FINAL

Field Sampling Plan
Outfalls 001 and 012, Great Salt Lake

Prepared for

Jordan Valley Water Conservancy District
Rio Tinto Kennecott Copper

February 2017 (Updated May 2017)

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Acronyms and Abbreviations

°C	degrees Celsius
AMAV	American Avocets
BNST	Black-necked stilts
cm^3	cubic centimeter
COC	chain-of-custody
DQO	Data Quality Objective
DWQ	Utah Division of Water Quality
EPA	United States Environmental Protection Agency
FSP	Field Sampling Plan
g	gram
GPS	global positioning system
GSL	Great Salt Lake
HSP	Health and Safety Plan
I	Interstate
JVWCD	Jordan Valley Water Conservancy District
KUC	Kennecott Utah Copper LLC
LCS	laboratory control sample
MB	method blank
MDL	method detection limit
µg/L	micrograms per liter
mg/kg	milligram(s) per kilogram
mg/L	milligram(s) per liter
mgd	million gallons per day
mm	millimeter
MS	matrix spike
MSD	matrix spike duplicate
ng/g	nanogram(s) per gram
ng/L	nanogram(s) per liter
oz	ounce
PD	positive development

PFD	personal floatation device
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RL	reporting limit
RO	reverse osmosis
RPD	relative percentage difference
RS	reference sample
RTKC	Rio Tinto Kennecott Copper
SOP	standard operating procedure
SWGWTP	Southwest Groundwater Treatment Plant
TDS	total dissolved solids
UPDES	Utah Pollution Discharge Elimination System

SECTION 1

Introduction

This Field Sampling Plan (FSP) was prepared on behalf of Jordan Valley Water Conservancy District (JVWCD) and Rio Tinto Kennecott Copper (RTKC) to meet requirements set forth by their respective Utah Pollution Discharge Elimination System (UPDES) permits for outfalls along the south shore of the Great Salt Lake (GSL) in Gilbert Bay (Figure 1). This FSP provides for the routine survey of birds, collection of environmental samples and reporting of concentrations of selenium and mercury in the water, macro-invertebrates, and bird eggs during the nesting season in the outfall channel and delta. This FSP also provides for the routine collection of environmental samples and reporting of concentrations of selenium and mercury in lake water and brine shrimp offshore in the vicinity of these outfalls during the nesting season and month of October.

1.1 Background

JVWCD is operating the Southwest Groundwater Treatment Plant (SWGWTP) to remediate contaminated groundwater from historic mining activities in southwest Salt Lake County and other groundwater impacted by nonmining conditions. A reverse osmosis (RO) treatment process is being used at the treatment plant to treat contaminated groundwater and supply drinking-quality water to its member agencies to meet increasing drinking water demands. The RO byproduct water is routed via a 21-mile pipeline and discharged to Gilbert Bay, GSL at JVWCD Outfall 001 under UPDES Permit No. UT0025836. Currently, the byproduct discharge from JVWCD is 1.5 million gallons per day (mgd); the ultimate build-out flow rate is 3 mgd. JVWCD's Outfall 001 is located approximately 20 feet east of RTKC's Outfall 012.

RTKC is currently operating a copper mine and tailings impoundment with a periodic discharge to Gilbert Bay, GSL. The discharge at Outfall 012 is permitted under UPDES Permit No. UT0000051. The flow rate from RTKC's Outfall 012 varies from zero to 50 mgd.

1.1.1 Objectives

The objective of this FSP is to collect and report the information defined in JVWCD's and RTKC's UPDES permits to the Utah Department of Environmental Quality, Division of Water Quality (DWQ). This FSP defines the sampling quality objectives, survey and sampling procedures, analytical procedures, safety considerations, and documentation and reporting requirements to be implemented by JVWCD and RTKC.

1.2 Site Description

Outfall 001 is located on the south shore of Gilbert Bay, generally 1,000 feet northwest of Interstate (I) 80 near Mile Marker 105 (Latitude 40°45'37.59"N; Longitude 112°10'13.32'W) (Figure 1). Outfall 012 is located approximately 20 feet west of Outfall 001, at Latitude 40°45'37.63"N; Longitude 112°10'13.95"W (Figure 2). The outfalls are most-readily accessed at a gate located on a frontage road on the north side of I-80 via Exit 102 on I-80 (i.e., Saltair exit). The outfalls are approximately 0.5 mile from this gate. Parking is limited due to a very narrow and soft shoulder along the frontage road.

JVWCD's discharge is from an 18-inch-diameter pipeline into an existing, incised channel that ranges from 15 to 40 feet wide (Figure 3). This channel also conveys the discharge from RTKC's 54-inch-diameter pipeline. The channel flows approximately 2,500 feet generally to the northwest where it disperses into a wide delta region before reaching the waters of Gilbert Bay. The delta consists of numerous braided, very shallow channels (Figure 4). The location of the confluence of flows from the

outfalls and Gilbert Bay varies depending upon flow rate, the location of the low flow channel, and lake levels.

