

Evaluation of Nutrient Cycling in Willard Spur, Great Salt Lake: Scope, Schedule and Budget



Submitted to:

Utah Department of Environmental Quality
Division of Water Quality

Submitted by:

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I. Detailed Scope of Work and Approach

A. Project Background and Primary Research Question

Focus of the DWQ Willard Spur research program stems from the proposed discharge from the Perry Willard Regional Wastewater Treatment Plant (PWRWTP) to Willard Spur. While effluent from Willard City's wastewater lagoons previously discharged into the same ditch and outfall that is now used by PWRWTP, there is concern that changes in hydrology and nutrient load as the PWRWTP increases its operating capacity may negatively impact wildlife and habitat of Willard Spur.

The goal of this project is to provide an understanding of the natural variability of biological processes and productivity related to nutrient cycling in Willard Spur and to identify thresholds to nutrient loading as related to responses of biological indicators. Ultimately, the proposed research will assist DWQ and the Steering Committee in determining if and what changes to water quality standards are required to ensure the long-term protection of Willard Spur's beneficial uses. More specifically, the overarching science question is: What are the seasonal patterns of wetland dynamics, and does nutrient loading affect these dynamics? The strategy to answer this question is to test wetland response (specifically SAV and associated flora and fauna and phytoplankton) to ambient, mid-range, and high-range nutrient loading scenarios in a manner that reflects in-situ conditions to the highest degree possible. Analysis of our results will identify potential biological indicators that will be meaningful for the Willard Spur aquatic system and will ideally be directly tied to beneficial uses designated for Willard Spur. It is our full intent that we will establish a sound research design that will produce at least three biological indicators during the first year of study (2012). During the subsequent year, our approach will be refined to identify threshold nutrient loads based on biological indicator responses.

B. Scope of Work and Approach

Several tasks were identified in the RFP that collectively organize the project around the central approach. We will address the 5 tasks in order as outlined in the RFP.

Task 1: Coordination and Reporting

We will develop a detailed Work Plan that includes: a Scope of Work reflecting details within this proposal and any modifications after consultation with the Science Panel and DWQ; a schedule of our activities; an estimated level of effort; a budget; a list of deliverables; a communication plan; a safety plan; and a change management plan. We will also prepare draft and final SOPs and DQOs for studies to be conducted under Tasks 3 and 4 per EPA 2006 prior to beginning field or laboratory work. DWQ has prepared a draft Quality Assurance Project Plan (QAPP) and draft Willard SOPs that will be reviewed and implemented by our research team. We will provide any comments to DWQ and gain endorsement of any changes in methods from DWQ and the SP prior to implementation. We will work closely with DWQ and the SP in order to meet project criteria prior to initiating the study. We will also maintain and update the Work Plan, SOP's and DQO's as required.

We recognize the success of the Willard Spur research program relies heavily on collaboration among scientists and exchange of information in a timely and seamless manner. Therefore, it is essential to prepare and coordinate lines of communication among the research team, the project manager, the SP and DWQ, so that all members are aware of, and meet project requirements, schedule, and deliverables and so that collaboration across project areas is enhanced to the fullest. The following plans to be included in the Work Plan will facilitate coordination of the project:

- Our Communication Plan will outline the chain of communication for all correspondence and will follow elements of the project schedule – detailing flow charts of communication actions for each element so that project requirements and final deliverables are met.
- Our Safety Plan will outline procedures for maintaining a safe working environment both in the field and at the laboratory. Elements such as required safety equipment lists, directions to the nearest emergency room, contact information and procedures should an emergency arise. We understand that events can happen that are out of our control and that when personnel are prepared to handle a variety of situations, accidents can be avoided. All team members will be required to carry the safety plan when in the field or working at a laboratory.
- Our Change Management Plan will outline procedures for communicating the need for a change in protocol, requesting approval and implementing the change. We understand that every procedure must be tracked and duplicatable as any well-designed study should be. We will work with DWQ and the SP to develop the most efficient and effective “organic management” plan.

Listed below are our general assumptions pertaining to the proposed effort:

- Timely project start date such that the proposed schedule will be met.
- Laboratory analysis of water, sediment, and macroinvertebrate samples will generally be completed through a separate DWQ contract.
- Provision of a sample tracking tool for use in this project by DWQ’s contractor and the nutrient cycling project team, DWQ’s contractor will create an electronic sampling plan for the first month per input from the project team. Given actual sampling will likely change, the project team will update and maintain (i.e., provide input to) the electronic sampling plan as needed. DWQ’s contractor will provide support (i.e., monthly tool update and answer questions) after the initial electronic sampling plan is completed.
- Timely delivery of State subcontracted data (water and sediment chemistry, macroinvertebrates) to allow on-schedule progress in analysis and reporting.
- Timely response to draft documents submitted to the SP and DWQ to allow on-time delivery of final reports.
- Macroinvertebrate samples will be collected by the selected project team and samples will be analyzed/identified by the DWQ subcontractor.
- Sample numbers during the second year may change depending on analysis of the first year results.

We will coordinate our research internally by holding regular conference calls or face-to-face meetings during the field season and during data analysis. In the past, our team conference calls have proved very helpful particularly when we discuss results across disciplines. Each researcher gains a better perspective of their contribution relative to the entirety of the study and enables a more complete interpretation of the data.

We will conduct the following required coordination:

- Facilitate a kickoff meeting with DWQ on April 15th to discuss the Work Plan (including Scope of Work, schedule, budget, and deliverables), coordination, safety, and change management.
- Inform DWQ of any changes that may affect the Work Plan as soon as practicable after they are identified.
- Provide laboratory analytical data to DWQ’s contractor for integration into the program database (the database will be managed by the DWQ’s contractor). We will be responsible for meeting the requirements of DWQ’s QAPP and SOPs. Data will be made public after review and acceptance by SP after the conclusion of the project.

- Coordinate with other laboratories used by the project team (other than the Utah State Health Laboratory and Dr. Larry Gray for macroinvertebrates) as required ensuring compliance with the QAPP and SOPs. Responsible to resolve any discrepancies between QAPP and work by these laboratories.
- Provide data management for this project using sample tracking tool per the QAPP. DWQ's contractor will provide support in the use of the tool but the project team will be responsible for providing the inputs to the tool, quality control of the data in the tool, and final output for data validation. We will work with DWQ's contractor to help format EDDs from the Utah State Health Laboratory for entry into the sample tracking tool.
- Establish monthly telephone contact with DWQ's project manager to provide an overview of progress.
- Attend a quarterly project coordination meeting facilitated by DWQ to coordinate efforts among the program's offerors. It is assumed that DWQ will facilitate coordination among the various program offerors.
- Coordinate activities with other offerors as required; include DWQ's project manager in "all major e-mail correspondence".
- Provide a quarterly progress update to DWQ and the SP at quarterly SP meetings.

