in the lake. Steps are taken to prioritize research needs to understand these variations better and revise baseline sampling program as needed.
Inputs to the Decision	**Informational Inputs** The following information will be collected: • Water and brine shrimp will be sampled twice per year at 11 locations in Great Salt Lake as shown in Figure 1—Once during the bird nesting season (in the month of June) and once during the fall brine shrimp cyst harvest (in the month of

Step	DQOs for Great Salt Lake Baseline Sampling Plan
	October). Water samples will be collected 0.5 meters from the bottom of the water column and 0.2 meters from the surface. • A minimum of five (preferably eight) bird eggs each will be collected from American avocets and Black-necked stilts at two locations when present: Bridger Bay on Antelope Island and Saltair. Co-located water, sediment and macronvertebrate samples will be measured concurrently at the site. This will be completed during the bird nesting season (April through June) at a minimum of once every 2 years. An annual assessment will be used to determine if egg sampling will be completed every year and if changes will be made in how many eggs will be collected and from how many locations. **Variables/Characteristics to Be Measured** Total selenium, methyl mercury and total mercury concentrations in the following: • Water • Brine shrimp • Bird eggs Other metals and metalloids (at a minimum total arsenic, total copper, cadmium, lead, and thallium; others included if part of the same analysis suite or determined to have higher priority) concentrations in the following: • Water • Brine shrimp Nutrients (total and dissolved nitrogen, total and dissolved phosphorus, and ammonia) and chlorophyll-a concentrations in the following: • Water In situ field water measurements include: • Dissolved oxygen, pH, temperature, specific conductivity, secchi depth, total water depth, and the depth of deep brine layer (if present) Report dry-weight concentrations and moisture percentage of biota samples.
Study Boundaries	The study area for this project is shown in Figure 1. This area includes Gilbert Bay (i.e., South Arm), Farmington Bay, Bear River Bay, and Gunnison Bay (i.e., the North Arm) when access becomes available. **Temporal** • Water and brine shrimp samples will be sampled twice per year—once during the bird nesting season (June) and once

Step	DQOs for Great Salt Lake Baseline Sampling Plan
	during the fall brine shrimp cyst harvest (October). An annual assessment will be used to determine if sampling will be completed more frequently. • Bird eggs and co-located water, sediment and macronvertebrate samples will be collected during nesting season (April through June) a minimum of once every 2 years. An annual assessment will be used to determine if sampling will be completed more frequently. **Practical Constraints on Data Collection** • Availability of boats and other field equipment, as well as equipment functionality, may limit some activities. • Staffing and funding availability will need to be confirmed. • Weather is a major constraint for all sampling and monitoring activities because storms can limit ability to safely conduct sampling and measurement activities at the study area. • Great Salt Lake levels may be a constraint and affect sampling locations. Currently, there is no readily available access to Gunnison Bay. Gunnison Bay samples will be collected as opportunities arise but no regular sampling location is identified. • Successfully obtain collection permits from USFWS. • The presence of bird eggs for sample analysis may be a constraint. • Not all sampling and analytical methods are fully tested and confirmed.
Decision Rules	If information is adequate to accurately quantify the concentration of potential pollutants of concern for Great Salt Lake, UDWQ will complete reporting as noted. If information is not adequate to accurately quantify the concentration of potential pollutants of concern for Great Salt Lake, UDWQ will evaluate results, revise methods, develop appropriate sampling and analytical methods for Great Salt Lake, revise the baseline sampling program as needed, and complete reporting as noted.
Data Quality Indicators	Data quality will be evaluated based on their precision, accuracy, representativeness, completeness, comparability and sensitivity which are defined as follows: • **Precision** - Precision is a measure of reproducibility of analytical results. Total precision is a function of the variability associated with both sampling and analysis. Precision will be evaluated as the relative percent difference (RPD) between field duplicate sample results, laboratory control sample/laboratory control sample duplicate (LCS/LCSD) results, and Matrix Spike Matrix Spike Duplicate (MS/MSD) results. The precision requirements for the GSL Baseline Sampling Plan are summarized in Table 6

Step	DQOs for Great Salt Lake Baseline Sampling Plan
	• **Accuracy** - Accuracy is the degree of agreement between a measured value and the "true" or expected value. As such, it represents an estimate of total error from a single measurement, including both systematic error, or "bias," and random error that may reflect variability due to imprecision. Accuracy will be evaluated in terms of percent recoveries determined from results of MS/MSD and LCS/LCSD analyses. The accuracy limits are summarized in Table 6. • **Representativeness** - Representativeness is a qualitative term that refers to the degree to which data accurately and precisely depicts the characteristics of a population, whether referring to the distribution of contaminant within a sample, a sample within a matrix, or the distribution of a contaminant at a site. Representativeness is determined by appropriate program design, with consideration of elements such as sampling location, procedures, and timing. Assessment of representativeness shall be achieved through the use of the standard field, sampling, and analytical procedures. Standard operating procedures for both field and analytical procedures are described in this QAPP in Appendix A and B. • **Completeness** - Completeness is a measure of the amount of valid data obtained compared with the amount that was expected to be obtained under correct, normal conditions. The number of valid results divided by the total number of measurement or analyte results, expressed as a percentage, determines the completeness of the data set. For completeness requirements, valid results are all results not qualified with an R flag after a usability assessment has been performed. The completeness goal for this project is 90 percent. • **Comparability** - Comparability is a qualitative indicator of the confidence with which one data set can be compared to another data set. The objective for this QA/QC program is to produce data with the greatest possible degree of comparability. The number of matrices that are sampled and the range of field conditions encountered are considered in determining comparability. Comparability is achieved by using standard methods for sampling and analysis, reporting data in standard units, normalizing results to standard conditions, and using standard and comprehensive reporting formats. Complete field documentation using standardized data collection forms shall support the assessment of comparability. Historical comparability shall be achieved through consistent use of methods and documentation procedures throughout the project. Assessment should include a discussion of the level of uncertainty associated with the comparability of the specific data set and the potential consequences of using non-comparable data. • **Sensitivity** - Sensitivity is the ability of an analytical method or instrument to discriminate between measurement responses representing different concentrations. It is important to be able to detect the target analytes at the levels of interest. Sensitivity requirements include the establishment of various limits such as calibration requirements, method detection limits (MDLs), and project-specific reporting limits (RL). The sensitivity limits are listed as RL objectives in Table 6.
Tolerable Limits on Decision Rules	The measurement quality objectives are specified using the performance criteria in terms of the precision, accuracy, representativeness, completeness, and comparability of the data. These performance criteria provide a measure of how well the established measurement quality objectives were met. The measurement quality objectives for field and laboratory measurements

Step	DQOs for Great Salt Lake Baseline Sampling Plan
	are provided in Table 6. In general, the measurement quality objectives for metals and metalloids are about ±20 percent, ±24 percent for total mercury and ±35 percent for methyl mercury. The QAPP will specify all quality assurance/quality control objectives for sample measurement based on each matrix and may be more restrictive or less restrictive than ±20 percent.
Optimization of the Sampling Design	The baseline sampling program includes the collection and analysis of water, brine shrimp, and bird egg samples to monitor the water quality of Great Salt Lake and assess its condition with respect to water quality criteria. UDWQ's Water Quality Strategy for Great Salt Lake includes supplemental studies that are intended to improve implementation and interpretation of results from the baseline sampling program.

Special Training Requirements/Certifications

All personnel involved with the GSLBSP will have reviewed this QAPP. Field personnel must be experienced and have received training in water quality sample collection including proper use and maintenance of all sampling equipment, sample processing and handling and field documentation. Training by USGS personnel or those with equivalent expertise in the "clean hands-dirty hands" techniques for the collection of trace metals is required. Documentation of training will be maintained in the project file.