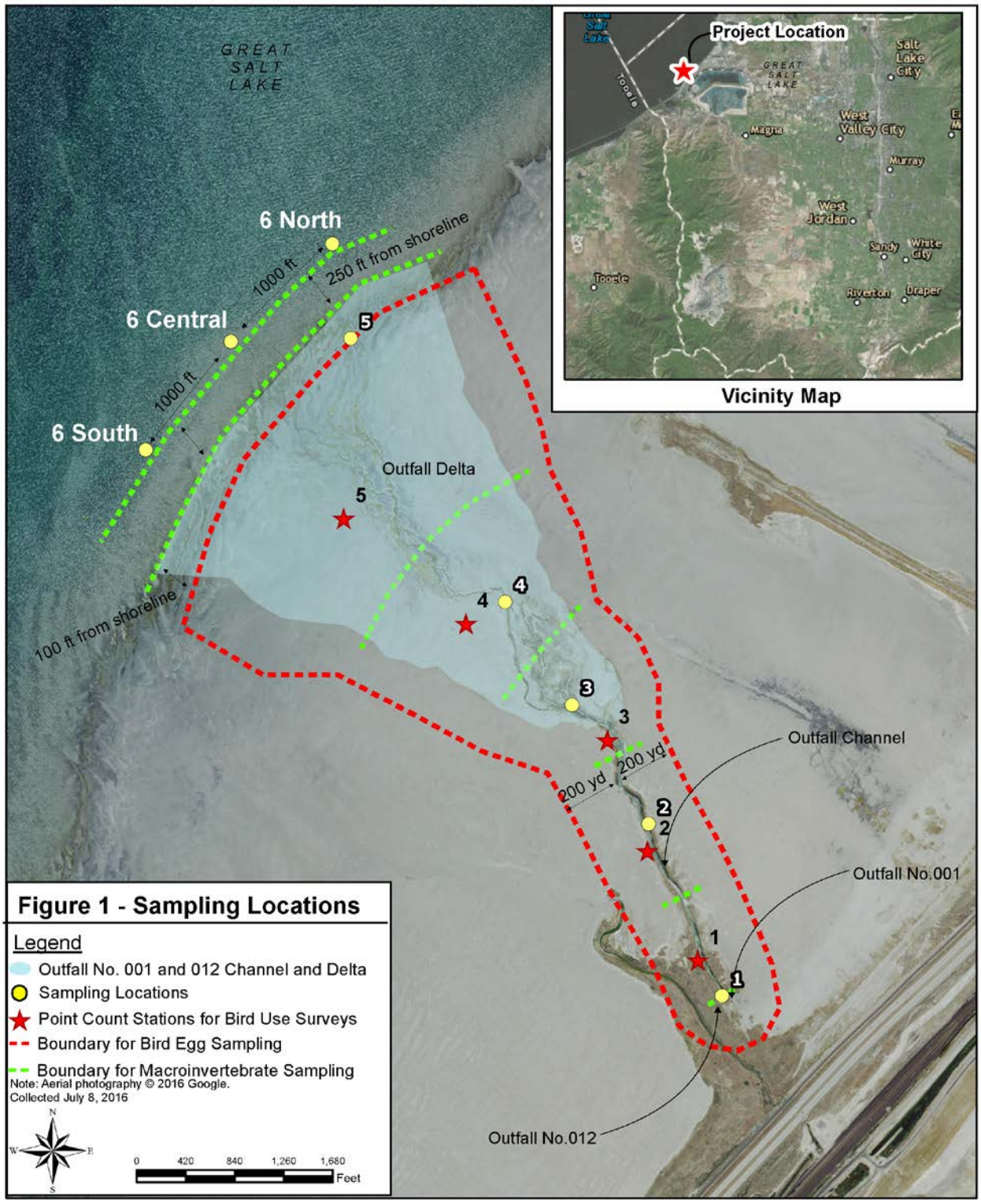

Figure 2. Outfall 001 on the Left and Outfall 012 on the Right

Figure 3. Incised Channel Ranging from 15 to 40 Feet Wide

Figure 4. Wide Delta Area Consisting of Numerous Braided, Shallow Channels

SECTION 2

Data Quality Objectives

The United States Environmental Protection Agency's (EPA's) seven-step Data Quality Objective (DQO) process (EPA, 2006) was used to guide the requirements and design rationale for the GSL sampling and analysis plan. The DQO's 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 1 details the DQOs for this study.

Table 1. DQOs for GSL Monitoring Program for JVWCD's Outfall 001 and RTKC's Outfall 012 at Gilbert Bay

Step	DQOs for JVWCD and RTKC
1. Problem Statement	**Problem:** DWQ has issued discharge permits for Outfalls 001 and 012. The two permits require JVWCD and RTKC to conduct bird surveys and monitor the concentration of selenium and mercury in water, macro-invertebrates, and bird eggs during the annual bird nesting season in the outfall channel and delta. The permits include regulatory limits for selenium concentrations in bird eggs. The permits also require JVWCD and RTKC to collect samples of lake water and brine shrimp biannually from GSL in the vicinity (offshore) of the outfall channel. **Available Resources:** JVWCD and RTKC will supplement its staff with consultants as required to complete the required sampling, analysis, and reporting. **Relevant Deadlines:** JVWCD and RTKC are required to submit laboratory results to DWQ by February 1 following the end of the calendar year for which the results were obtained as a part of an Annual Project Operating Report.
2. Goal of the Study/Decision Statements	**Key Questions:** 1. What are the concentrations of total selenium, total mercury, and methyl-mercury in co-located samples of water and what are the concentrations of total selenium and total mercury in macro-invertebrates, collected within the outfall channel and delta during the shorebird nesting season? 2. What are the abundance, diversity, and nesting and feeding habitats of birds at the outfall during the nesting season? 3. What are the concentrations of total selenium and total mercury in bird eggs representing shore birds foraging within the effluent found in the channel and delta? 4. What are the concentrations of total selenium and mercury in co-located samples of lake water and brine shrimp sampled offshore of the outfalls during the nesting season and in the month of October? **Possible Outcomes:** 1. Able to collect samples from all required sampling locations 2. Due to physical conditions at the site; e.g., elevated GSL water elevation, no brine shrimp along shoreline of GSL, extreme weather, etc.; samples cannot be collected from the required sampling locations during sampling events in one or both sampling periods. 3. Less than eight bird eggs are available. Fewer eggs result in even lower confidence in the Geomean value of bird egg concentrations. 4. Bird eggs are not available. JVWCD and RTKC will notify DWQ and summarize sampling searches and all other data in the Annual Project Operating Report. 5. Significant changes in the GSL level may affect sampling locations and/or procedures defined in this FSP and will require an evaluation of and modification to the FSP.

3. Inputs to the Decision	**Informational Inputs:** The following information will be collected at the required sampling locations along the outfall channel and delta, as shown in Figure 1: 1. Annually, sample co-located water and macro-invertebrates from the outfall channel and delta and analyze for total selenium and total mercury; moisture content of macro-invertebrate samples will be measured and reported. Macro-invertebrate results will be reported on dry-weight basis. Water samples will also be analyzed for salinity and methyl-mercury concentrations. 2. Conduct annual bird surveys at approximate 2-week intervals between April 15 and June 30 (a minimum of five times per nesting season) to document bird species, abundance, diversity, and use of the joint JVWCD Outfall 001 and RTKC Outfall 012 area, particularly for evidence of feeding and nesting. 3. If it is determined the time interval between bird survey and/or field sampling site visits will exceed 14 days, then an observation site visit will be made in the time interval solely to determine if Black-necked Stilts (BNST) or American Avocet (AMAV) are present within the study area. The presence or lack of these shorebirds will be documented. If BNST or AMAV are observed in the study area during a bird survey, field sampling, or observation site visit as identified above then another observation site visits will be completed to confirm the presence of the birds previously observed, nesting behavior, and collect bird eggs if possible. Care will be taken to minimize bird disturbance. Additional observation site visits will be completed at 3 to 5 day intervals after the birds are first observed onsite and optimized to maximize the subsequent probability of collecting bird egg samples. Up to five observation site visits will be made during the nesting season in addition to the bird surveys and field sampling visits. 4. Annually, sample eight bird eggs (1 egg per nest), if available, or less if eight are not available, but not to exceed 20 percent of observed available eggs during the nesting season (April 15 through June 30). Eggs will be collected from bird nests in the joint JVWCD Outfall 001 and RTKC Outfall 012 area; within 200 yards of the water in the channel and delta to represent eggs from birds foraging within the effluent, as shown in Figure 1. Whole eggs shall be analyzed for total selenium and total mercury on dry-weight basis; moisture content of the samples also will be measured and reported. The location of each nest where each egg was collected will also be recorded. BNST and AMAV are the species first targeted for egg sampling. If eggs from these species are not available, other shorebirds will be targeted if available. 5. Biannually, collect a minimum of three samples of co-located lake water and brine shrimp at least 250 feet offshore of the outfall channel and delta and analyze for total selenium and total mercury; moisture content of brine shrimp samples will be measured and reported. Brine shrimp results will be reported on dry-weight basis. Water samples will also be analyzed for salinity and methyl-mercury concentrations. Sampling of lake water and brine shrimp shall occur once, ideally at the same time samples are collected from the outfall channel and delta, during nesting season (April 15 through June 30) and once during the month of October. **Variables/characteristics to be measured:** Total selenium and total mercury concentrations in the following: • Bird eggs • Co-located water and macro-invertebrates in the outfall channel and delta • Co-located lake water and brine shrimp • Methyl-mercury concentrations in all water samples • Salinity of all water samples • Moisture content of biological samples; report dry-weight concentrations and moisture percentage of biota samples • Bird species, abundance, diversity and use, particularly feeding and nesting within joint JVWCD Outfall 001 and RTKC Outfall 012 study area