We will provide draft and final deliverables as described in the tasks below. It is assumed that all data and draft deliverables will be reviewed by DWQ, the SP, and possibly an outside, independent peer reviewer. We will work with DWQ and the reviewers to discuss review comments and identify changes to be included in the final datasets and documents. We understand that DWQ will rely upon the SP for final acceptance of our work products.

DELIVERABLES (as detailed in the proposed project schedule, Table 2)

1. *Work Plan – presented and discussed at April 15th Kickoff*
2. *Review comments for DWQ's QAPP and SOPs (as pertaining to this Scope of Work) – after notification to proceed on project (March)*
3. *DQOs for proposed experiments – (April 20th)*
4. *Detailed SOPs – (April 20th)*
5. *Laboratory QAPP and SOPs from our laboratories for items not specified above – (April 30th)*
6. *Meeting summaries from DWQ and team coordination meetings*
7. *Quarterly progress updates at DWQ coordination meetings and SP meetings*

Task 2: Literature Review using Zotero

We will provide an overview of significant literature published on the interaction and effects of nutrients in the water column and sediment on primary producers (e.g., submerged aquatic and emergent vegetation, epiphytes, algae, phytoplankton, etc.) and macroinvertebrates in freshwater open water wetland systems that are similar to the ecosystem found in Willard Spur. In the review, we will identify information and analytical, experimental, and sampling methods that will help identify critical response thresholds to nutrients in Willard Spur. The literature review will be completed using typical methods of chain-of-citation and electronic database searches and consultation with leading researchers. We will use the Zotero interface (www.zotero.org) to collect, organize, cite, and share the identified literature. Zotero is useful for shared group libraries making it possible to collaboratively manage research sources and materials online. Zotero may serve an excellent tool for the project group's research, communication and overall organization. Annotations will be captured as notes within Zotero to describe how each piece of literature confirms or redirects the proposed experimental/sampling approach for Tasks 3 and 4. We will prepare a Technical Memorandum that includes a summary of methods, an annotated bibliography from Zotero, and key recommendations pertinent to later work

elements. A draft will be submitted to DWQ for review by DWQ and the SP. Comments will be discussed and incorporated into the final document.

DELIVERABLES

- 1. An electronic or hard copy of the original documents included in the literature review (9/30/12, provided to DWQ).*
- 2. Draft (due 6/30/12) and Final (due 9/30/12) Technical Memorandum (3 hard copies and an electronic copy).*

Task 3: Baseline Understanding

Our approach makes the best use of time by assessing ambient (natural) conditions along-side enrichment studies during the first year. This will allow us to capture natural variation of biological responses (Task 3) and identify biological indicators from which to determine threshold nutrient concentrations from indicator responses during the second year of the project (Task 4). From Sutula et al. 2011, indicators should:

- Have a clear link to beneficial uses
- Have a predictive relationship with causal factors
- Have a scientifically sound and practical measurement process
- Show a trend either toward increasing and/or decreasing eutrophication with an acceptable signal:noise ratio.

Monitoring ambient conditions and responses throughout the growing season will provide a baseline from which to compare biological responses to nutrient enrichment, as well as give a sense of how existing nutrient cycling processes and in-situ conditions change during the 2012 growing season.

Use of in-situ plots

Willard Spur is an open (not impounded) wetland system bounded by artificial dikes along Willard Bay, Harold Crane WMA, Bear River Migratory Bird Refuge, Great Salt Lake Mineral evaporation ponds, and the causeway across south Bear River Bay. There is continuous flow through vegetated areas of Willard Spur, a condition that allows some degree of flux and flushing of nutrients, other elements, and gases that accompany biogeochemical and geochemical processes. Hence, an enclosure that impedes these fluxes, and the flushing of water and dissolved/suspended constituents through the system, would not be representative of Willard Spur. However, it is important to note that during low runoff years, we believe it is common for the Willard Spur to become naturally impounded by a prominent sandbar. Yet, a representative experimental system must allow migration and establishment of biota (particularly macroinvertebrates, vascular macrophytes, phytoplankton, and algae). Finally, a representative system must undergo equivalent temperature cycling over daily and seasonal time scales, a condition that is impossible to obtain in ex-situ mesocosms.

Mis-match to in-situ conditions will lead to mis-matches in nutrient fluxes and temperature regimes. For this reason this team has chosen to work with in-situ plots with well-defined sources. In-situ, open plots present the challenge of applying nutrients consistently across the treatment area; however, we believe that such a challenge is achievable, and out-weighs the inherent biases imposed by enclosures.

Six experimental plots are proposed, and these may potentially be located in the area of WS6 or WS7, as will be decided following team review of satellite imagery with the SP and DWQ to determine a location

that is consistently flooded through wet (high runoff) and dry (low runoff) years. One of the natural stressors for biota within Willard Spur is its hydrology as related to seasonally changing flow and volume. While it will be important to monitor water level throughout the study, we need to be certain to place the plots in areas that will be permanently inundated. We will discuss the best location with the Project Manager, Science Panel and DWQ.

It is our intent to examine an area that representative, i.e., influenced by PWRWTP effluent, irrigation return flows, as well as other Willard Spur source waters, as well as sediment nutrient inputs. Choosing representative locations will enable determination of expected Willard Spur wetland responses to nutrient enrichments from all potential sources.

Defined nutrient sources

A successful strategy for the overarching question requires well defined nutrient addition to the in situ test plots. Furthermore, the nutrient addition needs to address two scenarios:

- 1) Nutrient addition directly to the water column
- 2) Nutrient addition from the sediment compartment

The rationale for these two scenarios is that the relative influences of nutrient enrichment from the water column versus sediment compartments needs to be understood to ultimately allow prediction of the effects of nutrient reduction in PWRWTP and other water column sources. Separate in-situ plots will therefore be needed to test the influence of nutrient sources in the water column versus sediment compartment.

The design of the nutrient reservoir for water column versus sediment sources must critically provide a continuous well-monitored nutrient concentration. High frequency monitoring of nutrient input into the water column and the sediment/pore water phase will be necessary, e.g. twice weekly until steady state is achieved for each flow state in all plots in order to assess the relative influence of inputs from water column versus sediment compartments, as well as transport of nutrients and other constituents between these compartments. Once steady state is achieved, we anticipate monitoring perhaps monthly. The specific designs for defined nutrient sources in the water column and sediment compartments are provided below, following description of in-situ plot boundaries and characteristics.

