Data Quality Objectives for Project 1B: Concentrations and Effects of Selenium in Gulls, Grebes, and Ducks

Step	DQO Guidance of Purpose and Outputs of Step	Great Salt Lake Project
1. Problem Statement	**Purpose:** Clearly define the problem that requires new environmental data so that the focus of the study will be clear and unambiguous. **Outputs From This Step** • A concise description of the problem. • A list of the planning team members and identification of the decision maker. • A summary of available resources and relevant deadlines for the study.	**Problem:** The objective of this project is to determine if selenium concentrations in the Great Salt Lake (GSL) are causing significant ecological effects in avian aquatic wildlife, and if so, to which ones and at which locations. We will concentrate our work on nesting California gulls at three gull colonies, grebes staging on the GSL in the fall, and overwintering ducks. These birds and their food-web relationships are generally described in the conceptual model for selenium cycling in the GSL as components 3, 5, 12, and 13, although the model identifies only northern shovelers and eared grebes as the species. High-priority questions to be answered in Project 1: • Where do California gulls nest and forage within the GSL? • What is the diet of nesting California gulls? • What are the ambient selenium concentrations in the water, sediment, and diet items at the foraging sites of nesting California gulls in the GSL? • What are the associated selenium concentrations in nesting California gulls (blood and liver), a random sample of gull eggs, gull eggs with dead or abnormal embryos, and deformed gull chicks? • What are selenium concentrations in adult eared grebes staging on the GSL when they first arrive and right before they leave, and how does body condition of grebes relate to selenium concentrations in their tissues? • What are selenium concentrations in overwintering ducks (adult male common goldeneye), and how does body condition of ducks relate to selenium concentrations in their tissues? • At which locations in GSL are high selenium concentrations in tissues associated with high ambient selenium concentrations? **Planning team members:** Dr. Mike Conover, Dr. Heather Keough, and Clay Perschon (Principal Investigators), and Gary Santolo (Project Advisor), with ultimate decision authority by Utah Department of Environmental Quality, considering input by the GSL Steering Committee and GSL Science Panel. **Resources:** Estimated budget for sampling year 2006-7 is $208,400, including lab costs. Technical expertise for conducting the field and laboratory studies is available from the Utah Division of Wildlife Resources and Utah State University, who also will provide needed equipment. Commercial analytical laboratories will be used to analyze ambient selenium concentrations and associated selenium concentrations in tissues. **Deadlines:** 30 days after completion of contract with Utah Division of Wildlife Resources • White paper that briefly summarizes each of the study efforts completed as part of the GSL Ecosystem Project • Map that summarizes DWR's and USU's knowledge of where birds have been most likely to nest on islands and along the shores of Gilbert Bay, and where fall-staging eared grebes and over-wintering ducks are most likely to be located on GSL. October 1, 2006 will serve as the deadline for the following deliverables: • Determine diet and foraging areas for California gulls • Determine selenium concentration in the diet of nesting gulls (i.e., exposure of gulls to selenium during egg-laying) • Assess selenium concentrations in adult California gulls sampled from the nesting population, a random sample of gull eggs, salvaged gull eggs, and deformed gull chicks. • Examine data for association between reproductive impairment in nesting gulls and selenium concentrations in tissues March 1, 2007 will serve as the deadline for the following deliverable: • Determine body condition and selenium concentrations in eared grebes staging in the fall May 15, 2007 will serve as the deadline for the following deliverable: • Determine body condition and selenium concentrations in ducks overwintering on the GSL

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2. Decision Statements	**Purpose**: Define the decision(s) that will be resolved using data to address the problem. **Approach**: Identify the key question that the study attempts to address and alternative actions that may be taken, depending on the answer to the key study question. **Outputs From This Step** • A statement of the decision that must be resolved using data in order to address or solve the problem. • A list of possible actions or outcomes that would result from each resolution of the decision statement. *Note from EPA guidance on DQO: If the principal study question is not obvious and specific alternative actions cannot be identified, then the study may fall in the category of exploratory research, in which case this particular step of the DQO Process may not be needed.*	• **Decisions:** The overall questions to be resolved can be stated as "What are the transfer factors for selenium from the diet to birds? Are current selenium loadings to GSL significantly impacting birds (represented by gulls, grebes, and ducks), and if so, at which locations?" **Possible outcomes:** • Current selenium loadings may have no significant impact on California gull productivity, body condition of grebes, or body condition of overwintering ducks, indicating current selenium loadings have no expected impact on these species of aquatic wildlife in the open-water GSL ecosystem. If so, future selenium loadings to GSL can be maintained at this level or increased concurrent with low-intensity water-quality and biological monitoring. • Current selenium loadings may significantly reduce California gull productivity, body condition of grebes, or body condition of overwintering ducks, indicating current selenium loadings may have a significant impact on these species of aquatic wildlife in the open-water GSL ecosystem. If so, steps should be taken to reduce present and future selenium loadings by establishing a more protective site-specific standard for selenium. • Information is not adequate to determine whether current selenium loadings significantly impact California gull productivity, body condition of grebes, or body condition of overwintering ducks. If so, further studies are needed to make a defensible conclusion about the significance of effects.