Documentation and Records

QAPP Revisions and Distribution

The PM is responsible for maintaining adherence to the QA/QC requirements specified in this QAPP and updating and editing the official approved QAPP and its associated quality documents including the Standard Operating Procedures (SOPs). Each time the QAPP is revised, the revision number will be noted on the title page and the document will be distributed to those listed on page 1. The most current version of the QAPP will be posted on UDWQ's website for Great Salt Lake.

Field Documentation and Records

Field data sheets including sample location, coordinates, in situ field measurements, and any other data collected will be provided by the FMs for incorporation into the GSL database on UDWQ's server. Chain of Custody (COC's) forms that accompany the samples to the laboratory will be scanned and sent to the PM for the record. Field equipment will be calibrated according to the manufacturers' instructions immediately prior to field sampling. Calibration documentation will be sent by the FM's to the PM to be stored in the project file.

Laboratory Documentation and Records

The analytical laboratory must have established procedures to conduct data reduction, review, and reporting. Laboratory-specific procedures are evaluated during technical systems audits to ensure that the process steps discussed in this section are properly performed.

The primary laboratory analyst(s) will be responsible for review of their work as it is being performed and for applying the measurement qualifiers based on the DQOs. During this process, a case narrative or QC exception report will be generated documenting nonconformance issues and resolutions. A designated peer reviewer, defined as a qualified staff member who is not the primary analyst, will perform an independent review to determine that project specifications have been met. The Laboratory Manager or designee will be responsible for final approval of the laboratory analytical report prior to sending the report to project staff. All raw data will be archived in confidential laboratory files.

Most laboratories use a Laboratory Information Management System (LIMS) to store, transfer, and report analytical data. These files must also undergo a QC check to verify that results are complete and correct. The laboratory is responsible for generating hard copies (i.e., final analytical report) and electronic files of the analytical results in standard formats needed by the project staff. The specific information and electronic file formats are established and tested before analysis of any samples to ensure that the formats will be compatible with the project database, and that all required information is reported.

The hard copy and electronic laboratory reports for all samples and analyses will contain the information necessary to perform data evaluation. The following information is typically included for each preparation batch (when applicable) and each analytical batch:

- Field ID number
- Date received
- Date prepared
- Date analyzed
- Method
- Results for each analyte
- Sample-specific method detection limit and method reporting limit
- Units
- Laboratory qualifier flags, also called measurement qualifiers, for all data that do not meet project QC specifications
- Data Case Narrative identifying the problems associated with the samples and the limitations of the data
- Matrix spike and laboratory control spike concentrations
- Matrix spike and laboratory control spike results
- Matrix spike and laboratory control spike recoveries and RPDs
- Method blank results
- Initial and continuing calibration verification results (hard copy only)
- Initial and continuing calibration verification recoveries and accuracies (hard copy only)
- Analytical batch number
- Preparation batch number
- Analytical sequence or laboratory run log that contains sufficient information to correlate samples reported in the summary results to the associated method QC information, such as initial and continuing calibration analyses.
- Calibration blank results (required in hardcopy format only)
- Internal standard recovery and retention time information, as applicable
- Instrument Tuning and mass calibration information for gas chromatography/ mass spectrometry and ICP-MS analyses
- Any other method-specific QC sample results

Complete documentation of sample preparation and analysis and associated QC information will be maintained by the laboratory for all project samples in a manner that allows easy retrieval in the event that additional validation or more information is required.

Reporting, Record Storage and Retention

The GSLBSP file will be the central repository for all documents relevant to sampling and analysis activities. The PM is the custodian of the project file and maintains the contents of the files for the project, including relevant records, reports, logs, field notebooks, pictures, and data reviews. Records of raw analytical laboratory data, QA data, and reports will be kept by the laboratory for at least 7 years.

The documents and records produced by the GSBSP will be stored by the PM on UDWQ's server in perpetuity and include the following:

- Current Quality Assurance Project Plan and earlier versions
- Standard Operating Procedures
- Field data including the field data sheets, multi-parameter probe data and COC forms.
- Laboratory Reports including COC forms, analytical bench sheets, instrument printouts, certificates of analyses, QA/QC report summaries and the data.
- Data Validation Reports

DATA GENERATION AND ACQUISITION

Sampling Design and Methods

The GSLBSP was designed to assess the overall water quality of the open waters of GSL. Specific objectives of the plan are to assess the:

- Concentrations of potential pollutants of concern (i.e., selenium, mercury, copper etc.) in Great Salt Lake's water, brine shrimp and the eggs of nesting birds
- Spatial, and temporal variability

While the approach to sampling on GSL may change, the GSLBSP will be incorporated into UDWQ's long-term monitoring program of waters of the state. Figure 3 summarizes the design for the sampling plan. The following sections summarize the methodology for environmental sample collection of water, brine shrimp and eggs of nesting birds.

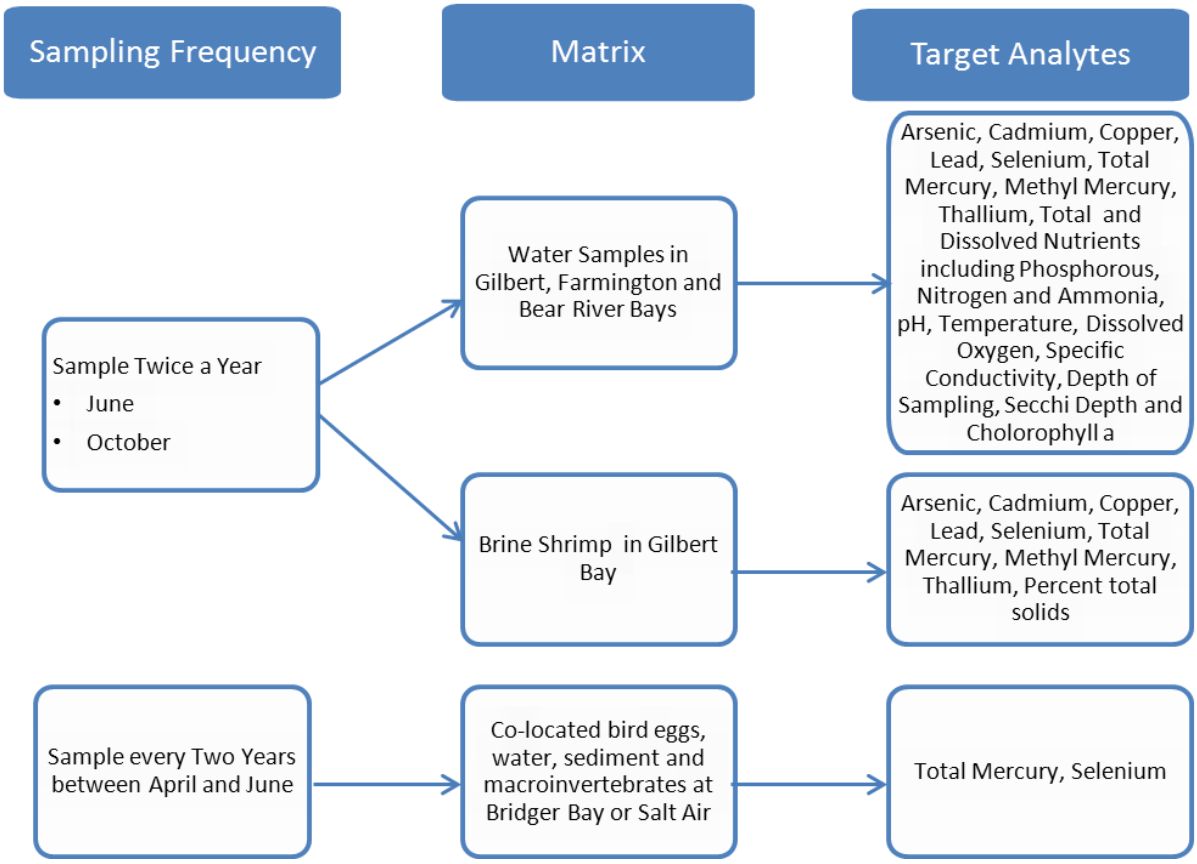

FIGURE 3 SAMPLING DESIGN

Water and Brine Shrimp

Water and brine shrimp will be sampled twice per year; once during the bird nesting season (June) and once during the fall brine shrimp cyst harvest (October). Samples will be collected at a minimum of 11 locations; 8 locations in Gilbert Bay, 2 in Farmington Bay and 1 in Bear River Bay (Figure 1 and Table 3). These locations were selected to remain consistent with locations used in routine sample collection and research since 1994, conducted by the Utah Division of Wildlife Resources/Great Salt Lake Ecosystem Program and USGS, Utah Water Science Center (Naftz et al., 2008b). Additional locations, such as in Gunnison Bay, may be added or samples collected more frequently as resources and access become available.