Experimental design for in situ plots

To match in-situ conditions our strategy will avoid placing partitions between plots, and instead will focus on two criteria to define plot boundaries:

- a) The plot dimension perpendicular to flow (width) will be sufficiently large to ensure that a representative population of plant and invertebrate species exists immediately down-stream of this boundary. We estimate that 20 m width (perpendicular to flow) will be sufficient for this purpose, and have consulted with the SP and DWQ and assume it to be adequate. The length of the plot parallel to flow will be sufficient to maintain a defined constant nutrient source over an area that accommodates all proposed sampling and observation without risking degradation of the plot due to intensive sampling. We estimate that 6 m length will be sufficient for this purpose; however, the final dimension will be chosen in consultation with the SP and DWQ.
- b) The spacing between adjacent plots will be sufficient to avoid crossing of added nutrient and other mobile constituents across plots. There will be sufficient space between the plots for boats to pass through and we will coordinate with the Airboat Association to notify them of its location. This will

be monitored using water column nutrient concentrations and field parameters, and will be augmented via tracer tests with fluorescent dyes if necessary.

- c) Plot boundaries will be defined with four corner posts delineating approximately a 6 x 20 meter area (flagged for identification and posted with signage indicating purpose of study and request for no trespass). Lines (with floats) will run between the posts on the perimeter (and the interior as described below), and will serve two primary functions: a) to allow a continuous line source of nutrient to be suspended in the water column; b) to provide a mooring system for canoe/kayak to allow sampling to occur from a floating raft, thereby minimizing disturbance of the water column and/or sediment). Depending on distance from local access points, the plots may be accessed by a combination of airboat (parked downstream of plot) and towed raft/canoe/kayak.

Controls and treatments

Because the system (temperature, biological activity, dissolved oxygen, biomass, etc.) is changing during the course of the growing season, it is necessary to follow this evolution over the course of the season from April through October. This will require control plots (ambient nutrient inputs of existing system) that represent the natural progression of changes throughout the growing season. The control plots will also serve as benchmarks from which to compare mid-range and high-range nutrient treatments (for both sediment and water column nutrient additions) and provide information regarding spatial variability in sediment and water chemistry (as observed in Johnson et al., 2011, 2012) (see Figure 2).

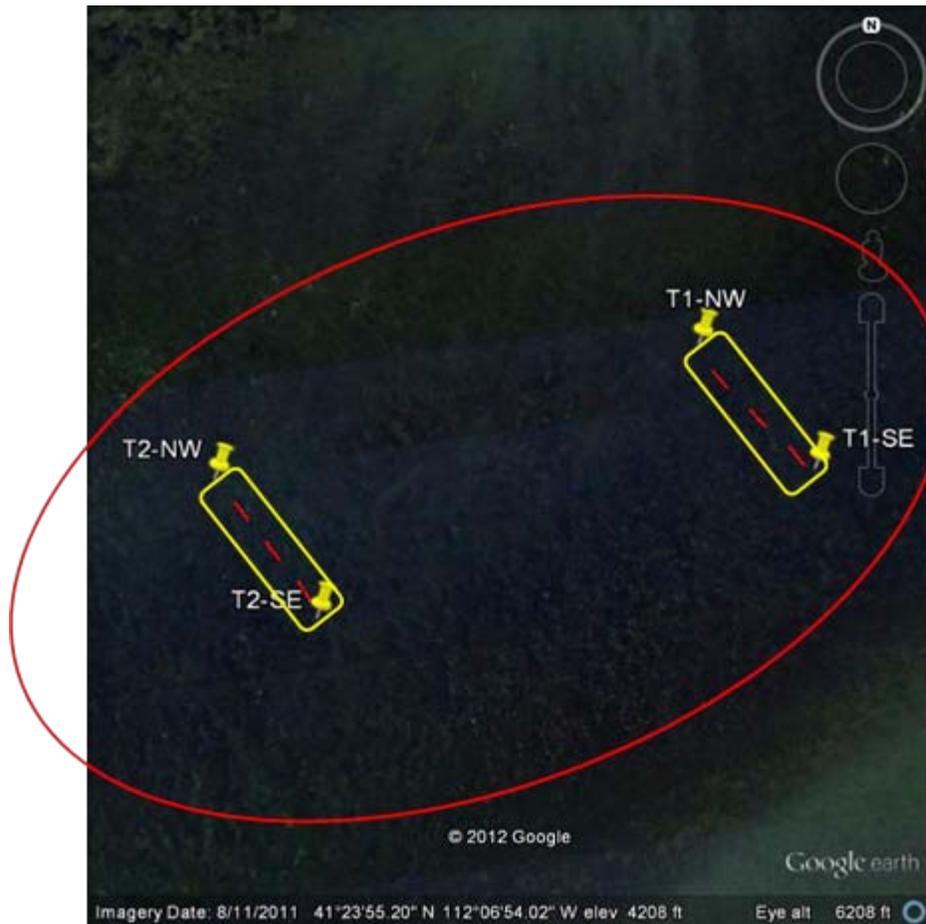


Figure 2. Schematic of nutrient treatments showing two sets of three treatment plots (for sediment-phase and aqueous-phase nutrient treatments). Plots (20m x 6m) will be bounded on each corner by posts. Control plots (one control in each set of three) will reflect ambient nutrient-loading conditions. The remaining two plots of each set of three will provide medium-range and high-range nutrient addition to water or sediment. Note: sediment-source and water-source nutrient plots will not be located within up/downstream influence of one another. Spacing between plots will guarantee zero overlap of treatments.

The objective will be to maintain a constant nutrient input concentration with an area source within the plots over the course of the growing season for the mid and high concentration treatments. Time release compound, e.g. Osmocote (Scotts, Inc.) or time-release rods will be used. Osmocote has been used for estuarine nutrient enrichment open-flow mesocosm studies and in-situ estuarine enrichment studies (e.g. Short et al. 1995, Heck et al. 2000) and after discussing the option with the SP and DWQ, it was agreed that Osmocote was a good candidate. We will initiate plot development using Osmocote Smart Release 19:6:12 which is locally available.

The water column area source will be established by suspension of (for example) slow release fertilizer in perforated plastic bottles from plot boundary floating lines. The strength of the nutrient source will be dictated by the degree of perforation of the bottles. Since we anticipate the system to become naturally impounded at least during 2012, we will be able to remove nutrient spikes as needed to adjust nutrient concentrations in the water column and sediment. We will suspend the same number of bottles at the same spacing with inert material to replicate the effects of adding nutrients in this manner.

The sediment area sources will be established by emplacement of mesh bags filled with slow release fertilizer at a depth of 6" below the sediment surface in a frequency that produces the desired concentration on the up-gradient boundary of the plot sediment.