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3. Inputs to the Decision	**Purpose**: The purpose of this step is to identify the informational inputs that will be required to resolve the decision, and to determine which inputs require environmental measurements. **Activities** • Identify the information that will be required to resolve the decision. • Determine the sources for each item of information identified. • Identify the information that is needed to establish the action level for the study. • Confirm that appropriate field sampling techniques and analytical methods exist to provide the necessary data. **Outputs From This Step** • A list of informational inputs (including sources and potential action levels) needed to resolve the decision. • The list of environmental variables or characteristics that will be measured.	**Informational inputs:** • Estimated selenium concentration in the diet of nesting California gulls based on diet composition and ambient selenium concentrations in food items and water at gull foraging areas. Diet composition will be based on quantitative analyses of crop contents from adults sampled from the nesting population. • Selenium concentrations in the food items, sediment, and water at California gull foraging areas, and in adult California gulls, California gull eggs with dead or abnormal embryos, and deformed California gull chicks • Selenium concentrations in tissues (blood and/or liver) of grebes and ducks, along with measures of body condition of those birds **Variables/characteristics to be measured:** • Selenium in the following media: – Brine flies (larvae, pupae, and/or adults) and brine shrimp (whole-body tissues) sampled from each of the areas where California gulls from nesting colonies are foraging – Water and sediment samples from each of the areas where California gulls from nesting colonies are foraging – Blood and/or liver samples from adult California gulls – California gull eggs – Deformed California gull chicks – Blood and/or liver samples from eared grebes – Blood and/or liver samples from ducks • Other variables: – Crop contents of sampled adult California gulls – Incidence of California gull embryo mortality and abnormalities in embryos and chicks – Body condition of grebes and ducks

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4. Study Boundaries	**Purpose**: Specify the spatial and temporal circumstances that are covered by the decision. **Activities** • Define the domain or geographic area within which all decisions must apply. • Specify the characteristics that define the population of interest. • When appropriate, divide the population into strata that have relatively homogeneous characteristics. • Define the scale of decision making. • Determine when to collect data. • Determine the time frame to which the study data apply. • Identify any practical constraints on data collection. **Outputs From This Step** • Characteristics that define the domain of the study. • A detailed description of the spatial and temporal boundaries of the decision. • A list of any practical constraints that may interfere with the study.	**Spatial:** The project area is defined as the open waters of the Great Salt Lake (also referred to as Gilbert Bay) located north and west of Farmington Bay, west of the Weber River input, and south of Promontory Point, Bear River Bay, and the North Arm (bounded by the railroad causeway). We will concentrate our work on nesting California gulls at three gull colonies. There are four nesting colonies of gulls on the South Arm of the Great Salt Lake that are consistently active: Hat Island colony, GSL Mineral colony, Egg Island colony, and White Rock Island colony. However, the Egg Island and White Rock colonies are so close together that the foraging areas for gulls in these two colonies probably overlap. Hence, we will consider them a single colony but will collect gulls, their eggs and deformed hatchlings (if found) from both of them. **Temporal:** During 2006 and 2007, the maximum period of data collection will be from mid-April 2006 through March 2007. Later sampling during 2007 will be largely determined by what we learn in 2006 and early 2007 and what additional species or populations need to be examined. Hence, we cannot at this point accurately provide a time table for activities after March 2007. The 2006 Interim Final Report concerning gulls will be completed by October 1, 2006, and will provide a summary of the data collected and initial results of analyses. The 2006 Interim Final Reports for grebes and overwintering ducks will be complete 60 days after completion of sampling of those birds and submittal to the lab, or 30 days after the lab provides their analyses to USU, whichever comes last. Target dates for the reports are March 1, 2007 for grebes and May 15, 2007 for ducks. **Practical constraints on data collection:** Weather is the major constraint. Because storms can limit our ability to conduct any of the sampling activities on the lake, we describe the number of samples that will be collected by particular deadlines instead of detailed sampling schedules. The availability of aircraft and boats for surveys, technical expertise for identifying abnormal embryos and obtaining tissue samples, and costs of conducting selenium analyses on samples also may limit some activities.

