Data Quality Objectives for Great Salt Lake Project 4: Measurement of Selenium Flux

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 development of a selenium standard for the open water of the Great Salt Lake must be supported by a budget for selenium, which is provided in this project. The selenium inputs determined in Project 3 must be balanced against selenium outputs, which are expected to occur mainly via two mechanisms: 1) release of selenium vapor to the atmosphere; 2) permanent burial of selenium in the sediment. These output fluxes cannot be estimated from published literature because these two release processes in the Great Salt Lake have not been heavily investigated. Furthermore, the existing literature for other systems does not address a system of the size, salinity, vertical and spatial heterogeneity, and temporal variability as represented in the Great Salt Lake. The execution of Project 4 requires well-conceived field measurements that are not widely available, but which can be completed locally via the combination of university, federal, and private analytical capabilities as pooled in the CWECS group. High-priority questions to be answered in Project 4: 1. What are the rates of volatilization and ebullition for selenium from the Great Salt Lake? 2. What is the rate of permanent sequestration of selenium via sedimentation? 3. Do transient suspension events re-suspend and re-solubilize selenium into the water column to an extent that has biological significance? 4. Do lake level rises re-introduce selenium into the water column to an extent that has biological significance? **Planning team members:** Dr. William Johnson and Dr. David Naftz (Principal Investigators), and Dr. Earl Byron (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 years 2006-7 is $382,000, including USGS cost-sharing ($35,000) and lab costs. Sampling equipment, vehicles, and laboratory trailers used for sampling and sample processing are available from current equipment resources at the USGS Utah Water Science Center in Salt Lake City. Analytical facilities and technical support for selenium vapor analyses are available at the University of Utah. Analytical facilities and technical support for particulate selenium analyses are available at the University of Utah. Equipment and expertise for sediment coring are available via an agreement made between Dr. David Naftz and Dr. Peter van Metre at the USGS. Expertise and equipment needed for dissolved gas probes and total dissolved gas samplers are available via an agreement made between Dr. W.P. Johnson and Dr. D. Kip Solomon at the University of Utah. The database infrastructure for reporting analytical results (NWIS) is available via Dr. David Naftz at the USGS. **Deadlines:** March 2007 will serve as the deadline for the following deliverables: 1) preliminary estimate of selenium flux to atmosphere via vaporization and volatilization 2) preliminary estimate of selenium flux to lake bottom via sedimentation 3) preliminary estimate of selenium permanent burial flux and remobilized flux during diagenesis 4) preliminary estimate of selenium remobilization flux via lake area change

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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:** A specific decision will not be made with the selenium output data; however, these data will be used in the overall decision of determining a scientifically defensible selenium standard for the open water of GSL. **Possible outcomes:** 1. Selenium removal fluxes may indicate that current selenium loadings to GSL have no expected impact to the open-water GSL ecosystem. If so, future selenium loadings to GSL can be increased concurrent with low intensity water-quality and biological monitoring. 2. Selenium removal fluxes may indicate that current selenium loadings to GSL have significant impact to the open-water GSL ecosystem. If so, steps should be taken to reduce present and future selenium loadings.
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:** Dissolved volatile selenium concentrations in the water column. Selenium concentrations among biological and mineral phases ranging from molecular to particulate in the water column, newly accumulating sediment, and accumulated sediment. **Variables/characteristics to be measured:** Semi-monthly measurements of dissolved volatile selenium concentrations at 3 locations and 3 depths below surface. Semi-monthly measurements of total dissolved vapor pressure at 20 locations and 5 depths. If total dissolved vapor pressure exceeds hydrostatic pressure, selenium vapor concentrations will be measured via floating flux chamber. Selenium vapor concentrations via quadrupole mass spectrometry (available at University of Utah). Sediment samples from 20 locations will be measured for total organic carbon and total selenium (to support determination of vapor sources). Semi-monthly measurements of sediment flux (via sediment traps) at 2 locations. Analysis of accumulating sediment for total selenium (via hydride generation AA after extraction) as well as selenium burden among the biological and mineral particulates according to size fraction ranging from molecular through colloidal (via field flow fractionation coupled to collision cell-inductively coupled plasma mass spectrometry). Semi-monthly measurements of selenium burdens in particulate phase in water column overlying sediment traps. Continuous measurement of extent of mixing of Deep Brine Layer with Shallow Layer between and during storm and wind events (turbidimeter and thermistor strings) at 2 locations and 5 depths, with additional characterization of water column (2 depths) immediately following storm events at these locations. Meteorological data are available from the National Weather Service. Total Se and Se burdens on particulate size-fractions from submerged sediment cores (10-15 locations). Extractable Se from submerged sediment cores. Total Se extracted via fresh water leaching from exposed sediment samples (10-15 locations). Total Se in three cores (3 locations) as a function of depth (age via ^{137}Cs) at 8 depths per core. Additional elemental information (e.g. Cs or Al) via ICP-MS.