Table 1. DQOs for GSL Monitoring Program for JVWCD's Outfall 001 and RTKC's Outfall 012 at Gilbert Bay

Step	DQOs for JVWCD and RTKC
4. Study Boundaries	For co-located outfall water and macro-invertebrates; open channel and delta formed by flow from Outfalls 001 and 012, extending from the discharge point to the confluence with open waters of Gilbert Bay. For bird eggs, the objective is to collect eggs from birds who are foraging within the effluent from the outfalls, thus the sampling area extends to within 200 yards of the edge of water in the channel and delta and would be preferentially at least 100 feet away from the lake water. For co-located lake water and brine shrimp; at least 250 feet perpendicular from GSL's water edge (i.e., offshore within Gilbert Bay) in the vicinity of the outfall channel and delta. The discharge point of JVWCD Outfall 001 is located at Latitude 40˚45'37.59"N; Longitude 112˚10'13.32"W. The discharge location for RTKC Outfall 012 is Latitude 40˚45'37.63"N; Longitude 112˚10'13.95"W. **Temporal:** The period of data collection for most samples will be during the nesting season, April 15 through June 30. Co-located lake water and brine shrimp samples will be collected again sometime during the month of October. **Practical Constraints on Data Collection:** • Occurrence of breeding birds feeding and nesting along Outfalls 001 and 012 is a constraint, as it will dictate the presence of appropriate bird eggs for sampling. • Predators (e.g., gulls, ravens, coyotes, etc.) and people are a constraint as they may limit breeding along and near Outfalls 001 and 012 and result in inability to find eggs. • GSL lake level may be a constraint as it may affect sampling locations and limit breeding along and near Outfalls 001 and 012 and result in inability to find eggs. • The presence, depth of water, and lack of presence of macro-invertebrates in Outfalls 001 and 012 channel and delta may be a constraint; all sites may not equally yield co-located samples. • Brine shrimp may or may not be found within the lake sampling zone due to winds, lake currents, etc.
5. Decision Rules	1. If samples collected and data analyzed are adequate *to describe the influence of the outfall's effluent*, JVWCD and RTKC will complete reporting as required. 2. If samples collected and data analyzed are not adequate to quantify selenium and mercury in bird eggs *and the influence of the outfall's effluent*, then JVWCD and RTKC will notify DWQ and complete reporting as required. 3. If samples collected and data analyzed are not adequate to quantify selenium and/or mercury in water and/or macro-invertebrates *and the influence of the outfall's effluent* then JVWCD and RTKC will notify DWQ in a timely manner and complete reporting as required.
6. Tolerable Limits on Decision Rules	Tolerance limits for laboratory analysis data quality are specified under Section 5 above, in terms of acceptability criteria. In general, acceptability criteria for analysis of selenium and mercury in tissues are ±10 percent and for water are ±25 percent. The quality control (QC) procedures specify all quality assurance (QA)/QC objectives for sample measurement based on each matrix.
7. Optimization of the Sampling Design	**The sampling plan is summarized as follows:** Bird use in and adjacent to the outfall channel and delta will be surveyed a total of five times during the annual bird nesting season (approximately every 2 weeks, April 15 through June 30). Observers will document bird abundance, diversity, and patterns of use for feeding and nesting. Additional observational visits (up to five per season) will occur to keep the time between visits less than 14 days and to follow up on previous sightings. Co-located samples of outfall water and macro-invertebrates will be collected annually from five sampling locations located along the outfall channel and delta. Samples will be analyzed and results reported for total selenium and total mercury, plus moisture content of invertebrates and methyl-mercury and salinity in water samples. Up to eight bird eggs (one egg per nest), from the area adjacent to the outfall channel and delta (within 200 yards of the channel, as shown in Figure 1) will be collected and analyzed for total selenium and total mercury on a dry-weight basis. Moisture content of the samples will also be

Table 1. DQOs for GSL Monitoring Program for JVWCD's Outfall 001 and RTKC's Outfall 012 at Gilbert Bay

Step	DQOs for JVWCD and RTKC
	measured and reported. BNST and AMAV are the species targeted for egg sampling; if these are unavailable, eggs of other species such as Killdeer or Snowy Plover will be collected in lieu of the targeted species, if they are available. Co-located samples of lake water and brine shrimp will be collected biannually from the area offshore of the outfall channel and delta (a minimum of 250 feet from the edge of the GSL, as shown in Figure 1). Samples will be analyzed and results reported for total selenium and total mercury, plus moisture content of invertebrates and methyl-mercury and salinity in water samples. Outfall channel and delta sampling sites 1-4 are fixed to facilitate comparison of year-to-year data. Site 5 is located at the confluence of the outfall flow and the lake, thus the location will vary depending upon the location of flow in the delta and lake water level. Locations of sites may be adjusted to account for significant changes in lake level (±2 feet). New site locations, if needed, or the loss of sampling site locations will be coordinated with DWQ before sample collection and included in the annual operating report. Locations of offshore sampling will change at each sampling date due to the fluctuating lake level. Sample locations should be approximately in the same location relative to the edge of the lake and will be recorded at the time of sample collection.

SECTION 3

Sample Locations

Figure 1 illustrates the required locations within the outfall channel area for bird surveys and the collection of water, macro-invertebrate, and bird egg samples. Sampling locations 1-4 are at fixed locations. Sample point 5 is at the confluence of the outfall flow and the lake, thus the location will vary depending on the location of flow in the delta and lake water level. The offshore lake sampling locations will also change each sampling period, as they are based on a distance from the edge of the lake and are not fixed coordinates. Lake samples are to be collected at a distance of at least 250 feet perpendicular from GSL's water's edge (i.e., offshore within Gilbert Bay) near the outfall channel and delta. The three samples collected will be comprised of co-located lake water and brine shrimp at a south, central, and north location (each approximately 1,000 feet apart as shown in Figure 1). The use of these sampling locations will facilitate future analysis of year-to-year changes at these locations. Outfall channel and delta sample points and their coordinates are summarized in Table 2.

GSL water levels are expected to vary over time. If lake levels rise and inundate any or all of the sampling locations, JVWCD and RTKC will notify DWQ as soon as reasonably possible. Any changes to sampling locations agreed to with the DWQ will be documented in the Annual Project Operating Report. Changes to sampling locations will not necessitate a revision to this FSP.

Table 2. Outfall Channel and Delta, and Offshore Sample Points and Coordinates

Sample Points	Coordinates
1	40˚45'37.45"N 112 ˚10'14.03"W
2	40˚45'51.95"N 112 ˚10'22.48"W
3	40˚46'1.96"N 112 ˚10'31.18"W
4	40˚46'10.63"N 112 ˚10'38.83"W
5	At the confluence of the outfall flow in the outfall delta and GSL
6 (north)	250 feet from GSL shoreline, 1,000 feet north of central location
6 (central)	250 feet from GSL shoreline, in front of outfall channel discharge
6 (south)	250 feet from GSL shoreline, 1,000 feet south of central location

Broad areas will be surveyed for bird species, abundance and diversity, as well as for feeding and nesting activity along the discharge channel. The approximate location of stations for bird use surveys are shown in Figure 1. Broad areas will also be searched to obtain the required diversity and abundance of biota tissue samples. Birds feeding from the discharge channel and the delta are expected to nest along the edge of water in the outfall channel and delta. For this reason, an area of about 200 yards (600 feet) on either side of the discharge channel will be considered appropriate for bird egg sampling. Based on previous experience (Skorupa and Ohlendorf, 1991), this area is an average area expected for the foraging of these bird species around their nests. Eggs collected from this area will be a better indicator of bird species feeding directly from the channel and delta. The area is shown in red dashed lines in Figure 1. Similarly, sufficient mass of macro-invertebrates should be collected to be able to enable analysis of concentrations of selenium and mercury and a relatively large area may be needed to collect adequate biomass. Thus, the area for macro-invertebrates sampling will be evenly spread with the five sampling points as central locations and are indicated in green dashed lines in Figure 1.