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5. Decision Rules	**Purpose**: The purpose of this step is to integrate the outputs from previous steps into a single statement that describes the logical basis for choosing among alternative actions. **Activities** • Specify the parameter that characterizes the population of interest. • Specify the action level for the study. • Combine the outputs of the previous DQO steps into an "if...then..." decision rule that defines the conditions that would cause the decision maker to choose among alternative actions. **Outputs From This Step** • An "if...then..." statement that defines the conditions that would cause the decision maker to choose among alternative courses of action.	In all cases described below, transfer factors for selenium from diet to bird tissue and/or eggs will be determined. • If there is a significant association between ambient selenium concentrations and selenium concentrations in the diet of nesting California gulls and/or in the blood or liver samples from nesting gulls that exceed expected threshold effect levels, then selenium exposure will be considered a factor of concern during egg-laying. If not, then selenium exposure will be considered negligible. • If there is a significant association between ambient selenium concentrations and selenium concentrations in California gull eggs with dead or abnormal embryos and/or in deformed gull chicks that exceed threshold effect levels, then current selenium loadings will be considered to be negatively affecting California gull productivity. Also, if there is a significant association between selenium concentrations in the diet and/or the blood or liver of nesting gulls and selenium concentrations in their eggs with dead or abnormal embryos and/or deformed chicks, then current selenium loadings will be considered to be negatively affecting California gull productivity. If neither of the above associations occurs, then current selenium loadings will be assumed to have no significant impact on California gull productivity. • If there is a significant association between selenium concentration in fall-staging grebes or overwintering ducks and their body condition, then current selenium loadings will be considered to be negatively affecting grebe and/or duck survival. If these associations do not occur, then current selenium loadings will be assumed to have no significant impact on fall-staging grebes or overwintering ducks. • If selenium exposure is found to be a factor of concern during egg-laying and current selenium loadings are found to have a significant negative effect on California gull productivity or on body condition of fall-staging grebes or overwintering ducks, then it is expected that the Science Panel will assist the Utah DEQ and the Steering Committee in establishing a site-specific selenium standard to reduce selenium loading. • If selenium exposure is not found to be factor of concern during egg-laying but current selenium loadings are found to have a significant negative effect on California gull productivity or on body condition of fall-staging grebes or overwintering ducks, then it is expected that the Science Panel will assist the Utah DEQ and the Steering Committee in establishing a site-specific selenium standard to reduce selenium loading. In addition, future studies should examine why selenium exposure was not associated with selenium concentrations in the diet and blood of nesting California gulls. Are there alternative mechanisms for selenium absorption? • If selenium exposure is found to be a factor of concern during egg-laying but current selenium loadings are found to have no significant effect on California gull productivity or on body condition of fall-staging grebes or overwintering ducks, then it is expected that the Science Panel will assist the Utah DEQ and the Steering Committee in establishing a site-specific selenium standard, presumably maintaining the current level or increasing it, concurrent with low-intensity water-quality and biological monitoring. In addition, future studies should determine whether continued (long-term) exposure to selenium loadings in the GSL negatively impacts gull productivity. • If selenium exposure is not found to be factor of concern during egg-laying and current selenium loadings are found to have no significant impact on California gull productivity or on body condition of fall-staging grebes or overwintering ducks, then it is expected that the Science Panel will assist the Utah DEQ and the Steering Committee in establishing a site-specific selenium standard, presumably maintaining the current level or increasing it, concurrent with low-intensity water-quality and biological monitoring.