Increase of the nutrient-amended area beyond the up-gradient boundary will be considered on the basis of initial measurements of down-gradient transport across plots, as well as available budget, as described further below.

We originally proposed that surface water nutrient concentration goals should be based on measured concentrations of phosphorous, as based on previous 3-4 years of data, which indicate that surface mats develop at concentrations of approximately 0.3 mg/L (as P in water column) (Miller, personal communication). Based on this information, we propose 0.6 mg/L (as P) for the high concentration in the water column, and 0.25 mg/L (as P) for the mid-range concentration in the water column, which corresponds to increased algal production and diversity, but no surface mat development. This data provides an idea of what is a "normal" high for P in surface water. Based on eighteen samples (in 2007) from impounded wetland sediments; mean N content (% wt) was 0.22 (or 2200 mg/kg), with a standard deviation of 0.090 (or 900 mg/kg), a minimum of 0.090 (900 mg/kg), and a maximum of 0.43 (4300 mg/kg). Mean P content (mg/kg) was 1047 with a standard deviation of 332, a minimum of 545, and a maximum of 1650.

Preliminary discussion with the science panel identified the following nutrient parameters for Willard Spur waters: Total phosphorous mean was 19 and max was 47 (mg/Kg), and total nitrogen mean was 15 and max was 27 (mg/Kg). The relative risk-based concentrations based on data from the Willard Spur study were:

	TP (σ)	NO3 (σ)	ON (σ)	NH4 (σ)
Low	0.16 (0.07)	0.70 (0.20)	0.19 (0.02)	1.39 (0.27)
High	0.33 (0.07)	1.23 (0.17)	0.24 (0.02)	2.07 (0.20)

Target nutrient concentrations based on the relative risk values for total phosphorous and ammonia were discussed and initially chosen as to be*:

	Tot Phosphorous	Nitrogen (ammonia)	Nitrogen (nitrate)
Water High (mg/L)	0.1	2.5	ND
Water Low (mg/L)	0.4	1.1	ND
Sediment High (mg/kg)	1000	ND	ND
Sediment Low (mg/Kg)	200	ND	ND

* ND = Not Determine

However, based on a quoted cost of \$4/kg for Osmocote, the cost of achieving 200 mg/kg P in sediment in the up-gradient boundary (20 m²) of a test plot is approximately \$400. We therefore suggest that target sediment concentrations for total phosphorous should be lower than originally estimated, at 200 and 100 mg/kg on test plot up-gradient boundaries. These target concentrations are factors of four and two greater than the existing maximum concentrations at Willard Spur, and are factors of ten and five greater than the existing mean concentrations at Willard Spur. The final target nutrient concentrations are thus the following:

	Tot Phosphorous	Nitrogen (ammonia)	Nitrogen (nitrate)
Water High (mg/L)	0.1	2.5	ND
Water Low (mg/L)	0.4	1.1	ND
Sediment High (mg/kg)	200	ND	ND
Sediment Low (mg/Kg)	100	ND	ND

The cost for emplacing sediment P on the up-gradient boundaries at the two test plots at 200 and 100 mg/kg would be approximately \$600.

Osmocote release will be complete after four months; therefore, application may need to be repeated twice each year (approximately \$1800 per year including water column amendment). Therefore, we need to consider whether the existing budget accommodates this expense. Also, to extend the amendment from the up-gradient boundary, the budget will need to be further increased.

Monitoring

The following summarizes the monitoring strategy for sediment, pore water and surface water chemistry; sediment flux analysis; SAV and associated macroalgae; phytoplankton and macroinvertebrates. Monitoring will begin in April prior to nutrient applications to treatment plots on all six treatment plots. This will provide a benchmark from which any changes can be compared across treatments. We will generally use prescribed SOPs for the monitoring activities and the sample type and frequency is summarized in Table 1 following description of methodology.

A primary issue we address in our plot design is to ensure that the plots meet the criteria of allowing nutrient and other fluxes through the site while providing a well-defined constant source of nutrient to a sufficiently representative population of SAV. To establish that a desired and constant concentration of nutrients is provided in the water column and sediment, frequent in-situ analyses will be conducted during plot and source set up. The analyses are described below.

To understand the necessary size of the plots to accommodate all analyses and a buffer from any edge effects, we consider the original configuration of 20 m x 6 m (= 120 m²) plot area. We will first exclude 1 meter immediately adjacent to the perimeter of all plots from sampling activities, which will render a 19 m x 5 m (= 95 m²) sampling area within the interior of each plot. This will be equivalent to 95 sampling quadrats (1 m² each), that will support plant, macroinvertebrate, water, and sediment chemistry monitoring. The location of each sample to be taken over the seven month period will be randomized prior to the first sampling event so that each selection is a random selection from 95. To avoid unwanted disturbance among these phases, water chemistry and nutrient flux studies will initiate each sampling period, followed by macroinvertebrate collection, all primary producer metrics (without biomass/branch density cores). Subsequently, biomass/branch density cores and sediment chemical cores (located in same quadrat) will be collected. Collection will be performed only once in each quadrat in order to avoid artifacts from disturbance. During set up we estimate that 10-15 chemical cores will be required, which is well-accommodated within the present plot design.

During monthly post-set-up monitoring of the water column nutrient treatment and control plots, 5 randomly chosen quadrats per plot (not previously sampled) will be sampled. The quadrats for macroinvertebrate sampling will be different from those used for macrophyte and chemical sampling to avoid disturbing macroalgal distribution due to sweeping through the water column for macroinvertebrates. The seven-month annual sampling period therefore requires 30 quadrats for macroinvertebrates and 35 quadrats for macrophytes/chemistry. A total of 65 quadrats will therefore be analyzed each year, thereby ensuring that nearly one third of the 95 quadrat plots will not be disturbed.

Due to the anticipated cost to elevate sediment nutrients to the desired concentrations, we proposed a smaller plot area to the Science Panel and DWQ of 2 x 20m. All sampling will be conducted as proposed for the water column nutrient treatment and control plots, except that macroinvertebrate samples will be collected from quadrats that were assigned to macrophyte and chemical sampling during the previous month. The Science Panel agreed that any disturbance to macrophytes incurred during the previous month sampling event would likely not affect macroinvertebrate distribution and abundance the following month. The total number of quadrats from which to randomly sample in the sediment treatment plots will be 40.