At each location, water samples will be collected 0.5 meters (m) from the bottom of the water column and 0.2 m from the surface. If the water column is less than 1 m, 1 water sample will be collected 0.2 m from the surface. In situ field measurements including temperature, pH, specific conductivity, dissolved oxygen, secchi depth, total water depth, and depth to deep brine layer will be made using a multi-parameter probe at the location where water and/or brine shrimp samples are collected. Procedures for calibration and use of the multi-parameter probe (In-Situ Troll 9000) are provided in the Standard Operating Procedures (SOPs) (Appendix A). Multi-parameter probe data is recorded in the field notebook and stored on the instrument. Also recorded in the field book are any notes about site conditions observed during the measurement. Prior to field sampling, the multi parameter probe should be calibrated using the manufacturer's instructions.

A composite sample of brine shrimp from three vertical hauls will be collected at Sites 1 through 8 in Gilbert Bay when present. All results for brine shrimp tissue samples will be reported on a dry-weight basis, along with the percent moisture for each sample, insofar as adequate biomass (at least 5 grams) can be collected. Water samples and brine shrimp will be analyzed for the minimum analytes shown in Table 4. Additional analytes may be included if part of the same analytical suite, as resources are available, as having greater priority or per the objectives of independent research studies. All trace-element water and brine shrimp samples will be submitted to Brooks Rand Labs. The determination of total and dissolved nutrients (Total Nitrogen, Total Phosphorous, and Ammonia) will be analyzed by the USGS National Water Quality Laboratory in Lakewood, Colorado. Dissolved nutrients samples will be processed through a 0.45 micrometer filter at the collection site. A field blank and field duplicate per matrix per trip will be collected. All field and nutrient data will be entered and archived in the USGS NWIS database. All sample collection and analysis will be conducted using the Standard Operating Procedures (SOPs) and the QAPP requirements.

TABLE 3 SAMPLING SITE INFORMATION INCLUDING TARGETED BAY, LOCATION, MATRIX AND FREQUENCY

UDWQ Sample Points	Target Bay and Abbreviation	Approximate Coordinates	USGS NWIS Site Name and Description	Matrix/ Depth of Sample	Frequency
1	Gilbert Bay (GB)	Latitude 40°46'07", Longitude 112°19'38"	USGS 404607112193801 GSL 4069, 8 Miles West Of Saltair Marina	Water Sample - 0.2m from surface Water Sample – 0.5m from bottom Brine Shrimp	June and October
2	Gilbert Bay (GB)	Latitude 40°53'56", Longitude 112°20'56"	USGS 405356112205601 GSL 3510, 6 Miles West Of Antelope Island	Water Sample - 0.2m from surface Water Sample – 0.5m from bottom Brine Shrimp	June and October

3	Gilbert Bay (GB)	Latitude 41°02'23", Longitude 112°30'19"	USGS 410323112301901 GSL 2820, 2 Miles East OF Carrington Island	Water Sample - 0.2m from surface Water Sample – 0.5m from bottom Brine Shrimp	June and October
4	Gilbert Bay (GB)	Latitude 41°04'22", Longitude 112°20'00"	USGS 410422112200001 GSL 2767, 4 Miles West Of North Tip Of Antelope Island	Water Sample - 0.2m from surface Water Sample – 0.5m from bottom Brine Shrimp	June and October
5	Gilbert Bay (GB)	Latitude 41°06'44", Longitude 112°38'26"	USGS 410644112382601 GSL 2565, Northwest Of Hat Island	Water Sample - 0.2m from surface Water Sample – 0.5m from bottom Brine Shrimp	June and October
6	Gilbert Bay (GB)	Latitude 41°06'37", Longitude 112°27'04"	USGS 410637112270401 N1018 6 Miles Southwest Of Fremont Island	Water Sample - 0.2m from surface Water Sample – 0.5m from bottom Brine Shrimp	June and October
7	Gilbert Bay (GB)	Latitude 41°11'16", Longitude 112°24'44"	USGS 411116112244401 GSL 2267, 1 Mile Northwest Of Fremont Island	Water Sample - 0.2m from surface Water Sample – 0.5m from bottom Brine Shrimp	June and October
8	Gilbert Bay/ Farmington Bay (GB)	Latitude 41°04'52", Longitude 112°13'51"	USGS 410401112134801 GSL Farmington Bay Outflow At Causeway Bridge	Water Sample - 0.2m from surface Water Sample – 0.5m from bottom Brine Shrimp	June and October
9	Farmington Bay (FB)	Latitude 41°02'24.36", Longitude 112°09'51.12"	USGS 410224112095101 Farmington Bay, 1.4 Miles East, 3.5 Miles South of Farmington Bay marina	Water Sample - 0.2m from surface Water Sample – 0.5m from bottom	June and October
10	Farmington Bay (FB)	Latitude 41°01'53", Longitude 112°08'23"	USGS 410153112082301 GSL 2963, Farmington Bay 4 Miles Southeast Of Antelope Island Marina	Water Sample - 0.2m from surface Water Sample – 0.5m from bottom	June and October
11	Bear River Bay (BRB)	Latitude 41 17.340, Longitude 112	USGS 10010060 Bear River Bay Outflow at Causeway Bridge near	Water Sample - 0.2m from surface Water Sample – 0.5m	June and October

		22.006	Warren	from bottom	

Co-Located Bird Eggs, Water, Sediment and Invertebrates

The eggs of shorebirds will be sampled to characterize the birds' exposure to metals present in the open waters of GSL. Bird eggs will be sampled a minimum of once every 2 years to allow UDWQ to assess compliance with GSL's tissue-based, numeric water quality standard for selenium and document levels of exposure to mercury. Per the recommendations of UDWQ's Selenium Science Panel, American avocets and black-necked stilts foraging along the shoreline of Gilbert Bay, GSL will be targeted initially (CH2M HILL, 2008)..

Prior to egg collections, the following areas will be surveyed for aggregations of nesting shorebirds; Bridger Bay located on the north end of Antelope Island and Salt Air located north of I-80 near the Kennecott Copper Tailings Pond discharge. Additional locations may be added or additional eggs collected as allowed by the egg collection permit, as resources are available, or per the objectives of independent research studies. All samples will be collected adjacent to GSL so samples are representative of pollutant exposure from the open waters of Great Salt Lake. All results for tissue samples will be reported on a dry-weight basis, along with the percent moisture for each sample, insofar as adequate biomass can be collected.