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SECTION 4

Sampling Procedures/Methodology

Before going out for field sampling, a checklist of all routine material and equipment needed during sampling will be prepared. A separate list will be created for specialized sampling equipment, if required. Specialized sampling may include materials and equipment for clean sampling methods. In addition, safety gear, such as life jackets and safety vests, as well as appropriate clothing and shoes, will be worn as required during sampling.

4.1 Health and Safety

A site hazard analysis and Health and Safety Plan (HSP) should be prepared before completing sampling activities as required by JVWCD and RTKC. While possible hazards include accessing the outfall and working in and around moving water, the field sampling team should assess all hazards and address them in the HSP before going to the field. All staff involved with field sampling activities will follow the HSP. Possible hazards include, but are not limited to:

1. Outfalls 001 and 012 are located approximately 1,000 feet northwest of the frontage road. The shoulder in this area is very narrow, thus presenting safety concerns for both parking and walking to sampling sites.
2. Sampling will be performed in and around moving water, possibly involving the use of a boat. Sampling personnel should work in groups of two, at a minimum, when obtaining samples and wear all appropriate safety gear, including a personal flotation device (PFD) when using a boat. Sampling personnel should not wade into water deeper than waist-high. If water is deeper than waist-high, a boat shall be used to perform sampling. During and after sample collection, personnel should keep their hands away from their eye and mouth areas and always wash their hands with soap and water after sampling. Staff should be watchful for sharp objects, such as broken glass, and should not pick up suspicious objects.

4.2 Bird Use Surveys

Bird use surveys will be conducted along the discharge watercourse from the discharge point to the water edge where Outfall 001 and Outfall 012 enter the standing waters of the GSL. Five surveys between April 15 and June 30 will be conducted at intervals of about 2 weeks. Additional observation visits will be included as necessary. The objective of bird surveys along the channel and delta will be to characterize the relative abundance and diversity of birds along with their feeding and nesting activity.

4.2.1 Presampling Checklist

The presampling checklist of materials will include, at a minimum, the following:

- A global positioning system (GPS) unit
- A map showing survey sites with coordinates
- Digital camera
- Field measuring tape (300 yards)
- Bird survey form
- Clipboard

- Bound field logbook
- Binoculars
- Pens and pencils
- Cell phones in case of emergency
- First-aid kit

4.2.2 Field Method

The basic method for the bird survey will be a modification of the Point Count method (Ralph et al., 1993, 1995). This method uses a series of point counts at fixed stations a minimum distance of 300 yards apart within the site with the observer recording all birds seen and heard within a 10-minute time period and avoiding counting birds that were recorded at previous sampling stations. In addition, observers will record observations of birds seen between the identified fixed stations separately. All surveyors will be familiar and experienced with using the Point Count method.

The approximate location of the five Point Count stations for this FSP is shown in Figure 1. Actual GPS coordinates of stations will be recorded by surveyors. All surveys will be conducted from one side of the channel. Before surveying, surveyors will delineate the observing area into three zones based on distance from the channel boundary as follows:

- Zone 1 – Less than 100 yards
- Zone 2 – Between 100 and 200 yards
- Zone 3 – More than 200 yards

The observers will be familiar with most, if not all, of the bird species likely to be encountered. Bird activity, time of day, and weather conditions will be recorded on a standard form by species along with the counts. Standard bird survey forms are shown in Table 3. In addition, nesting activity and the presence of nests will be noted and counted as a measure of habitat quality and bird use. Any observations and evidence of birds and bird nest predation will be clearly documented. Field notes of all field activity will be recorded in a bound field logbook. Field notes will include date and time; names of personnel conducting the survey; the work performed; any problems identified, as well as corrective actions taken; and other appropriate general comments or observations.

Table 3. Bird Survey Forms

Location:		**Date:**	
Observer:		**Start Time:**	
Wind (mph):		**End Time:**	
Cloud (%):		**Temperature:**	
Species	**Numbers**	**Activity**	**Remarks/Behavior/Predation**
Less than 100 yards from Point Count Station			
100 to 200 yards from Point Count Station			
More than 200 yards from Point Count Station			

4.3 Bird Observation Visits

A key objective of this FSP is to collect shorebird eggs associated with birds foraging within the water of the outfall channel and delta and reflect the bird's exposure to potential contaminants in the effluent. Bird observation visits will be completed to enhance the probability of collecting these bird eggs while, simultaneously, not disturbing birds potentially nesting in the study area.

4.3.1 Presampling Checklist

The presampling checklist of materials will include, at a minimum, the following:

- A map of the study area
- Digital camera
- Bound field logbook or electronic note app
- Binoculars
- Pens and pencils
- Cell phones in case of emergency
- First-aid kit

4.3.2 Field Method

Up to five bird observation visits, in addition to the bird survey and field sampling visits, will be completed to identify the presence of AMAV and BNST and confirm their nesting behavior. These bird observation visits are different from bird surveys and may be different than bird egg sampling events. These observation visits are triggered and will be completed if any of the following occurred:

1. If it is determined the interval between site visits (i.e., bird survey and/or field sampling) was going to be more than 14 days, then a bird observation visit will be completed to determine if AMAV and/or BNST were present at the site.
2. If AMAV and/or BNST were observed at the site during a bird survey, field sampling, or observation site visit as identified in #1 above, then a bird observation visit will be completed to confirm the presence of AMAV and BNST previously observed at the site to confirm their nesting behavior and collect bird eggs, if possible. It is assumed these site visits will be completed at 3 to 5 day intervals after AMAV and/or BNST are first observed onsite and optimized to maximize the subsequent probability of collecting bird egg samples.

Each bird observation visit will be composed simply of walking along the outfall channel and delta outside of the bird egg collection area identified in Figure 1 and determining if AMAV or BNST are present and whether or not they may be nesting. Any AMAV or BNST activity will be noted. Observations made during an observation visit will inform the need for a subsequent observation visit (if AMAV and BNST are present) and need to make an attempt to collect bird eggs (if nesting behavior is observed and depending upon the period of time AMAV/BNST have been onsite).

4.4 Bird Egg Sampling

Sampling of bird eggs for selenium and mercury analysis will provide a direct measure of the bioaccumulation of these constituents in resident nesting birds likely to be foraging (at least in part) in Outfalls 001 and 012 during the nesting season. The results may be used to relate water and invertebrate concentrations to those observed in the bird eggs if the birds were foraging within the outfall channel and delta. This, along with the nest location and timing of when the egg was laid, will aid in the estimation of exposure and risk to the birds from selenium and mercury from the outfall. It should be noted that **appropriate regulatory agencies should be contacted to ensure that permits and/or documentation are obtained before sampling bird eggs**.