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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 boundaries of the system are as described in the conceptual model. The number of locations proposed for sampling sediment and water column selenium is described above. **Temporal:** The initial period of data collection will be from on or about April 15, 2006 through February 28, 2007. **Practical constraints on data collection:** The major constraint is weather. Since storms can impact our ability to measure and sample on the lake, we have described the samples as “semi-monthly” to reflect the fact that weather will likely impact a strict monthly sampling plan. A secondary constraint is boat availability, which is being negotiated through Dr. David Naftz. An additional potential constraint is sediment coring equipment availability and technical expertise. Dr. David Naftz is negotiating aid from Dr. Peter van Metre, who is a USGS researcher focused on sediment coring.

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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.	1. If the measured volatile selenium concentrations are significant, then the selenium flux to the atmosphere via volatilization will be included in the selenium budget. If the measured dissolved volatile selenium concentrations are below detection at all locations and depths during the summer and fall months, then selenium volatilization will be considered negligible. 2. If the measured total dissolved gas pressure is significantly greater than hydrostatic over a significant time at any location, then funds will be requested for a floating flux chamber to collect vapor at these locations for selenium analysis and estimation of ebullition flux. In this event, the ebullition flux of selenium to the atmosphere will also be added to the selenium budget. 3. If mixing of the Deep Brine Layer into the Shallow Layer is significant during storm events, then this redistribution of selenium between these layers will be added to the selenium budget. 4. If the selenium flux to sediment (via sediment traps) exceeds the flux of selenium permanently buried (via dated cores) the difference will be assumed to represent loss of sediment selenium to the water column during diagenesis. This diagenetic loss will be factored into the rate of permanent selenium burial in the selenium budget. 5. If the proportion of selenium to biological and mineral particulate phases differs between sediment cores and sediment traps, these differences will improve understanding of the processes operating during diagenesis, and these findings will guide the refinement of the sedimentation flux terms in the selenium budget. 6. If the extraction of selenium from exposed sediment via representative surface water is significant, then this flux will be included into the selenium budget to reflect the influence of lake area change on the selenium budget. Likewise, if the extraction of selenium from submerged anoxic cores and submerged Littoral Sediment cores show significant extractability of selenium, this information will be used to refine selenium flux terms related to lake area change.

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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%.
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 total dissolved gas pressure measurements: plan for 20 locations and 5 depths to allow measurement across a large area, to address spatial variability in ebullition rates. Monitor on a semi-monthly basis to address temporal variability. • For measurement of vapor selenium in equilibrium with dissolved selenium in the water column, choose three depths that represent the vertical zone where mass transfer to the lake surface is limited (occurs via diffusion rather than mixing). Utilize established sampling methodologies for dissolved volatile compounds. • For measurement of settling flux, sediment traps should be deployed at 2 or more locations, and this information should be supplemented with water column samples at these locations plus an additional 6 locations. Two sediment traps are deployable under an existing monitoring project (USGS-DWQ). For measurement of re-suspension flux, thermistor strings should be deployed at 5 locations, with at least three over the deep brine layer. Thermistor strings should span a vertical distance to bracket the interval over which sediment and Deep Brine Layer suspension are expected to occur. Turbidimeters on the thermistor strings should be placed at depths expected to be representative of mixing over significant distances, rather than immediately adjacent to interfaces. • Exposed and submerged core samples should be sufficient in number to reflect spatial variability in the system. Hence, 20-30 cores (submerged and exposed) will be taken to meet this requirement. These cores will undergo tests for extractability of selenium via geochemical shifts that correspond to expected effects from lake level variation. Three sets of replicate cores from distinct locations will be used to determine Se sedimentation rates and elemental information as a function of depth. This number represents a tradeoff between the need to capture spatial variability and the expense associated with ^{137}Cs and elemental analyses.