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6. Tolerable Limits on Decision Rules	**Purpose**: Specify the decision maker's acceptable limits on decision errors, which are used to establish appropriate performance goals for limiting uncertainty in the data. **Activities** • Determine the possible range of the parameter of interest. • Define both types of decision errors and identify the potential consequences of each. • Specify a range of possible parameter values where the consequences of decision errors are relatively minor (gray region). • Assign probability values to points above and below the action level that reflect the acceptable possibility for the occurrence of decision errors. • Check the limits on decision errors to ensure that they accurately reflect the decision maker's concern about the relative consequences for each type of decision error. **Outputs From This Step** • The decision maker's acceptable decision error rates based on a consideration of the consequences of making an incorrect decision.	Because of the judgmental nature of the sampling approach used in this study, no acceptable limits for decision error rates were determined for the sampling design. Specifications of tolerable limits on decision errors through the use of standard statistical methods are not applicable for these parameters. Data quality may also be specified under Measurement Quality Objectives. This quality assessment typically involves specifying 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. For this investigation, Measurement Quality Objectives for chemical measurements will be specified in the Quality Assurance Project Plan (QAPP); in general, the Measurement Quality Objectives for selenium are about ±20% and for non-selenium measurements they are ±10%. The QAPP will specify all QA/QC objectives for sample measurement based on each matrix and may be more restrictive or less restrictive than ±20%.

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7. Optimization of the Sampling Design	**Purpose**: Identify the most resource-effective sampling and analysis design for generating data that are expected to satisfy the DQOs. **Activities** • Review the DQO outputs and existing environmental data. • Translate the information from the DQOs into a statistical hypothesis. • Develop general sampling and analysis design alternatives. • For each design alternative, formulate the mathematical expressions needed to solve the design problems. • For each design alternative, select the optimal sample size that satisfies the DQOs. • Select the most resource-effective design that satisfies all of the DQOs. • Document the operational details and theoretical assumptions of the selected design in the Sampling and Analysis Plan. **Outputs From This Step** • The most resource-effective design for the study that is expected to achieve the DQOs, selected from a group of alternative designs generated during this step.	After detailed consideration of reasonable alternatives, the following design is the most resource effective: • For measurement of selenium concentrations in the blood or liver and the diet of adult California gulls: collect 10 adults near 3 colonies during the 2006 breeding season to address individual variability in uptake and deposition of selenium, and spatial variability in selenium concentrations in the sediment, water, and forage items. Diet composition will be based on established sampling methodologies for conducting quantitative analyses of crop contents. All blood, liver, and crop samples will be analyzed for selenium. • For measurement of ambient selenium concentrations: during the egg-laying period, collect 5 samples of brine flies (for each life stage being consumed to a significant degree by gulls), 5 samples of brine shrimp, a sample of sediment, and a water sample from each of the areas where gulls from the 3 colonies are foraging during the 2006 breeding season to address spatial variability in selenium concentrations in the water and forage items. All samples will be analyzed for selenium. • For measurement of selenium concentrations in California gull eggs: collect one egg from up to 20 nests in each of the 3 colonies and examine up to 50 salvaged eggs from each colony for dead or abnormal embryos. Collection efforts will be conducted during the 2006 breeding season at all 3 colonies with a focus on collecting eggs with late-stage embryos, because they are most readily assessed for the adverse effects of selenium. Up to 10 randomly collected eggs and up to 10 non-random eggs with dead or abnormal embryos from each location will be analyzed for selenium. If more than 10 eggs with dead or abnormal embryos are available from a particular colony, the eggs for analysis will be selected at random from the eggs that are available. This design addresses individual variability in uptake and deposition of selenium, and spatial variability in selenium concentrations in the water and forage items. • For measurement of selenium concentrations in deformed California gull chicks: after chicks have hatched, collect all deformed chicks from up to 20 nests in each of the 3 colonies during the 2006 breeding season to address individual variability in uptake and deposition of selenium, and spatial variability in selenium concentrations in the water and forage items. Up to 10 deformed chicks from each location will be analyzed for selenium. • For measurement of selenium concentrations in the blood or liver and the diet of adult eared grebes and male common goldeneyes: collect up to 20 grebes and 20 goldeneyes when they first arrive on the GSL and 20 more of each species within four weeks of their expected departure date from GSL. We will attempt to collect these birds from the same three areas where we are sampling gulls (Gilbert Bay, near Egg Island, and near the Great Salt Lake Mineral colony). If we are unable to collect 20 male goldeneyes per sampling period, we may borrow specimens collected during the appropriate time of year during the winter of 2005-2006 for another project. All blood, liver, and crop samples will be analyzed for selenium. Birds will also be analyzed for body condition. If there is a downing during the winter of 2006-2007, up to 20 downed grebes will be collected and analyzed for selenium and body condition.