4.4.1 Presampling Checklist

The presampling checklist of materials needed during egg sampling will include the following:

- Permits (eggs should be collected under Utah Scientific and Federal collecting permits)
- A GPS unit
- A map showing sampling sites with coordinates
- Bound field logbook or electronic note app
- Binoculars
- Field distance measuring instruments
- Digital camera
- Padded egg collection boxes (hard-sided container [e.g., egg cartons, Tupperware, or a tackle box with foam padding])

- Labels
- Marker pens and pencils
- Cell phones in case of emergency
- Cooler filled with ice
- First-aid kit

4.4.2 Field Methods

Eight eggs (one per nest) from AMAV or BNST nests will be collected from the area around the channel (Figure 1) during the nesting season from April 15 through June 30. If eggs from these species are unavailable, eggs from nests of other shorebirds such as Killdeer or Snowy Plovers with similar feeding habits will be collected, if these species nests are available. Every attempt will be made to collect an equal number of eggs from the two species (four eggs from each species), but if there is a shortage for one species the total number will be collected by taking more eggs of the other species. If the required number of eggs and an equal number of eggs from each species cannot be obtained during a nesting season, and one species is represented more than the other is, this will be noted while reporting and interpreting the data.

Some nests will be located during bird surveys by watching for the adults leaving the nest, displaying, or "sneaking" away from the nest. Other bird nests will be located by looking for birds displaying behaviors associated with nesting activities, searching for adults on nests with binoculars, and opportunistically finding nests while conducting surveys and other activities. Locations identified during bird surveys will be searched for nests with eggs.

Eggs will usually be collected as soon as a nest is discovered to avoid losing samples to predation and to maximize the number of nests sampled for selenium and mercury. After a nest is located, one egg will be removed if the nest contains two or more eggs. At collection, each egg will be marked with a unique nest code and the date it was removed using a marker pen. Collected eggs should be whole and not cracked, since cracking increases variation in percent moisture and may lead to leakage or contamination of contents.

Information will be collected that will include a unique nest/egg identification code, bird species, location (using GPS coordinates for the nest), date, and number of eggs in the clutch. The egg will be placed in a container to avoid damage and the container will be placed in a cooler with wet ice. Collected eggs should be whole and not cracked. Eggs removed from nests will be transported to the laboratory in a hard container with sufficient padding. Eggs will be refrigerated at 4 degrees Celsius (°C) within 1 to 2 hours of collection and will remain refrigerated until opened, ideally no longer than 30 days.

Field notes of all field activity will be recorded. Field notes will include date and time, names of personnel conducting the survey, the work performed, any problems identified as well as corrective actions taken, and other appropriate general comments or observations.

4.4.3 Egg Breakout

Store eggs in a refrigerator as previously required if they cannot be processed immediately after collection. Do not freeze whole eggs because this will crack the shell. Ideally, eggs should be processed as soon as possible after collection and within 7 days of collection. However, because refrigeration arrests development, the vascularization and bright red color of the blood in an egg collected with a living embryo is preserved for a longer period of time.

The following describes the process of harvesting avian eggs in the laboratory. The goal of this description is to collect a standardized set of data on whole eggs, embryos, and shells while minimizing the possibility of laboratory contamination of samples.

All methods and results will be recorded in a bound laboratory logbook. Laboratory notes will include date and time, names of personnel processing the eggs, the work performed, any problems identified as well as corrective actions taken, and other appropriate results and general comments and observations.

4.4.3.1 Required Supplies

The supplies needed for the procedures include:

1. **Whole Egg Measurements:** distilled-deionized water, Kimwipes, laboratory balance (to 0.05 gram [g] increments), vernier caliper (graduated to 0.01 millimeter [mm]).
2. **Egg Harvest:** glass jars of appropriate size (chemically-cleaned and with TFE cap-liners) or Nalgene jars (depending on contaminant), weigh boats, stainless steel surgical scissors, forceps, blunt probe, lead pencil, or waterproof marker.
3. **Shell Thickness:** Contaminants being investigated, selenium and mercury, do not cause effects to eggshell thickness, thus this measurement will not be completed.

4.4.3.2 Egg Measurement Procedure

1. Eggs will be examined to determine if cracks are present in the shell. Any cracked egg should not be rinsed or immersed in water as this may contaminate the sample.
2. If an egg is not cracked and is dirty (soil, feces) it should be cleaned with a Kimwipe and distilled-deionized water that is at or near the temperature of the egg.
3. Write the sample ID number on the eggshell with a dull pencil or waterproof marker (IDs must be legible).
4. Record any remarkable characteristics of the egg (e.g., cracked, dented, discolorations, small in size, etc.).
5. Record the mass (g) of the whole egg, then measure the length (mm) and breadth (mm) of the egg at their greatest dimensions with calipers. To obtain an accurate measurement of length, ensure the caliper jaws are parallel to the longitudinal axis of the egg. For the breadth measurement, the jaws must be held perpendicular to the longitudinal axis of the egg.
6. Calculate the egg volume (cubic centimeter [cm^3]). For investigating contaminants such as selenium the volume can be calculated from measurements, egg volume is estimated using the length and breadth measurements and an equation from the published literature (e.g., Westerskov, 1950; Stickel et al., 1973; Hoyt, 1979) and recorded.

4.4.3.3 Egg Harvest

(Note: All tools used in an egg harvest and embryo exam must be cleaned between egg exams. Investigators should wear surgical gloves and change gloves between eggs.)

1. **Vent egg if necessary.** For eggs with a strong odor (indicating advanced decomposition of the contents), it is advisable to vent the egg before attempting to open it (explosions are possible). With safety glasses in place, gently insert a chemically-clean needle into the blunt end of the egg. Use gentle but steady pressure to pierce the shell.
2. **Open window at blunt end of the egg**. Tare a chemically- clean jar, loosen the lid, and tare the jar. Work over a clean glass Petri dish or weigh boat. Method 1 – using surgical scissors, apply gentle

pressure while rotating the scissors so a small hole is made in the shell at the blunt end of the egg just above the air cell. Continue cutting from the hole and cut around the entire egg above the air cell. Method 2 – Rest the egg lengthwise on an appropriate surface (compatible with the analyses requested). Using a clean sharp scalpel, gently score the egg about the blunt end of the egg. Apply gentle, steady pressure and make several rotations. If candling of the egg revealed an advanced state of incubation with air cell development, try to remove shell from just above the air cell. Membrane may need to be peeled back to allow further inspection of the embryo.

3. **Inspect embryo position in the egg.** Visually inspect the egg contents through the window and note the size of the air cell. This window is used to assess whether the position of the embryo in the egg is normal. Note embryo position and whether the embryo has pipped into the air cell. Determination of embryo position is not accurate until the embryo is ready to pip the air cell (i.e., the last 4 to 5 days of incubation). Shedding the nare caps is a good landmark for avocets and stilts. Normal position of the embryo during the final stages before pipping is with the head in the blunt end of the egg, with the head under the right wing and with the beak pointed toward the air cell. If incubation stage is very late (i.e., just before pipping from the shell), the embryo beak is in the air cell to allow pulmonary respiration to begin. There are six malpositions of the avian embryo, as follows:

    a. Head between thighs

    b. Head in small end of egg

    c. Head under left wing

    d. Embryo rotated so that the beak is not directed toward air cell

    e. Feet over head

    f. Beak over right wing

    Malpositioned embryos usually do not hatch, and positions a, c, and e are usually lethal.

    Usually the egg contents can be poured out into the container from the window opened for embryo inspection. If necessary, use surgical scissors and make transverse cuts from the blunt end to the narrow end of the egg to facilitate egg opening.