A single egg will be collected from a minimum of five avocet nests and five stilt nests (preferably eight nests of each species) after the clutches are completed for a total of 10 eggs. Each embryo will be checked for stage of development as determined by egg flotation. Late-stage embryos will be examined for developmental abnormalities, including a determination of the embryo's position in the egg. Observations of embryo development and position will be recorded and photographed according to the SOP. Egg contents will then be analyzed for total selenium and total mercury and concentrations reported on a dry-weight basis, along with percent moisture of each sample. Bird eggs will be sampled and evaluated and tissues analyzed using the SOPs and the QAPP requirements

TABLE 4 PARAMATERS, MATRIX, COLLECTION METHOD, SOP AND RECEIVING LABORATORY

Parameter	Sample Matrix	Sampling Method	Standard Operating Procedures	Receiving Laboratory
Arsenic, Cadmium, Copper, Lead, Methyl Mercury, Selenium, Total Mercury, Thallium, Zinc	Water	Pump or Grab Sample; Clean Hands/Dirty Hands	Total and Dissolved Water Sampling SOP	Brooks Rand Labs
Filtered (Dissolved) Nutrients - Ammonia, Nitrate , Nitrite, Total Phosphorus and Total Nitrogen	Water	Pump or Grab Sample; Clean Hands/Dirty Hands and Field Filtering	Total and Dissolved Water Sampling SOP	USGS National Water Quality Laboratory
Nutrients (Ammonia, Total Phosphorus and Total Nitrogen)	Water	Pump or Grab Sample; Clean Hands/Dirty Hands	Total and Dissolved Water Sampling SOP	USGS National Water Quality Laboratory

Parameter	Sample Matrix	Sampling Method	Standard Operating Procedures	Receiving Laboratory
Chlorophyll a	Water	Pump or Grab Sample; Clean Hands/Dirty Hands	Total and Dissolved Water Sampling SOP	USGS Utah Water Science Center using EPA Method 445.0
Arsenic, Cadmium, Copper, Lead, Thallium, Zinc, Total Mercury, Methyl Mercury and Selenium	Brine Shrimp	Composite Sample from 3 Vertical Hauls with a Plankton Tow Net	Brine Shrimp Sampling	Brooks Rand Labs
Temperature, Specific Conductance. Dissolved Oxygen, pH, ORP	Water	Multi-Parameter Probe	Multi-Parameter TROLL 9000	NA
Total Mercury and Selenium	Egg Tissue	Egg Sample	Shorebird Food Items, Water and Sediment Sampling	Brooks Rand Labs
Total Mercury and Selenium	Sediment	Composite Sample from 5 sediment core samples from FISA sites	Shorebird Food Items, Water and Sediment Sampling	Brooks Rand Labs
Total Mercury and Selenium	Macroinvertebrates	Composite Sample from 3 1 meter sweeps using a standard dip net	Shorebird Food Items, Water and Sediment Sampling	Brooks Rand Labs
Total Mercury and Selenium	Water	Composite Sample from 5 different sites	Shorebird Food Items, Water and Sediment Sampling	Brooks Rand Labs

Container Types, Preservatives and Holding Compliance

Laboratories will provide the required sample containers for samples wherever possible. All containers will have to be cleaned and certified to be free of the analytes of concern for sampling. No sample containers will be reused. Preservatives, if required, may be added by the laboratories prior to shipment of the sample containers to the field or can be added after the shipment. If added before, the adequacy of preservation will be verified by the laboratory upon receipt of the samples, and additional preservative will be added, if necessary. If added after, all samples must be shipped to the laboratory prior to appropriate holding days of the samples without preservation as indicated in Table 5.

All sample preparation and analysis shall be completed within the method-required holding times. The holding time for a sample begins at the time of sample collection. The preparation holding time is calculated from the time of sample collection to the time of completion of the sample preparation process as described in the

applicable method, before any volume reduction procedures. If no preparation is required, the analysis holding time is calculated from the time of sample collection to the time of completion of all analytical runs, including dilutions and any required re-analysis. In methods requiring sample preparation before analysis, the analysis holding time is calculated from the time of preparation completion to the time of completion of all analytical runs, including dilutions and any required re-analysis. Holding times are determined on the basis of days, hours, and minutes. If the time of the sample collection is not provided, the laboratory must assume the most conservative (i.e., earliest) time of day. If holding times are exceeded and the analyses are performed, the results shall be flagged accordingly.

Type of containers, minimum sample quantities, required preservatives, and maximum holding times are shown in Table 5.

TABLE 5 SAMPLE CONTAINERS, PRESERVATION AND HOLDING COMPLIANCE REQUIREMENT

Parameter	Matrix	Container	Preservative	Maximum Holding Times
Total Selenium	Water	1-L acid cleaned and pre-tested glass or high density polyethylene bottle (HDPE)	HNO_3 to pH < 2;	14 days to in-lab preservation, 180 days to analysis (6 months)
	Sediment	250-mL wide-mouth glass or HDPE jar	Cool 4°C in field; store frozen	1 year
	Biota	250-mL wide-mouth glass or plastic jar or zip-type plastic bag	Cool 4°C in field; store frozen	1 year
Arsenic, Cadmium, Copper, Lead, Thallium and Zinc	Water	500-mL with lids Fluoropolymer, conventional or linear polyethylene, polycarbonate or polypropylene bottles	HNO_3 to pH < 2;	14 days to in-lab preservation, 180 days to analysis (6 months)
	Sediment	250-mL glass or HDPE jar	Cool 4°C in field; store frozen	1 year
	Biota	250-mL wide-mouth glass or plastic jar or zip-type plastic bag	Cool 4°C in field; store frozen	1 year
Low Level Total Mercury	Water (Method 1631E)	500-mL acid cleaned glass or fluoropolymer bottles with fluoropolymer or fluoropolymer-lined caps	5-mL/L of 12N HCl or BrCl solution	28 days to in-lab preservation, 90 days after preservation
	Sediment	Glass, polyethylene or fluoropolymer jars, polyethylene bags for all but very low level and/or very wet solid samples, dry samples in heavy gauge paper pouches	Cool 4°C in field; store frozen	1 year
	Biota	Glass, polyethylene or fluoropolymer jars, polyethylene	Cool 4°C in field; store frozen	1 year

Parameter	Matrix	Container	Preservative	Maximum Holding Times
		bags for all but very low level and/or very wet solid samples, dry samples in heavy gauge paper pouches		
Methyl Mercury	Water	500-mL acid cleaned glass or fluoropolymer bottles with fluoropolymer or fluoropolymer-lined caps	2-mL/L 9M H_2SO_4, Cool 4°C in field	48 hours to in-lab Preservation if pre-preserved sample containers are not used, 180days after preservation (6 months)
Filtered (Dissolved) Nutrients: Total Phosphorus and Total Nitrogen	Water	125 mL polyethylene bottle, amber, filtered, chilled	Filtered with 0.45um filter in field Cool 4°C in field	28 days to analysis
Nutrients: Total Phosphorus and Total Nitrogen	Water	125 mL polyethylene bottle, whole water, chilled, acidified	1mL of 4.5M H_2SO_4, solution in field Cool 4°C in field	28 days to analysis
Ammonium as N	Water	125 mL polyethylene bottle, whole water, chilled, acidified		
Chlorophyll a	Water	125 mL polyethylene bottle, raw, untreated	Cool 4°C in field, Avoid direct sunlight	24 hours

Sample Handling and Custody

Sample Documentation and Tracking

Environmental samples will be collected directly into pre-cleaned containers or bags provided by the laboratory when appropriate. Containers will generally be provided with preservatives, where applicable by the laboratory that will be completing the analytical testing, but can also be purchased in some cases by the sampling team. However, purchased containers must be thoroughly cleaned before use.

Sample labels will be affixed to all sample containers and bags and covered with clear tape before sampling efforts. The project name, sample identification, date and time of sampling, sample matrix (coded as water, or biota type) and sampler's initial will be entered on the label immediately after collection using waterproof permanent marker pens.