Chemical Analyses

The 2011 Willard Spur Sampling Plan lists the following parameters as having been measured in the water column:

Field Parameters: Temperature, specific conductance, pH, dissolved oxygen, turbidity, secchi depth
Biochemical Oxygen Demand (BOD): Carbonaceous BOD
Total (Nonfiltered) Nutrients: Ammonia, Nitrate/Nitrite, Total Phosphorus, TKN
Dissolved (Filtered) Nutrients: Nitrate/Nitrite, Total Phosphorus, TKN or ON
General Chemistry: Carbonate, bicarbonate, carbon dioxide, hydroxide, chloride, sulfate, alkalinity, turbidity, specific conductance, total suspended solids, carbonate solids
Total (Nonfiltered) Metals: Total Selenium, Total Mercury
Dissolved (filtered) Metals: Aluminum, arsenic, barium, boron, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, nickel, and potassium
Other: Total Suspended Solids, phytoplankton and macroalgae chlorophyll a, and ash-free dry mass, and volatile organic compounds

Specific sediment parameters to be measured in sediment samples by the Utah Public Health Laboratories are not listed in the 2011 Willard Spur Sampling Plan, and will need to be specified following award. We will need to review them and make recommendations to the SP. We will include %LOI, SRP, and SOD as they are important components for understanding nutrient cycling.

Our team (Dr. Johnson and Dr. Goel) will be responsible for field chemical measurements of the water column and sediment; whereas, the Utah Public Health Laboratories will be responsible for the remainder of the above analyses for water and sediment. To allow rapid determination of nutrient concentrations in the field plots during set up, Dr. Johnson will conduct in-situ measurements of ammonia, nitrite, phosphorous, sulfate, and sulfide, along with field parameters. These in-situ analyses are not intended to supplant Public Health Laboratory analyses which will be used for statistical comparison to biological responses; but rather, to guide field plot set up and nutrient source establishment. Notably, our sediment core squeezing capability to extract pore water (Johnson et al. 2011; Johnson et al., 2012) will allow rapid assessment of nutrient transport from the source in sediment.

Previous studies in impounded wetlands, (e.g. Johnson et al. 2011; Johnson et al. 2012; Hoven et al. 2011; Miller et al., 2011) indicate that non-nutrient constituents, e.g. sulfide and trace elements (e.g. Hg), were highly correlated to negative responses by submerged aquatic vegetation (SAV) and macroinvertebrates in Farmington Bay. These previous studies demonstrate that plant health metrics are tied to sediment constituents to a greater extent than surface water constituents. Hence, it is critical to monitor both sediment and surface water compartments for both nutrients and trace elements. Therefore, in addition to the parameters described above, Dr. Johnson will monitor the following constituents:

Total Hg and methyl Hg according to EPA methods 1630 and 1631 using cold vapor atomic fluorescence spectrophotometry (CVAFS) in both sediment and water column samples for both filtered and unfiltered samples.

Trace elements (Se, Ag, Al, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, Pb, Sb, Se, Sr, Ti, Tl, U, V, Zn) using collision cell inductively coupled plasma mass spectrometry (ICP-MS) in both sediment and water column samples for both filtered and unfiltered samples.

Major anions (nitrate, sulfate, chloride) using ion chromatography in filtered water column samples.

Whereas a few of the parameters listed immediately above overlap with analyses to be performed by the Public Health Laboratory, this overlap will allow comparison between laboratories, and will allow greater confidence in results.

Spatial variability of nutrient uptake

Determining nutrient fluxes or concentration changes are critical to assess various biogeochemical consequences including the potential for eutrophication. For example, in a recent publication, Wurtsbaugh et al. (2009) termed Gilbert Bay in Great Salt Lake to be N-limited although they noted that this area of the GSL receives N from various sources. In absence of data generated from “Nutrient Limiting” studies, it is sometime difficult to judge whether a given ecosystem is N-limited or P-limited.

To examine N- and P- limitations; in-situ flux chambers (cylindrical 3-L chambers encompassing a surface area of 0.015 m²) will be used to quantify the rate of loss of added nutrient within the water column only (closed bottom), of within the water column and sediment (open bottom). Two chambers (one open bottom and one closed bottom) will be placed in each plot and flux or change in nutrient concentration will be monitored every 20 to 30 minutes. Collected samples will be filtered and will be stored on ice for further analysis in the field or in Dr. Goel’s lab using ion chromatography and HACH kits. These short term (3-6 hour) measurements (monitoring at least every two hours) will allow determination of nutrient loss rates from small areas/volumes, thereby allowing determination of the influence of vegetation percent cover and other variables on nutrient uptake. Addition of isotopically-labeled nutrient sources (e.g. ¹⁵N-labeled labile compounds) will be considered and implemented, if we find we can purchase the nutrient and conduct analyses within the project budget.

Analyses of SAV, Macroalgae and Phytoplankton

SAV is widely recognized as an important food source for many waterfowl as leafy vegetation, drupelets, seeds, tubers, and macroinvertebrates associated with the vegetation provide a variety of nutrients, protein, and fat (Chamberlain 1959; Anderson and Low 1976; Moore 1980; Kantrud 1990; Dennison et al. 1993; Winslow 2003). As an aquatic wetland vegetation type, SAV is known to help purify the water through filtration, and nutrient and metal cycling and provide important habitat for macroinvertebrates that rely on substrate to cling to, gastropods, arthropods (including insects, crustacea and ostracods), and juvenile fish. Willard Spur (and Bear River Bay) support dense SAV growth (Hoven 2011), which in turn is vitally important for wildlife.

Plants are often excellent indicators of wetland condition because of their direct response to environmental change (EPA 2002). Because of the constrained time-line of the study, preliminary data will be collected to gather basic understanding of the Willard Spur system at the same time as subjecting a small portion of the system to a gradient of nutrients we will be using our control plots to serve as reference condition as is necessary for developing biological indicators (Karr & Chu 1999; Simon 2002). Thus, biological response from primary producers exposed to medium and high levels of nutrients will be compared to the natural temporal variation observed in the control or ambient condition plots. Particularly, submerged aquatic vegetation (SAV) and the associated macroalgal community and phytoplankton will be monitored from April through October. The following metrics will be assessed:

- Vegetative Percent Cover of SAV and macroalgae change seasonally and in some cases, prematurely or excessively in nutrient enriched impounded wetlands of Great Salt Lake (Hoven and Miller 2009; Hoven 2009, 2010 a and b; and Hoven et al. 2011). In this study, percent cover will be determined of

SAV, epiphytes and surface macroalgae and / or other floating vegetation (surface mat) at 5 randomly located 1m² quadrats within each treatment plot on a monthly basis from April (if visibility allows) through October. Vegetation percent cover will be determined following the approved SOP for the project.