4. **Open egg.** Inspect embryo position and note age of the embryo. To estimate age of the embryo use stages of incubation from literature. The model reference for aging embryos is Lillie's development of the chick (Hamilton, 1952) Chapter 3. Good day-by-day embryo stage data with pictures exist for chickens, avocets (Skorupa and Ackerman 2009), mallards (Caldwell and Snart, 1974), American kestrels (Pisenti et al., 2001), and cockatiels (Abbott et al., 1991). If no embryo can be found, examine the yolk for the presence of a blastodisc. If fertile and the yolk is intact, this will appear as a white donut shape floating on top of the yolk. If infertile, no distinct donut will be apparent. Positive development (PD) is when the germ dies soon after fertilization but cell growth continues. Note presence (and whether they are of normal size for the stage of development) or absence of eyes, limbs, or limb buds; note presence and number of digits on the feet; measure length of tarsus and upper mandible. Look for evidence of internal hemorrhage, edema, brain swelling, presence or absence of eyes, or failure of the body wall to completely close. Minimize handling of the embryo to the degree possible and conduct as much as possible of the above exam in the half shell. Use clean forceps, and beware of cross contamination. Pour the contents into the opened jar. If necessary, use a clean spatula to scrape any remaining contents into the jar (be careful not to tear the shell membrane when using a spatula). Record presence or absence of an embryo, estimated age of embryo, other measurements taken, and abnormalities (if any).

5. **Egg contents mass (g):** Measure and record the weight in grams of the tared jar.

6. Label jar with sample ID and sample mass (place one label on the lid and the other on the jar itself) and immediately store the sample in the freezer. Sample shall be kept frozen during transportation to the laboratory for analysis.
7. Rinse the interior of the shell halves with tap water being careful not to tear the membrane, or erase the sample IDs. After the shells dry, use a waterproof marker to remark the shells with their sample ID. Store the shells in a cool dry place for at least 30 days or until they have attained a constant mass. Recycled egg cartons serve as excellent storage containers for egg shells. One tip to ensure that shells do not migrate from their respective compartments, is to place a folded sheet of paper over the shells before closing the carton.

4.5 Macro-invertebrate Sampling

Macro-invertebrate samples will be collected to measure total selenium and total mercury in the discharge channel and delta and also in three offshore locations within Gilbert Bay (offshore samples will be entirely made up of brine shrimp). Macro-invertebrates are the primary food for the bird species targeted for egg collection and are good indicators of water quality. If present in the discharge channel and offshore, they may bioaccumulate selenium and mercury and pass it on to the higher trophic levels of the food chain. The results obtained from sampling macro-invertebrates may be used to relate concentrations in water to those observed in the bird eggs.

4.5.1 Presampling Checklist

The presampling checklist of materials needed during macro-invertebrate sampling will include the following:

- A GPS unit
- A map showing sampling sites with coordinates
- Bound field logbook or electronic note app
- Field distance measuring instruments
- Digital camera
- Waders and boots
- Aquarium nets or larger kicknets
- Whirlpak or Ziploc bags with labels
- Gloves
- Labels
- Marker pens and pencils
- Cell phones in case of emergency
- Cooler filled with ice
- First-aid kit
- Distilled water
- White plastic sorting tray
- Forceps

4.5.2 Field Methods

The five sampling areas for macro-invertebrates within the channel and delta are shown in Figure 1. Three additional sample locations will be offshore at least 250 feet into Gilbert Bay so as to represent lake water rather than the mixing zone. Approximate locations are shown in Figure 1. Samples at all locations will be collected once every nesting season, as close in time as practical to the bird egg collection from the delineated areas and as close as practical to each of the fixed sampling locations. The three offshore locations will have an additional sample collected during the month of October. Sampling of water and macro-invertebrates should be completed in conjunction with each other. The objective of providing delineated areas within the channel for macro-invertebrate sampling, instead of specific sampling points, is to allow samplers to identify regions within each area where the birds are foraging, and to be able to collect sufficient macro-invertebrate biomass for analysis. A 5-minute feeding observation before sampling within each foraging area may provide guidance on where macro-invertebrates will be collected from the water column. Preference should be given to collecting macro-invertebrates at the same location as water samples are collected.

Aquatic invertebrate food items will be collected opportunistically in the general sampling area. Although abundant along the lake edge, sampling of adult brine flies should be avoided. Invertebrates collected at each station should be of sufficient biomass for analysis (target 10 g, minimum 5 g) and additional biomass when feasible, using aquarium nets or larger nets (kicknets) by sweep netting or light traps. Each sample will be stored in a Whirl-pak or Ziploc bag and labeled with its location or sample number and collection date. Samplers will make a visual estimation of relative abundance (by mass) of families of macroinvertebrate within each sample and record this information. Samples will be stored in a cooler until transported to laboratory.

In the laboratory, each sample should be sorted by family of macroinvertebrate if adequate mass is available for separate samples (target 10 g, minimum 5 g). Debris in samples should be removed and the samples should be rinsed with deionized water. Each sample will then be weighed, documented, and frozen until analyzed. Brine shrimp samples should be rinsed three times before being frozen. Preservation method, recommended containers, and minimum mass required for each test are outlined in Table 4.

Lack of sufficient organisms for testing requirements at any location will be noted in the field notes. Field notes of all field activity will be recorded in a bound field logbook or electronic app. Field notes will include date and time, names of personnel conducting the survey, the work performed, any problems identified as well as corrective actions taken, and other appropriate general comments or observations.

4.6 Water Sampling

Water samples will be collected to measure total selenium and total mercury and methyl-mercury in the discharge channel and delta and offshore of the discharge channel.

4.6.1 Presampling Checklist

The presampling checklist of materials needed during water sampling will include the following:

- A GPS unit
- A map showing sampling sites with coordinates
- Bound field logbook or electronic note app
- Waders
- Wading boots, if required

- 1-liter glass bottles with fluoropolymer or fluoropolymer-lined cap with labels
- Refractometer (0-28% salinity)
- Hydrometer (
- Digital camera
- Disposable gloves/elbow gloves
- Labels
- Marker pens and pencils
- Cell phones in case of emergency
- Cooler filled with ice
- First-aid kit
- Distilled water

4.6.2 Field Methods

The five in-channel water sampling locations are shown in Figure 1 and their coordinates are provided in Table 1. Site 5 is located at the confluence of the outfall flow and lake water. The location of this site may change depending upon lake level and where water is flowing in the outfall delta. The three offshore water sampling locations will be chosen by the sampler at least 250 feet from the edge of GSL, central to the outfall location, and approximately 1,000 feet to either side of central, offshore sampling location. Water samples will be collected 6 to 12 inches below the water surface directly as grab samples into 1-liter sample bottles, where possible. At the delta stations where water is less than 6 inches deep, a 1-foot-deep hole will be dug and the water will be allowed to flow through to flush out disturbed sediments before collecting water from the hole. Any suspended sediments will be allowed to settle down, after which the water sample will be collected as previously explained. Sampling locations with less than 6 inches of water depth will be recorded and a description of the manner used for sampling will be documented.

The field team will follow EPA Method 1669 (EPA, 1996) for clean hands/dirty hands techniques to collect water samples to be analyzed for total selenium, total mercury, and methyl-mercury.

Each bottle will be labeled with the sample number and date and time of collection (in most cases, containers will be prelabeled). Preservation method, containers, and minimum volume required are outlined in Table 4.