All vital information regarding the collection of each sample will be recorded in field notebooks as outlined in the SOPs. Information recorded during the collection of each sample will include:

- Sample location and description. (Sketch and measured distances from reference points will be recorded if there is no established identification for the sample location.)
- Sample identification.
- Sampler's name.
- Date and time of sampling.
- Sample designation as composite or grab.
- Sample matrix (water, or biota type).
- Type and identification of sampling equipment used.
- Field measurement data (pH, temperature, conductivity etc.).
- Field observations that may be relevant to the analysis or sample integrity (odor, color, weather conditions).
- Associated quality control blanks.
- Preservative used.
- Lot numbers of sample containers, chain-of-custody number, and custody seal number.
- Shipping arrangement.
- Destination laboratory.

Sample Packaging and Transport

The following provides guidelines for sample packaging and transport.

Sample Container Preparation

- The labels will be secured to each container with clear tape, if not previously done.
- Container lids will be checked for tightness, and if the container is not full, the outside of the container will be marked with indelible ink at the sample volume level.
- Sample bottles will be double-bagged in heavy-duty plastic. Glass containers will be covered with bubble wrap to prevent breakage.

Shipping Cooler Preparation

- All previous labels used on the sample-shipping cooler will be removed.
- The drain plugs will be sealed to prevent melting ice from leaking.
- A cushioning layer of packing material such as bubble wrap will be placed at the bottom of the cooler (approximately 1 inch thick) to prevent breakage during shipment.
- All ice will be double-bagged in a Ziploc® bags. If samples are shipped frozen with dry ice, proper paperwork from the shipping carrier will be followed.

Placing Samples in the Cooler

- The Chain of Custody (COC) form will be placed in a Ziploc bag inside the cooler.
- Samples will be placed in an upright position in the cooler.
- Double-bagged ice will be placed on top of samples and between samples.
- Void space between samples will be filled with packing material, if necessary.

Closing the Cooler

- The cooler lid will be taped with strapping/packaging tape, encircling the cooler several times.
- Custody seals may also be affixed to the cooler lid to further ensure the integrity of the samples. Usually custody seals are provided by the laboratory that will perform sample analysis.

Transport

- Sample coolers will be transported to the laboratory (an overnight courier may be used) as soon after sample collection as possible, preferably within 48 hours.
- The laboratory will be notified that samples are being shipped.
- It is recommended that a copy of the COC is kept by the samplers for record.

Sample Receipt

The laboratory will designate a sample custodian who will log in samples using a standardized Sample Receipt Form. The custody seal will be inspected to verify that it is intact, and the sample custodian will then check the condition of samples and verify COC records. Any breakage, leakage, or other damage will be noted. The sample custodian will record all tracking information and pass it to the data librarian and the laboratory project manager. All of this information will appear on the Sample Receipt Form. If discrepancies are noted between the COC report and the actual contents of the container, these will immediately be reported to the UDWQ project manager. Along with sample receipt documentation, the following information will be documented on the Sample Receipt Form by the sample custodian:

- Date of samples received
- Contractor sample identification number
- Laboratory sample identification number
- Analytical tests requested for each sample batch
- Sample matrix
- Number of samples in the batch
- Container description and location in the laboratory
- After being logged in, the samples will be refrigerated or frozen as appropriate.

Chain of Custody

Procedures must be taken to preserve and ensure the integrity of all samples from the time of collection through analyses. Records of the custody of samples must be maintained both in the field and in the laboratory. A sample is considered to be in someone's custody if it is either in his or her physical possession or view, locked up, or kept in a secured and restricted area. Until the samples are shipped, their custody will be the responsibility of the sampling team leader.

Chain of Custody (COC) records document sample collection and shipment to the laboratory. A COC form will be completed for each sampling event. The original copy will be provided to the laboratory with the sample shipping cooler and a copy will be retained in the field documentation files. The COC form will identify the contents of each shipment and maintain the custodial integrity of the samples. All COC forms will be signed and dated by the responsible sampling team personnel. The "relinquished by" box will be signed by the responsible sampling team personnel, and the date, time, and air bill number will be noted on the COC form. The laboratory will return the executed copy of the COC with the hardcopy report.

At a minimum, the COC form must contain the following:

- Site name
- Project manager's name, telephone number, and email address
- Unique sample identification
- Date and time of sample collection
- Source of sample (including name, location, sample type, and matrix)

- Number of containers
- Analyses required
- Name of sampler
- Custody transfer signatures and dates and times of sample transfer from the field to transporters and to the laboratories
- Bill of lading or transporter tracking number (if applicable)
- Lab name, address, and contact information
- Any special instructions

Erroneous entries on COC records will be corrected by drawing a line through the error and entering the corrected information. The person performing the correction will date and initial each change made on the COC form.

Transfer of Custody and Shipment

When transferring the samples, from field to laboratory or from laboratory to laboratory, the individuals relinquishing and receiving the samples will sign, date, and note the time on the COC form. If the samples are required to be shipped, the laboratory coordinators will be notified of when and how samples were sent. Notification will include the following information:

- Date of shipment
- Name of shipping company
- Air bill number
- Number of coolers
- Name, phone number, and facsimile number of point of contact
- Estimated date of shipment arrival
- Type of samples (water, sediment, soil or biota)
- On receipt of each sample cooler and after verification of the COC records, the laboratory will provide a sample confirmation report within 24 hours to the PM that will document samples received and methods requested as well as any discrepancies such as, but not limited to, the following:
- Inappropriate sample containers or preservation
- Broken sample containers
- Cooler temperature outside range of 2 to 6°C (where applicable)
- Missing COC form or QA sample form
- Errors on COC or QA sample form
- Missing custody seals

The laboratory PM will notify the PM of any such discrepancies within 24 hours of receipt of the samples. Notification can be via phone or email. The PM will discuss the discrepancy with the QA/QC team and inform the laboratory of the corrective action to be taken.

A subcontract laboratory must notify the primary laboratory of any such discrepancies within 24 hours of its receipt of the samples. The primary laboratory will relay this information to the PM within 24 hours of notification.

Analytical Methods and Reporting Limits

All laboratories providing analytical services will hold National Environmental Laboratory Accreditation certification (NELAC) for the analytical methods listed in Table 6. The laboratory managers will be responsible for ensuring that all personnel have been properly trained and are qualified to perform their assigned tasks. Data collection and analyses will be consistent with the DQOs, which are designed to ensure consistency in data reporting and comparability among sampling site locations, so that spatial and temporal variability in key pollutants can be adequately evaluated. Table 6 presents the analytical methods to be used for the GSLBSP. It should be noted that these analytical methods may change after UDWQ conducts a laboratory round robin for GSL waters to understand which method works best for each of the listed analytes. The Method Detection Limit is the minimum concentration of an analyte that can be identified, measured and reported with 99% confidence that the analyte concentration is greater than zero. Project Reporting Limits (RLs) for the mentioned methods have been established that are low enough to evaluate effects for various environmental media and these are also summarized in Table 6. Laboratories should try to comply with the Reporting Limits for all analytical methods.