- Observations critical for documenting the general condition of the surrounding site and photodocumentation will be recorded monthly once visual estimates commence at the 5 quadrats per plot.
- Species composition will be determined in the field monthly at the 5 quadrats per plot per month using floristic keys (Prescott 1969; Welsh 1993). Additionally, one representative botanical sample voucher per species encountered will be collected at each plot to verify plant identification at the beginning of the study, once when fluorescence appear, and when any different species are encountered. This approach assumes that a nearly monotypic stand of SAV will be encountered and will keep voucher samples to a minimum. Vouchers will be verified by taxonomists and pressed specimens at the Brigham Young University Stanley Welsh Herbarium and / or Weber State University Herbarium.
- Light penetration through the water column and aquatic vegetation will be determined monthly from May through October at the 5 quadrats per plot using LI-COR LI-193 underwater spherical quantum sensor as described in Hoven (2010d). Although shading did not correlate with SAV die-off in nutrient enriched impounded wetlands of Farmington Bay (Hoven et al. in prep), phytoplankton could play a more prevalent role in Willard Spur, justifying monitoring light condition for the plants.
- SAV branch density will be determined on a monthly basis from May through October at the 5 quadrats per plot. Branch density has demonstrated earlier predictive capability of SAV die-off than percent cover determinations (Hoven et al. 2011).
- To determine available plant food for waterfowl, direct measurement of food production and linkage to beneficial use (Hoven 2010b; Hoven et al. 2011), drupelet and tuber biomass of SAV (as g (dw) m²) will be collected from June through October at 3 to 5 quadrats per plot. The biomass cores will be rinsed on site but downstream of the plot.
- SAV tissue nutrient content: To determine the fate of biologically available nutrients, three composite samples of the dominant species of SAV in each treatment plot will be collected for tissue carbon (as total organic carbon), nitrogen (as total nitrogen), and phosphorus (as total phosphorus) analyses following similar methods outlined in Hoven (2010d) likely during June and September (although review of the 2011 State Willard Spur data may indicate August as a better sampling time). We propose those months to reflect peak growth and uptake of nutrients by SAV during June and followed by either August or September to reflect pre-senescence and redistribution of nutrients by the plants. We assume that branch density data and/or conditions associated with water level will be determining factors in selecting the second sampling month. Processing CNP samples will take priority and must be done quickly (within 2 days) to avoid loss of nutrients by leaching (Vymazal 1996). After removal of debris, sediment, most periphyton and epifauna, samples will be sorted by tubers, shoots and leaves, and drupelets for individual analysis. There will be a total of 3 replicates of the three plant tissue types per plot per month when adequate sample is available. Percent carbon and percent nitrogen analyses will be conducted at the University of Utah. Since tissue CNP will provide important information in understanding nutrient cycling in Willard Spur and is cost prohibitive under the given budget, we will not plan on repeating CNP analysis during the second year. If, however, a strong biological indicator is implied from the preliminary data, we will recommend further research.
- Phytoplankton biomass and productivity will be determined following standard chlorophyll *a* extraction protocol used by the Utah Public Health Laboratories (State Laboratory). Samples will be analyzed by the State Laboratory. Although phytoplankton biomass is more accurately estimated using spectral signatures in deep water bodies, chlorophyll is regularly used as a standard index of biomass

for phytoplankton in shallow lakes and wetlands as $\mu\text{g L Chl } a$ (Lewis 1990; McLaughlin et al. 2011). Biomass and productivity ($\mu\text{g L Chl } a \text{ d}^{-1}$) will be determined on a monthly basis from May through October by collecting water samples from each plot following State approved SOPs. While phytoplankton productivity should be measured on an annual basis, we are only comparing seasonal response among treatments and not characterizing annual productivity of Willard Spur. Originally, it was proposed that phytoplankton would be retained in aquaria or acrylic tubes to prevent them from washing downstream. However, the consequences of fouling and risk of loss of the experiment was discussed with the science panel and all agreed that it would be better to sample directly from the plots. It was agreed that flow should diminish adequately after the runoff period so that water movement (and washing of phytoplankton out of the plots) would be minimal. Productivity and biomass will be sampled monthly for 5 months along with other water quality parameters (see Table 1). Sample number during the second year may change based upon the results of Task 3.

- Phytoplankton and benthic diatoms will be collected from each treatment enclosure, monthly from May - October. Preliminary studies have indicated that sediment diatom assemblages in Willard Spur differ according to geographic location and water chemistry (Hultquist et al. in prep). We are seeking other sources of funding to substantiate these preliminary results. These and phytoplankton samples will be kept chilled on ice and in a cooler and transported to Dr. Rushforth's phycology lab where they will be either frozen or filtered to 10 ml and then frozen for future analysis should the need arise. Additionally, 1L samples will be collected from control treatments during July, August, and September to document the phytoplankton assemblages present during the study. Samples will be kept chilled on ice in a cooler and transported to Dr. Rushforth's phycology lab where he will identify each species and develop a floral composition list. Characterization of the taxa will be important if phytoplankton blooms are observed, and it will be particularly important to know if the assemblage includes cyanotoxin producing cyanobacteria.
- Macroalgal biomass, will be collected monthly from May through October using floating periphyton samplers after Weber and Reschke (1970). Although artificial substrates will bias the data in that not all species of motile planktors will settle on the surface, it is our view that the dominant macroalga (both as epiphytic on SAV and in benthic and surface mats) is *Cladophora* sp., which does not show preference in substrate type and should be adequately represented. Glass microscope slides will be placed in the samplers and allowed to become conditioned for two weeks. Macroalgae will settle and grow for the following two weeks and the slides will then be removed for biomass analysis and replaced with new, clean slides. It will be important to collect samples every month so that algae are not lost due to sloughing. Three slides will be collected from each treatment monthly from May through October. The phycoperiphyton samples will be dried to a constant weight at 103 - 105°C for 24hrs, cooled, weighed on an analytical scale and then wetted with distilled water and scraped into a pre-labeled aluminum weighing tray. Individual containers with samples will be stored in individual sealed plastic bags until ash free dry mass (AFDM) is determined. To determine AFDM, samples will be placed in a muffle furnace and brought to 550°C for 15 minutes, cooled and placed in a desiccator. After reaching room temperature, samples will be weighed. The difference in weight will be determined and recorded as the biomass.

Macroinvertebrate sampling

Macroinvertebrates are important contributors of nutrient cycling as they mechanically and physically break down detritus and are a primary food base for wetland wildlife. In addition, macroinvertebrates are excellent indicators of water quality and are the most widely used biological group. Different taxonomic groups show unique sensitivities to pollutants and may prove to be a key biological indicator of nutrient gradients in Willard Spur.

Macroinvertebrate samples will be collected at 5 randomly selected locations in each research plot which will be composited into one sample per plot following DWQ's SOP for Willard Spur, except that we will collect samples from 5 random locations within the treatment plots rather than along a 100 m transect. Samples will be collected using a standard dip net and preserved with denatured alcohol for taxonomic identification. There will be six composite samples (1 per plot), monthly from June through October both years totaling 30 samples. It is assumed that DWQ will resume responsibility for the analysis of these macroinvertebrate samples.