The field team will measure pH and salinity at each sampling station. Salinity may be measured using a refractometer, estimated by measuring the specific gravity of the water (ASTM 1429), or by analyzing a water sample for TDS.

Table 4. Macro-invertebrate and Water Sampling Guidelines

Parameter	Matrix	Min. Mass/Volume	Recommended Container	Recommended Preservation	Maximum Holding Time
Se & Hg	Wet Tissue	10 g	4 ounce (oz) glass or plastic wide mouth jars, zip-type plastic bags, or plastic wrap	0 to 4°C during shipment, ≤ -15°C in lab	1 year
Trace Metals	Wet Tissue	10 g	4 oz glass or plastic wide mouth jars, zip-type plastic bags, or plastic wrap	0 to 4°C during shipment, ≤ -15°C in lab	1 year
Trace Metals	Water	1 L (or 2×1 L for QC)	1 L HDPE	HNO_3 to pH<2 in lab within 14 days of collection	6 months
Hg	Water	500 mL	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
Methyl-mercury	Water	500 mL	500 mL acid cleaned glass or fluoropolymer bottles with fluoropolymer or fluoropolymer-lined caps	2 mL/L 9M H_2SO_4, 0 to 4°C in field/shipment	48 hours to in-lab preservation if prepreserved sample container are not used, 180 days after preservation
TDS	Water	100 mL	250 mL HDPE	0 to 4°C during shipment,	7 days

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Field Documentation

The field team leader will record daily field notes in a bound field logbook or electronic note app. Field notes will include the work performed; problems identified as well as corrective actions taken; conversations of significance; and other appropriate, general comments or observations.

5.1 Field Logbook

Field activities will be documented through journal entries in a bound field logbook, which is dedicated to this project, or electronic note app. The field logbook will be water-resistant, the pages will be sequentially numbered, and all entries will be made in indelible ink. Each page of the field logbook will be dated and signed by the person making the entry. The electronic note app will record the date and integrate notes, location, and photographs. The field notes will contain all pertinent information about sampling activities, site conditions, field methods used, general observations, and other pertinent technical information. Examples of typical field entries include the following:

- Date and time of sample collection
- Name of personnel present
- Referenced sampling location description (in relation to a stationary landmark), GPS coordinates, and maps
- Daily temperature and other climatic conditions
- Field measurements, activities, and observations (e.g., depth of water, condition of water, other relevant conditions)
- Media sampled
- Sample collection methods and equipment
- Types of sample containers used
- Sample identification and cross-referencing
- Types of analyses to be performed
- Site sketches
- Visitors to the site
- As required by JVWCD and RTKC's project manager, additional information will be recorded in the field notebook.

5.2 Photographs

Color photographs taken during sampling activities will be numbered to correspond to photograph log entries. The name of the photographer, date, time, site location, and photograph description will be entered sequentially in the photo log as photographs are taken. If using and electronic notes app, this information will be captured automatically.

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SECTION 6

Laboratory Analyses Methods

All water, macro-invertebrates, and bird egg (egg contents only) samples will be analyzed for total selenium and total mercury concentrations. Entire contents of eggs and macro-invertebrates samples will be stored frozen at -20°C until analyzed. Water samples will be stored at 4°C. Care should be taken to avoid cracking or breaking of sample glass bottles when stored in -20°C. The laboratory will homogenize each sample before analysis so that the results represent the average concentrations. Analysis techniques for selenium, mercury, and methyl-mercury are shown in Table 5. All results for biota (i.e., tissue) samples shall be reported as a dry weight concentration.

Table 5. Analysis Techniques for Selenium, Mercury, and Methyl-mercury

Analyte	Matrix	Method	Method Detection Limit	Method Reporting Limit	Precision (Relative Percent Difference)	Accuracy (Percent Recovery)
Total Selenium	Biota	SW6020B with 3050B sample preparation. Use of ICP-MS with CRC or dual (or triple) quad MS technology is required.	0.06 mg/kg (dw)	0.20 mg/kg (dw)	≤25%	75-125
	Great Salt Lake Water	Modified EPA Method 1640 with column chelation or reductive precipitation	0.07 µg/L	0.21 µg/L	≤25%	75-125
	Channel/ Delta Water	Modified EPA Method 200.8 with ORC ICP-MS or Modified EPA Method 1640 with column chelation	0.07 ug/L	0.21 µg/L	≤30%	70-130
Total Mercury	Biota	SW7474 or EPA 1631E modified	0.5 ng/g (dw)	1.5 ng/g (dw)	≤30%	70-130
	Water	EPA Method 1631E	0.15 ng/L	0.40 ng/L	≤24%	71-125
Methyl-mercury	Water	EPA Method 1630	0.02 ng/L	0.06 ng/L	≤35%	65-135
Total dissolved solids	Water	SM2540C		5 mg/L		

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SECTION 7

Quality Control Procedures

7.1 Sample Labeling and Containers

Environmental samples of water, macro-invertebrates, and bird egg contents will be collected directly into precleaned containers provided by the laboratory when appropriate. Containers will generally be provided by the laboratory that will be completing the analytical testing, but will also be purchased in some cases by the sampling team.

Self-adhesive sample labels will be provided and affixed to each sample container. *This may be done by the sampling team or the laboratory.* The sample label will be completed using indelible ink and will include the following information:

- Project name
- Sample identification number
- Date and time of sample collection (added in field)
- Matrix (coded as to water or biota type)
- Sampler's initials (added in field)
- Analyses requested

Sample labels will be affixed to the sample containers and covered with clear tape.

7.2 Chain-of-Custody Procedures

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 fax number
- 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.

7.3 Sample Packaging and Transport

The following sections contain guidelines for sample packaging and transport.

7.3.1.1 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.

7.3.1.2 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 plastic bag. If samples are shipped frozen with dry ice, the proper paperwork from the shipping carrier will be followed.

7.3.1.3 Placing Samples in the Cooler

- The COC form will be placed in a Ziploc bag.
- Samples will be placed in an upright position in the cooler.
- Ice will be placed on top of samples and between samples. Ideally, ice will be placed in resealable plastic bags in duplicate to minimize leakage of ice melt into the cooler.
- Void space between samples will be filled with packing material.

7.3.1.4 Closing the Cooler

- The cooler lid will be taped with strapping tape, encircling the cooler several times.
- Custody seals may also be affixed to the cooler lid to further ensure the integrity of the samples.

7.3.1.5 Transport

Sample coolers will be transported to the laboratory (an overnight courier may be used) as soon after the sample collection as possible. The laboratory will be notified that samples are being shipped.

7.3.1.6 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 custody records. Any breakage, leakage, or other damage will be noted and recorded. 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 JVWCD and RTKC project manager. Along with sample receipt documentation, the following information will be documented on the Sample Receipt Form by the sample custodian:

- Date 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.

7.4 Quality Control Samples

The purpose of QC is to follow routine procedures to control the reliability and defensibility of data. QC samples collected in the field will be used to assess the overall quality of the project data. Field QC samples will include field duplicates. Laboratory QC will include method blank (MB), laboratory control sample (LCS) or reference sample (RS), matrix spike/matrix spike duplicate (MS/MSD), and sample duplicate. The analytical laboratory is responsible to ensure appropriate QC measures are implemented, verified, and recorded.

7.4.1.1 Field Duplicate Samples

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 and macro-invertebrates (where they are appropriately abundant). 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.