TABLE 6 MATRIX, ANALYTE, ANALYTICAL METHODS, METHOD DETECTION LIMITS, TARGET REPORTING LIMITS, PRECISION AND ACCURACY CRITERIA

Matrix	Analyte	Method	Method Detection Limit	Reporting Limit	Precision (Relative Percent Difference)	Accuracy (Percent Recovery
Water	Arsenic	EPA Method 1640	0.15 ug/L	0.50 µg/L	≤30%	70-130
	Cadmium	EPA Method 1640	0.0024 µg/L	0.01 µg/L	≤20%	75-125
	Copper	EPA Method 1640	0.024 µg/L	0.1 µg/L	≤20%	75-125
	Lead	EPA Method 1640	0.0081 µg/L	0.05 µg/L	≤20%	75-125
	Methyl Mercury	EPA Method 1630	0.02 ng/L	0.06 ng/L	≤35%	65-135
	Total Mercury	EPA Method 1631E	0.15 ng/L	0.40 ng/L	≤24%	71-125
	Total Selenium	EPA Method 1640	0.07 µg/L	0.21 µg/L	≤30%	70-130
	Thallium	EPA Method 1640	0.002 µg/L	0.01 µg/L	≤30%	70-130
	Zinc	EPA Method 1640	0.32 µg/L	1 µg/L	≤30%	70-130
	Phosphorous, total, dissolved	EPA Method 365.1	0.007 mg/L	0.035 mg/L	≤10	85-115
	Phosphorus, total, whole water	EPA Method 365.1	0.007 mg/L	0.035 mg/L	≤10	85-115
	Nitrogen, total	Alkaline	0.015 mg/L	0.075	≤10	85-115

Matrix	Analyte	Method	Method Detection Limit	Reporting Limit	Precision (Relative Percent Difference)	Accuracy (Percent Recovery
	dissolved	Persulfate Digestion Method – USGS WRI 03-4174		mg/L		
	Nitrogen, total whole water	Alkaline Persulfate Digestion Method – USGS WRI 03-4174	0.015 mg/L	0.075 mg/L	≤10	85-115
	Ammonium plus organic N (Kjeldahl)	USGS I-2515-91/4515-91	0.05 mg/L	0.025 mg/L	≤10	85-115
	Chlorophyll a	TD-700 Fluorometer with EPA Method 445.0	0.05 ug/L	0.05 ug/L	≤10	NA
Biota	Arsenic	EPA Method 1638	0.014 mg/kg (Wet)	0.04 mg/kg (Wet)	≤30%	70-130
	Cadmium	EPA Method 1638	0.003 mg/kg (Wet)	0.1 mg/kg (Wet)	≤30%	70-130
	Copper	EPA Method 1638	0.03 mg/kg (Wet)	0.2 mg/kg (Wet)	≤30%	70-130
	Lead	EPA Method 1638	0.004 mg/kg (Wet)	0.05 mg/kg (Wet)	≤30%	70-130
	Thallium	EPA Method 1638	0.002 mg/kg (Wet)	0.02 mg/kg (Wet)	≤30%	70-130
	Total Mercury	EPA Method 1631E	0.12 ng/g (Wet)	0.40 mg/kg (Wet)	≤30%	70-130
	Total Selenium	EPA Method 1638	0.06 mg/kg (Wet)	0.15 mg/kg (Wet)	≤30%	70-130
	Zinc	EPA Method 1638	0.28 mg/kg	1 mg/kg (Wet)	≤30%	70-130

Quality Control Requirements

Quality control (QC) checks indicate the state of control at the time of sampling and sample analysis. Field-originated blanks provide a way to monitor for potential contamination to which field samples are subjected, while checks such as matrix spikes (MS) and matrix spike duplicates (MSD), and laboratory duplicates (LD) indicate the presence of complex matrix effects on the sample. This QAPP specifies the data quality needed for both field sampling and laboratory quality control. Data quality will be evaluated based on the following indicators; precision, accuracy, representativeness, completeness, comparability and sensitivity of the data discussed in the DQO's. The performance and acceptance criteria for each indicator are provided in Table 6.

Field Sampling Quality Control:

Three types of Field QC samples will be collected and include field blanks, field duplicates and trip blanks.

FIELD BLANK

- QC Sample: Field Blanks are used to demonstrate that samples have not been contaminated in the sample collection process. One sample of reagent free deionized water will be added to the other bottles in the field and handled in the same manner as the other samples. Field Blanks will be collected at a rate of 1 blank per sampling run day per matrix or 1 blank per 20 samples per matrix, whichever is more frequent.
- Performance Criteria: A field blank concentration that is less than the Method Detection Limit or less than 1/10 the average concentration in the associated sampling run samples per analyte per matrix.

FIELD DUPLICATE

- QC Sample: A field duplicate sample is a second sample collected at the same location as the original sample. Duplicate sample results are used to assess precision, including variability associated with both the laboratory analysis and the sample collection process. Duplicate samples will be collected simultaneously or in immediate succession, using identical techniques, and treated in an identical manner during storage, transportation, and analysis. One field duplicate sample will be collected and analyzed each for surface water, brine shrimp tissue (where they are appropriately abundant) for each 20 or less samples of that matrix, representing 10% of the total collected samples. Eggs are already duplicated as they are all considered replicates, within species. The field sampling team will determine which materials will be used for QC samples.
- Performance Criteria: The field duplicate samples have less than the prescribed relative percent difference (RPD) between the sample and duplicate as listed in Table 6.

TRIP BLANK

- QC Sample: Trip Blanks are used to measure cross contamination of samples during shipping to and from the site. Trip Blanks are created in the laboratory and contain analyte-free water. Trip blanks accompany the sample bottles into the field and are returned to the laboratory along with the collected samples. One trip blank per sample shipment will be sent and analyzed.
- Performance Criteria: A trip blank concentration that is less than the Method Detection Limit

Field Measurement Quality Control

Field based QC measurements will include:

- Calibration and documentation of field water quality instruments including reference checks using standard reference materials.
- Review of all field documentation for completeness before leaving the site.

Performance Criteria: 100% compliance

Laboratory Analysis Quality Control

Analytical QC limits are described in each laboratory's quality assurance manual and must conform to the requirements outlined in this QAPP. The nationally certified laboratory will have a quality assurance plan in place and will adhere to standard protocols for

METHOD BLANK

- QC Sample: Method Blanks are used to monitor each preparation or analytical batch for interference and/or contamination from glassware, reagents, and other potential sources within the laboratory. A MB is an analyte-free matrix to which all reagents are added in the same amount or proportions as are added to the samples. It is processed through the entire sample preparation and analytical procedures along with the samples in the batch. At least three MB per preparation or analytical batch are required.
- Performance Criteria: Target analyte is found at a concentration less than $1/10^{th}$ the sample result

LABORATORY CONTROL SAMPLE

- QC Sample: The Laboratory Control Sample (LCS) will consist of an analyte-free matrix spiked with a known quantity of the target analyte from a traceable source. Trace metals and nutrients will be spiked using a certified reference material into the LCS. The LCS is used to assess the accuracy of routine analytical methods. 1 LCS per sample batch
- Performance Criteria: Method performance or accuracy is measured by a percent recovery between 75 – 125%

MATRIX SPIKE/MATRIX SPIKE DUPLICATE

- QC Sample: A sample matrix fortified with known quantities of specific analytes is called a Matrix Spike (MS). It is subjected to the same preparation and analytical procedures as the native sample. MS recoveries are used to evaluate the effect of the sample matrix on the recovery of the analytes of interest. A Matrix Spike Duplicate (MSD) is a second fortified sample matrix treated identically to the MS. At least one MS/MSD pair will be analyzed for each matrix, i.e., tissues, water, and sediment, for each sampling event.
- Performance Criteria: The MS percent recovery and the MSD relative percent difference are within acceptable limits provided in Table 6.

LABORATORY DUPLICATE

- QC Sample: A laboratory duplicate (LD) is 2 aliquots of the same sampled taken in the laboratory and analyzed separately with identical procedures. Both samples are subjected to the same preparation and analytical procedures. The data collected may also yield information regarding whether the sample is heterogeneous. At least 1 duplicate sample should be prepared and analyzed for each of matrix type for each sampling event
- Performance Criteria: The relative percent difference between the results of the LDs is within acceptable limits provided in Table 6.

Additional Quality Control Requirements

HOLDING TIME

The holding time requirements specified in this QAPP must be met. For methods requiring both sample preparation and analysis, the preparation holding time will be calculated from the time of sampling to the completion of preparation. The analysis holding time will be calculated from the time of completion of preparation to the time of completion of the analysis, including any required dilutions, confirmation analysis, and re-analysis. For methods requiring analysis only, the holding time is calculated from the time of sampling to completion of the analysis, including any required dilutions, confirmation analysis, and re-analysis.