Table 1 Schedule and number of samples per metric, per treatment plot by month and total sample number for all 6 plots. ^ = if visibility allows; * = separate DWQ contract for analysis; † = up to six plots.

	April	May	June	July	Aug	Sep	Oct	Total samples x 6 plots
% Cover SAV	5 [^]	5	5	5	5	5	5	210
% Epiphyte cover	5 [^]	5	5	5	5	5	5	210
% Cover Surface Mat	5	5	5	5	5	5	5	210
Light penetration		5	5	5	5	5	5	180
SAV Branch density		5	5	5	5	5	5	180
SAV Biomass cores (tubers, drupelets)			5	5	5	5	5	150
SAV Tissue CNP (3 per type)			9			9		108
Phytoplankton biomass and productivity		3	3	3	3	3	3	108
Phytoplankton flora				1	1	1		18
Benthic Diatom samples		1	1	1	1	1	1	36
Macroalgal biomass		3	3	3	3	3	3	108
Macroinvertebrates			1	1	1	1	1	30*
Surface Water								
State Lab (Chl A, TSS, dry m)			5	5	5	5	5	150*
State Lab (unfiltered nutrients, Se, Hg)			5	5	5	5	5	150*
State Lab (nutrients, alk, trace/major elements, major ions)			5	5	5	5	5	150*
UU – lab (mercury, trace elements, major anions, alkalinity) as budget allows			5	5	5	5	5	150
Sediment								
State lab (nutrients)			5	5	5	5	5	150*
State lab (trace elements)			5	5	5	5	5	150*
UU lab (trace and major elements) as budget allows			5	5	5	5	5	150
UU lab (%C and %N) as budget allows			5	5	5	5	5	150
Nutrient Flux		Up to 3				Up to 3		Up to 36 [†]

Statistical Synthesis of Results

We will conduct descriptive and summary statistics, exploratory data analysis, and visual interpretation of the data. Descriptive and summary statistics will include: mean, median, estimates of variability, graphical comparisons of responses, correlations, covariates, etc. We will also conduct non metric multidimensional scaling (NMS) ordination to explore and visualize relationships between the treatment responses for the SAV metrics and macroinvertebrate assemblage data. Depending on sample results and response variables, we will then conduct hypothesis testing statistics including MANOVAs, (or perMANOVAs), Mantel tests, nested design and repeated measures ANOVAs to determine if there were treatment, seasonal, or annual main effects and/or interaction effects. We have used this approach quite successfully to answer many of the complex questions that have arisen in wetland condition assessment and refine biological indicator analysis of Farmington Bay impounded wetlands (Johnson et al. 2011, Hoven et al. 2011, Miller et al. 2011).

Once we have a good understanding of the natural variability of biological responses in Willard Spur and the driving factor(s) in nutrient cycling from monitoring control and nutrient enriched plots in the study outlined in Task 3, we will identify a minimum of three biological indicators that respond to elevated nutrients in either or both the sediment and water column. In reality, the approach outlined in Task 3 will enable us to determine if certain components of the response metrics change as a result of nutrient enrichment, however it is beyond the scope of this project to determine the exact causal mechanisms of these changes. For example in the macroinvertebrate groups, gastropods (snails) may increase in abundances directly in response to increased periphyton (snail food) growth on macrophytes from nutrient enrichment, or from decreased competition or predation with other taxa that may have been negatively affected by nutrient addition, etc. Other macroinvertebrate taxa may decrease in abundance for several reasons including: decreased fitness compared with other taxa that are positively responding to nutrient enrichment, changes in macrophyte conditions (habitat availability), changes in food palatability to grazer taxa, or from direct physical intolerance to dissolved nutrients. Still other taxa groups may increase in abundance due to nutrient enrichment. For example, an increase in the % Phytophilous Macroinvertebrate Index will allow us to speculate on the importance of habitat structure at varying ranges of percent cover or epiphytic algae on the SAV due to differences in nutrient concentrations. However, additional studies would be needed to determine exact causal mechanisms due to nutrient enrichment.

We will prepare an Interim Report summarizing methods, observed responses and conditions, and possible trigger mechanisms for conditions observed in experiments conducted in 2012. The Interim Report will also recommend and prioritize possible indicators that can be used to assess wetland conditions (e.g., Sutula et al. 2011). We will present the Draft Interim Report to the SP in January 2013, along with recommendations for possible triggers to be investigated as part of Task 4. The basis of Task 4 is to define threshold values of the three identified biological indicators in the 2012 data set; however, Task 4 assumes that there will be three identifiable indicators.

DELIVERABLES:

- 1. Draft Interim Report to the SP by January 18th, 2014 (7 hard copies and an electronic copy)*
- 2. Final Interim Report will be provided 30 days after comments are returned to us (7 hard copies and an electronic copy)*

Task 4: Defining Threshold Values with proposed research design elements

The following is a proposed scope of work only. It could change (including the overall level of effort and number of samples) depending upon the findings from Task 3 and input from the SP. We will select indicator metrics from the original suite of phytoplankton, macroalgal, SAV, and macroinvertebrate metrics that show the strongest responses to nutrient enrichment during the first year of study (Task 3) to develop threshold values. The most likely scenario in order of observable responses due to nutrient addition is: phytoplankton, macroalgae, macrophyte, and finally macroinvertebrate metrics. We will then refine nutrient treatment concentration ranges based on this reduced number of indicator metrics. Therefore, we anticipate that the number of treatments (nutrient concentrations) will increase as could the number of replications, but the total number of metrics examined will decrease. Once we have identified potential biological indicators, we will revise and develop the following Work Plan that addresses the viability of the indicators by identifying and testing threshold values. Specifically we will determine which nutrient source (aqueous or sediment) is the driving factor for the selected biological indicators. If, for example, selected metrics respond predominantly to a particular source, then we will apply that source only (e.g., aqueous treatments only). From there we will narrow the range of nutrient concentrations that correlate with those biological responses by repeating either the medium (e.g., 0.25 mg L aqueous P) or high (0.6 mg L aqueous P) or both, if necessary. Furthermore, we will add a range of concentrations (e.g., 0.25, 0.3, 0.35, 0.4, 0.45 mg/L) to narrow the range of concentrations that resulted in different biological responses during Task 3. This would result in as many as 6 plots of similar configuration as that used in Task 3. However, if the biological responses of the selected indicators vary with nutrient source, we would anticipate adding 6 additional plots that similarly bracket the sediment concentrations achieved in Task 3.