7.4.1.2 Method Blank

MB are used to monitor each preparation or analytical batch for interference and/or contamination from glassware, reagents, and other potential sources within the laboratory. An 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. There will be at least one MB per preparation or analytical batch. If a target analyte is found at a concentration that exceeds the acceptance criteria as indicated in Table 6, corrective action must be performed to identify and eliminate the contamination source. All associated samples must be

reprepared and reanalyzed after the contamination source has been eliminated. No analytical data may be corrected for the concentration found in the blank.

7.4.1.3 Laboratory Control Sample/Reference Sample

The LCS or RS will consist of an analyte-free matrix spiked with a known quantity of the target analyte from a traceable source. Total selenium and total mercury will be spiked into the LCS/RS. Ideally, the spike levels will be less than or equal to the midpoint of the calibration range. If LCS/RS results are outside the specified acceptable limits as provided in Table 6, corrective action must be taken, including sample repreparation and reanalysis, if appropriate. If more than one LCS is analyzed in a preparation or analytical batch, the results of all LCS/RSs must be reported.

7.4.1.4 Matrix Spike/Matrix Spike Duplicate

A sample matrix fortified with known quantities of specific compounds is called a MS. It is subjected to the same preparation and analytical procedures as the native sample. Total selenium and total mercury will be spiked into the sample. MS recoveries are used to evaluate the effect of the sample matrix on the recovery of the analytes of interest. An MSD is a second fortified sample matrix. At least one MS/MSD will be analyzed for this project for each matrix; i.e., tissues and water; for each sampling event. The relative percent difference between the results of the MSDs should be acceptable based on limits provided in Table 6. Results outside acceptable criteria will be subjected to corrective measures.

7.4.1.5 Laboratory Sample Duplicate

A sample duplicate selected by the laboratory is called a laboratory sample duplicate. Both samples are subjected to the same preparation and analytical procedures. The data collected may also yield information regarding whether the sample is heterogeneous. The acceptable relative percent difference between the results is provided in Table 6. Results outside acceptable criteria will be subjected to corrective measures.

Table 5 summarizes the QC requirement for this field sampling and laboratory analysis for this study, including method detection limits, method reporting limits, field and laboratory QC samples, and acceptability criteria accuracy and precision.

7.5 Laboratory Procedures

7.5.1 Laboratory Deliverables

The laboratory that will perform analyses must have established procedures to conduct data reduction, review, and reporting. Laboratory-specific procedures will be evaluated to ensure that the process steps discussed in this section are properly performed.

The primary analyst(s) will be responsible for review of their work as their work is being performed and for applying the measurement qualifiers (i.e., laboratory qualifier flags). 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 before sending the report to project staff.

Most laboratories use a Laboratory Information Management System 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 a comparable list that may be included for each preparation batch (when applicable) and each analytical batch, however, the typical e-delivery tables from the laboratory will be reviewed for completeness. The final list of deliverables may not include all of these parameters:

- Field identification number
- Date received
- Date prepared
- Date analyzed
- Method
- Results for each analyte
- Sample-specific reporting limit
- Units
- Laboratory qualifier flags, also called measurement qualifiers, for all data that do not meet project QC specifications
- Narrative
- MS and laboratory control spike concentrations
- MS and laboratory control spike results
- MS 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 (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
- Confirmation results
- Method of standard addition results (if applicable; required in hard-copy format only)
- 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.

Data flow from the laboratory and field to the project staff and data users follows established procedures to ensure that data are properly tracked, reviewed, and validated for use. Analytical data from the laboratory will be matched to field data to ensure accurate reporting and adherence to project

specifications. Results will be reviewed for correct sample identification, dates, sample-specific detection limits, flags, and agreement.

7.5.2 Laboratory Quality Control and Reporting

7.5.2.1 Quality Assurance and Quality Control

Laboratory QA/QC is designed to detect, reduce, and correct deficiencies in a laboratory's internal analytical process before the release of results and improve the quality of the results reported by the laboratory. Table 5 shows the QA/QC procedures proposed for this sampling and analysis.

7.5.2.2 Data Reporting

The laboratory will perform an internal data check in accordance with their QA/QC protocols. The following will be reviewed: instrument performance, initial and continuing calibration verification, error determination (bias and precision), blanks results, compound identification, compound quantitation and reporting limits, performance evaluation sample results, and overall assessment of data. Any data that was manually entered into an electronic format will be verified by the responsible analyst. Data that does not meet QA/QC criteria will be flagged.

7.5.2.3 Laboratory Data Review

The analyst performing the laboratory tests will review all of the definitive data. Upon their completion, a senior analyst will perform an independent review of all data using the same criteria and methods. At a minimum, the following elements for review and verification must include:

- Sample receipt procedures and conditions
- Sample preparation
- Appropriate standard operating procedures (SOPs) and analytical methodologies
- Accuracy and completeness of analytical results
- Correct interpretation of all raw data, including integrations
- Appropriate application of QC samples and compliance with established control limits
- Verification of data transfers
- Documentation completeness

Data Qualifiers

During data reporting and review, qualifiers are applied to ensure that the laboratory has provided data of known quality. During data validation, qualifiers will be applied to alert the data end user to quality problems that may impact the usability of the data. Table 6 identifies the codes that will be used when reporting data values either meet the specified description outlined in the table or do not meet the QC criteria of the laboratory. *The laboratory may provide an alternate list of qualifiers for review and approval prior to use.*

Table 6. Laboratory Data Qualifiers

Qualifier	Description
Q	One or more QC criteria failed. Data must be carefully assessed by the project team with respect to the project-specific requirements and evaluated for usability. Subsequent assessment by the project team may result in rejection of the data.
M	Matrix effect: The concentration is estimated due to matrix effect.
J	Estimated: The analyte was positively identified, the quantitation is an estimation due to discrepancies in meeting certain analyte-specific quality control criteria.
F	Found: The analyte was positively identified but the associated concentration is an estimation above the method detection limit (MDL) and below the reporting limit (RL) (or lowest calibration standard).
B	Blank contamination: The analyte was found in an associated blank above 1/2 the RL, as well as in the sample.
U	Undetected: The analyte was analyzed for, but not detected.
UJ	The analyte was not detected; however, the result is estimated due to discrepancies in meeting certain analyte-specific quality control criteria.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet the QC criteria. Data is unusable for project purposes.

All data will be presented in a standardized format, with QA/QC results, and provided electronically. When appropriate, a summary of the data will be provided in addition to the complete data set. A case narrative will be provided to explain any problems encountered in the analysis of the samples, and identify conflicting results or unusable data. The data will then be reviewed by the project QA/QC manager to determine completeness, identify flagged data, and summarize any limitations of the data.

Each laboratory will maintain records for a period of 2 years. These records will include sample data, sample management, test methods, and QA/QC reports. These records allow for verification of the COC, analytical methods with anomalies noted, sample preparation and analysis, instrument calibration, test specific criteria, detection limits, and various QC checks.

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SECTION 8

Reporting to DWQ

Sampling is to be continued during the 2017 bird nesting season (mid-April through June) and will be repeated on an annual basis (biannual basis for offshore lake water and brine shrimp sampling) per conditions defined in JVWCD's and RTKC's UPDES permits. JVWCD and RTKC are to notify DWQ within 7 business days of becoming aware of any egg selenium concentrations that exceed 9.8 mg/kg. The detailed field and laboratory data, analysis, and summary of results will be submitted to DWQ in an Annual Project Operating Report. This report is due by February 1 following the end of the calendar year summarized in the report.

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SECTION 9

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