CLEANUP PROCEDURES TO MINIMIZE MATRIX EFFECTS

To maintain the lowest possible reporting limits, appropriate cleanup procedures will be employed when it is indicated by the method to remove or minimize matrix interference. Method blanks, MS/MSDs, and LCSs must be subjected to the same cleanup procedures performed on the samples to monitor the efficiencies of these procedures.

SAMPLE DILUTION

Dilution of the sample results in elevated reporting limits and ultimately affects the usability of data related to potential actions at the sampling site. It is important to minimize dilutions and maintain the lowest possible reporting limits. When dilutions are necessary because of high concentrations of target analytes, lesser dilutions should also be reported to fully characterize the sample for each analyte. The level of the lesser dilution will be such that it will provide the lowest possible reporting limits without having a lasting deleterious effect on the analytical instrumentation. When a sample exhibits characteristics of matrix interference that are identified through analytical measurement or visual observation, appropriate cleanup procedure(s) must be proven ineffective or inappropriate before proceeding with dilution and analysis.

Corrective Action

Corrective action may be required as a result of deviations from field and/or analytical procedures. Deficiencies identified in audits and data quality assessments may also call for corrective action.

The FM's are responsible for performing immediate corrective action in the field if a QC issues arises during field QC checks such as instrument maintenance or recalibration. Field personnel will document the corrective action taken on the field data sheets.

The QAPP has specified specific corrective action to be taken when deviations from calibration and QC acceptance criteria occur. The type of action to be taken in other situations would require judgment on the part of somebody directly involved with the situation. There should be a mechanism in place in the laboratory to allow for supervisory review of all deviations or deficiencies. A corrective action reporting system that requires immediate documentation of deviations or deficiencies and for supervisory review of the actions taken to correct them should be established. The corrective action report should include as a minimum:

The type of deviation or deficiency

- The date of occurrence
- The impact of the deviation or deficiency, such as samples affected
- The corrective action taken

The only time that a corrective action report may be waived is when a deviation or deficiency is immediately corrected and its impact is precluded. An example would be an unacceptable initial calibration that is repeated before samples are analyzed.

Each corrective action report must be reviewed and approved by a person of authority, such as the field manager or laboratory supervisor. Corrective action reports that could potentially affect data quality must be brought to the attention of the PM. Disposition of the reports will be the responsibility of the PM. Copies of corrective action reports must be maintained in the project files.

Instrument Testing, Inspection and Maintenance

Preventive Maintenance

The primary objective of a preventive maintenance program is to promote the timely and effective completion of a measurement effort. The maintenance program should be designed to minimize the downtime of crucial sampling and/or analytical equipment due to expected or unexpected component failure. In implementing this program, efforts should be focused in the following primary areas:

- Establishment of maintenance responsibilities
- Establishment of maintenance schedules for major and/or critical instrumentation and apparatus
- Establishment of an adequate inventory of critical spare parts and equipment.

Maintenance Responsibilities

Maintenance of laboratory instruments is the responsibility of the participating laboratory. Generally, the laboratory manager or supervisor of a laboratory is responsible for the instruments in his or her work area. This responsible person will establish maintenance procedures and schedules for each instrument.

Maintenance responsibilities for field equipment are assigned to the FM's for specific sampling tasks. However, the field team using the equipment is responsible for checking the status of the equipment prior to use and reporting any problems encountered. The field team is also responsible for ensuring that critical spare parts are included as part of the field equipment checklist. Non-operational field equipment should be removed from service and a replacement obtained. All field instruments will be properly protected against inclement weather conditions during the field investigation.

Maintenance Schedules

The effectiveness of any maintenance program depends to a large extent on adherence to specific maintenance schedules for each piece of equipment. Other maintenance activities are conducted on an as-needed basis. Manufacturers' recommendations should provide the primary basis for establishing maintenance schedules. Manufacturers' service contracts may be used for implementing the scheduled maintenance.

Each analytical instrument should be assigned an instrument logbook. All maintenance activities will be documented in this logbook. The information to be entered includes:

- Date of service
- Person performing service
- Type of service performed and reason for service
- Replacement parts installed (if appropriate)
- Date of next scheduled service
- Any other useful information

Spare Parts

In addition to a schedule for maintenance activities, an adequate inventory of spare parts is required to minimize equipment downtime. The inventory includes those parts and supplies that:

- Are subject to frequent failure
- Have limited useful lifetimes
- Cannot be obtained in a timely manner should failure occur

FM;s and the respective laboratory managers are responsible for maintaining an adequate inventory of spare parts. In addition to spare parts and supply inventories, an in-house source of backup equipment and instrumentation should be available.

Instrument Calibration and Frequency

Laboratory instruments will be calibrated by qualified personnel before sample analysis according to the procedures specified in each method. Calibration will be verified at method-specified intervals throughout the analysis sequence. The frequency and acceptance criteria for calibration are specified for each analytical method. When multi-point calibration is specified, the concentrations of the calibration standards should bracket those expected in the samples. Samples will be diluted, if necessary, to bring analyte responses to within the calibration range. Data that exceed the calibration range cannot be reported by the laboratory. The initial calibration curve will be verified as accurate with a standard purchased or prepared from an independent second source. The initial calibration verification involves the analysis of a standard containing all the target analytes, typically in the middle of the calibration range, each time the initial calibration is performed. Quantitation based on extrapolation is not desirable.

Field equipment will be calibrated according to the manufacturers' instructions immediately prior to field sampling. Calibration documentation will be sent by the FM's to the PM to be stored in the project file.

Standard Materials and Other Supplies and Consumables

Standard materials must be of known high purity and traceable to an approved source. Pure standards must not exceed the manufacturer's expiration date or 1 year following receipt, whichever comes first. Solutions prepared by the laboratory from the pure standards must be used within the expiration date specified in the laboratory's SOP.

All other supplies and consumables must be inspected prior to use to ensure that they meet the requirements specified in the appropriate SOP. The laboratory's inventory and storage system should ensure their use within the manufacturer's expiration date and that the supplies are stored under proper condition

Data Management

Data management entails storing, handling, accessing, and securing data collected for the GSLBSP. The data gathered will be consolidated and compiled into the GSLBSP database that will be used to support data reporting. The following sections describe the data management process and associated staff responsibilities.

Sample Tracking

The FMs will assign someone from their respective sampling teams to send the PM COCs of samples to initiate the sample tracking process. The PM is responsible for tracking samples and deliverables to ensure that the analytical results for all samples sent for analysis are received.

Data Tracking and Management

The PM will maintain a tracking system for each COC/laboratory sample delivery group collected. The data will be tracked from collection through completion and review of the data verification/validation process.

Data Collected in the Field

Sample location coordinates, depths, procedures used to collect the sample, field measurements, and any other data collected will be provided by the FMs for incorporation into the database. These data will be transferred in an electronic format, but may also be in hardcopy format. All field data submitted for inclusion into the database will undergo a technical review prior to submission by the FMs and loaded into the GSLBSP database.

Electronic Data Deliverables

Electronic Data Deliverables (EDDs) will be submitted by the laboratory in the specified format mutually agreeable between the laboratory and the PM.

Laboratory Data Hard Copy Storage

All raw analytical laboratory data are stored as the original hard copy. Hard copy information includes COC forms, analytical bench sheets, instrument printouts, certificates of analyses, and QA/QC report summaries.

Electronic Data Deliverables Verification

Once the EDD is received at UDWQ, the EDD must be checked to verify correct format and content. If errors are found, the file will be returned to the laboratory for correction and re-submittal. Checks must be conducted to ensure the consistency and the validity of the EDD's content before the data are electronically transferred for data validation.

PERFORMANCE EVALUATION AND AUDITS

Performance Evaluations

Performance evaluations may be required by the laboratories and will be administered by UDWQ. Performance audits quantitatively assess the data produced by a measurement system. A performance audit involves submitting project-specific performance evaluation samples for analysis for each analytical method used in the project. The project-specific PE samples are selected to reflect the expected range of concentrations for the sampling program. The performance audit answers questions about whether the measurement system is operating within control limits and whether the data produced meet the analytical QA specifications.

The project-specific PE samples are made to look as similar to field samples as possible and are submitted as part of a field sample shipment so that the laboratory is unable to distinguish between them and project samples. This approach ensures unbiased sample analysis and reporting by the laboratory.

The critical elements for review of PE sample results include (1) correct identification and quantitation of the PE sample analytes, (2) accurate and complete reporting of the results, and (3) measurement system operation within established control limits for precision and accuracy.

The concentrations reported for the PE samples shall be compared to the known or expected concentrations spiked in the samples. The percent recovery shall be calculated and the results assessed according to the accuracy criteria for the values from the PE sample provider. If the accuracy criteria are not met, the cause of the discrepancy shall be investigated and a second PE sample shall be submitted. If a second PE sample does

not meet accuracy criteria, an audit of the laboratory may be performed. Also, a secondary laboratory may be used until acceptable corrective action is implemented and a PE sample meeting criteria for the specific method in question is submitted.

External Audits

UDWQ reserves the right to conduct announced and unannounced audits of the field operations and of the primary laboratories during any stage of the project.

Internal Audits

Audits of the laboratory shall be conducted by the laboratory's Quality Assurance Officer (QAO). The audits shall verify, at a minimum, that written standard operating procedures are being followed; standards are traceable to certified sources; documentation is complete; data review is being done effectively and is properly documented; and data reporting, including electronic and manual data transfer, is accurate and complete. All audit findings shall be documented in QA reports to management. Necessary corrective actions shall be taken within a reasonable time frame. The QAO shall verify that such actions are effective and complete and shall document their implementation in an audit closeout report to management.

DATA VALIDATION AND USABILITY

Data validation will be performed on all of the analytical data using level 2, 3, or 4 procedures as defined below. The initial data packages for each laboratory/matrix/method combination will be reviewed following level 4 protocols. A tiered approach for data validation on the remaining data will be performed based upon the findings of the initial data validation.

Level 2 Validation

Level 2 data validation consists of reviewing the following items:

- A review of the data set narrative to identify any issues that the lab reported in the data deliverable
- A check of sample integrity (sample collection, preservation, and holding times)
- An evaluation of basic QC measurements used to assess the accuracy, precision, and representativeness of data, including QC blanks, LCSs, MS/MSD, and field or laboratory duplicate results
- A review of sample results and detection limits to verify that project analytical requirements are met
- Initiation of corrective actions, as necessary, based on the data review findings
- Qualification of the data using appropriate qualifier flags, as necessary, to reflect data usability limitations

Level 3 Validation

Level 3 validation procedures also will include reviewing the evaluation of calibration and QC summary results against the project requirements and other method-specific QC requirements.

Level 4 Validation

Level 4 validation procedures will include reviewing sample raw data and verification of analyte identification and calculations for at least 10 percent of the data:

- Data validation qualifiers can be electronically applied to the data, either directly or through upload from a spreadsheet or equivalent
- The laboratory selected can produce a data package that contains the necessary information to perform data validation in a logical, well-organized manner
- An initial data quality assessment report after the level 4 data validation is completed will be provided outlining the recommendations for the review of the remaining data
- A final data quality assessment report will be prepared after data collection activities are completed

The QA/QC staff conducting data evaluation is responsible for ensuring data qualifier flags are assigned as needed based on the established QC criteria and that any limitations are communicated to the data users. These data qualifier flags are not related to any flags that may be assigned by the laboratory. Data qualifier flags explain the type and extent of limitation placed on a result, while laboratory flags identify QC results that are outside laboratory tolerances and may or may not lead to subsequent data qualifiers assigned during data evaluation. The QA/QC staff is also responsible for initiating corrective actions for analytical or other problems identified during the data evaluation process. Corrective actions range from verifying that the method was in statistical control during the analytical runs, to re-analysis of the sample or resampling or reissuing the laboratory report for clerical errors.

Qualifier flags, if required, will be applied to the electronic sample results. If multiple flags are required for a result, the most severe flag will be applied to the electronic result. The hierarchy of flags from the most severe to the least severe will be as follows: R, UJ, U, and J (Table7). Data validation flagging will follow the criteria in Table 8 for general water chemistry.

TABLE 7 QUALIFIER VALIDATION FLAGGING

J	Analyte was present but reported value may not be accurate or precise.
R	This result has been rejected.
U	This analyte was analyzed for but not detected at the specified detection limit.
UJ	The analyte was not detected above the detection limit objective. However, the reported detection limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample

TABLE 8 DATA QUALIFYING CONVENTIONS – GENERAL CHEMISTRY

Quality Control Check	Evaluation	Flag	Samples Affected
Holding Time	Holding time exceeded for extraction, digestion or analysis by less than a factor of two	J positive results, UJ non-detects	Sample
	Holding time exceeded for digestion or analysis by a factor of two	J positive results; R non-detects	
Sample Preservation	Sample not preserved (If sample preservation was not done in the field but was performed at the laboratory upon sample receipt, no flagging is required)	J positive results; UJ non-detects	Sample
Initial Calibration (Multi-Point only)	Correlation Coefficient $\leq$ 0.995 %RSD >UCL	J positive results; R non-detects	All associated samples in analysis batch
Calibration Verification (ICV and CCV)	%R > UCL %R < LCL	J positive results J positive results, UJ non-detects	All associated samples in analysis batch
Laboratory Control Sample (LCS)	%R > UCL	J positive results	All samples in preparation batch
Method Blank	Analyte(s) detected > MDL	U positive sample results ≤ 5x highest blank concentration	All samples in preparation batch or analytical batch, whichever one applies, associated with method blank
Calibration Blank	Analyte(s) detected >MDL	U positive sample results ≤ 5x highest blank concentration	All samples in preparation batch or analytical batch, whichever one applies, associated with calibration blank
Equipment Blank	Analyte(s) detected > MDL	U positive sample results ≤ 5x highest blank	All samples, same site, matrix and date (water) or all samples, same site, matrix (soil) associated with equipment blank

Quality Control Check	Evaluation	Flag	Samples Affected
Matrix Spikes	%R > UCL	J positive results	Matrix spike analytes in parent sample and field duplicate, if any.
	%R < LCL	J positive results, UJ non-detects	
	%R < 10%	J positive results, R non-detects	
	RPD > UCL	J positive results	
	Sample concentration >4x spike concentration	None, note problem in data validation report	None
Sample Duplicate	RPD > UCL	J positive results	Sample
Retention Time Window (SW9056)	Analyte within established window	R all results	Sample
Field duplicates	Both sample results ≥RL, and RPD >UCL	J positive results	Normal and field duplicate
	One sample detected ≥RL and one sample non-detect	J positive result; UJ non-detect	Normal and field duplicate
Holding Time	Holding time exceeded for extraction, digestion or analysis by less than a factor of two	J positive results, UJ non-detects	Sample

REFERENCES

EPA, 2000. *Guidance for the Data Quality Objectives Process.* EPA QA/G-4. EPA/600/R-96/055. Office of Environmental Information, Washington, DC. August.

EPA, 2001. *Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual.* EPA-823-B-01-002. Office of Water. October.

APPENDIX A. FIELD DOCUMENTATION

Equipment/Instrument Manual

Standard Operation Procedures

APPENDIX B. LABORATORY DOCUMENTATION

QA Manual

Standard Operation Procedures

Data Report Format