By introducing a tighter range of nutrient concentrations we will be able to replicate biological responses observed during the first year and to more precisely estimate threshold values in order to determine: a) macroinvertebrate assemblage metrics that represent unhealthy conditions or represent major change in habitat structure; b) levels of phytoplankton biomass and productivity that are too high; and c) levels of macroalgal biomass and cover that are too high such that negative responses elsewhere (e.g., decreased SAV percent cover or branch density) occur; and d) set threshold values.

There is a strong likelihood that some of the more responsive metrics will do so at different treatments (i.e., some metrics may be more responsive in the concentration range between the control and medium-level treatment; whereas, some metrics may respond between the medium-level and high-level treatments). Also, some metrics may respond more to sediment versus water column treatments, or visa versa. We will select indicator metrics and treatments accordingly and after discussions with the SP and DWQ. At this time, we suggest that those metrics which respond more sensitively at lower-level treatments will provide higher value to DWQ for the development of a multimetric index.

We would conduct macroinvertebrate, phytoplankton and macroalgal sampling (following the same protocol as in Task 3) paired with supporting indicators such as SAV and epiphyte metrics conducted in Task 3. Water and sediment chemistry sampling will also follow that outlined in Task 3. The purpose of the supporting indicators (in addition to the original three) is to monitor the whole system response so that any significant responses from the primary indicators can be validated. We would conduct monthly monitoring from April through October following the same schedule as in Task 3.

Assumption of number of samples by subcontracted work

The following summarizes the total number of samples anticipated during Task 3 (2012) and Task 4 (2013) (Table 2) and analyzed under separate DWQ contract. If we only need to investigate nutrient gradients from one source during 2013, Task 4 will require at least the same number of samples as listed above in Task 3. That is, there will be 5 plots of five different levels of nutrient enrichment and one control totaling 6 plots. If both sediment and aqueous sources of nutrients prove important to different indicators, there will be a minimum of 12 treatment plots two of which are controls, thereby doubling the number of samples necessary to refine threshold values. The present budget only covers 6 plots during Task 4.

Table 2 Number of samples to be analyzed under separate DWQ contracts both years (details for 2012 from Table 1). 2012=Task 3, 2013-A=Task 4, 1 nutrient source; 2013-B=Task, 2 nutrient sources

Sample Type	# Months Sampled	2012 (6 Plots)	2013-A (6 Plots)	2013-B (12 Plots)
Surface water	7	450	450	900
Sediment	7	300	300	600
Macroinvertebrates	5	30	30	60

Additional Assumptions: The Work Plan presented in response to Task 4 is based on the assumption that the three biological indicators will be identified from analysis of phytoplankton biomass and productivity, macroalgal biomass, and macroinvertebrate data, such as phytoplankton productivity, macroalgal biomass, and % PMI. However there will also potentially be several SAV and macroinvertebrate metrics that respond and any resulting recommendations for additional research and analysis will be discussed and approved by the SP first. We assume the Task 4 Work Plan will change to reflect our interpretation of Task 3 data results and we will revise it accordingly upon consultation with the SP and DWQ. We also assume that if complex interactions occur among the Task 3 data such that the selected biological indicators insufficiently describe wetland biological integrity of Willard Spur, we will look to other primary and supporting (secondary) indicators as potential data gaps and make recommended additional research needs. Ultimately, we would seek at least one indicator with clear linkage to beneficial use, which could necessitate the identification of other ecologically associated primary or secondary biological indicators. Additionally, if stressors other than nutrients are indicated in the analysis of Task 3 data, we will recommend *ex-situ*, microcosm research (i.e., if trace elements or sulfides are suspected of toxic effects on the SAV) to establish separate dose-response data.

We will prepare an Interim Report summarizing the results of the studies completed for Task 4, as well as conclusions and recommendations to the SP. The Interim Report will, at a minimum, address the following:

- The viability of each indicator to be used for assessing wetland conditions
- Factors that may affect the viability of each indicator
- Determination of the uncertainty related to each indicator
- Threshold values for each indicator that would trigger a direct response to nutrients
- Suggestions for additional primary or secondary indicators and associated research to investigate their viability
- Recommendations for possible triggers to be investigated as part of Task 4

DELIVERABLES:

- 1. Draft Interim Report to the SP by January 17th, 2014 (7 hard copies and an electronic copy).
- 2. Final Interim Report will be provided 30 days after comments are returned to us (7 hard copies and an electronic copy).

Task 5: Final Report

We will integrate the Interim Reports (from Tasks 3 and 4) into one Final Report and submit it to DWQ by June 30th, 2014. The Draft and Final report will include a 5- to 10-page Executive Summary that captures the questions and findings of the initial study, the approach used to determine threshold values for the identified biological indicators, the viability of each indicator and suggested research for additional assessment of the viability of additional primary or secondary indicators that may provided added value toward interpreting the extent of degradation of the Willard Spur wetland system. It is assumed that results and data from this project will be integrated and used by DWQ in support of the Willard Spur research program. We will attend at least two 1-day workshops in the spring of 2015 to discuss results with the other research teams of the research program and the SP.

DELIVERABLES:

- 1. Draft (April 30th, 2014; 7hard copies and an electronic copy): 30 days to incorporate comments following SP 30-day review.
- 2. Final Report (June 30th, 25 hard copies and an electronic copy).
- 3. Copy of all field forms, models, and analytical data
 ~ All information, reports, models, tables, data, and supporting documents shall become property of the DWQ upon delivery.

Summary of time spent per individual:

Individual efforts by task are shown in Table 3 below.

Table 3 Amount of time (hours) to be spent by each individual on each task. (R= researcher, S=student)

	Task 1 Coord/mtgs		Task 2 Lit. Review		Task 3 Baseline Study		Task 4 Define Thresholds		Task 5 Final Report
	R	S	R	S	R	S	R	S	R
Johnson	30		30	60	130	620	130	620	60-match
Hoven	65		70		285	524	257	524	90
Goel	30-match		30-match	50	50-match	400	50-match	400	60-match
Rushforth	40		10		10		10		10
Richards	4		1		45		45		45

II. Project Schedule.

The following project schedule (Table 4) includes major milestones and other relevant activities toward the successful completion of the proposed Scope of Work. It is assumed that timely award of contract will enable us to proceed on schedule. We will commence plot development in April upon notice to proceed. We will not sample any later than October in order to meet the rigorous reporting schedule.

Table 4. Project Schedule

Task	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012												
Project Start			X									
Finalize Work Plan			X	X								
Project Kickoff Meeting (4/15)				X								
Review existing SOP's / DQO's; develop draft and final SOP's /DQO's			X	X								
Construct Research Plots				X								
Begin Treatment Applications and Adaptation				X								
Monitoring and Analysis				X	X	X	X	X	X	X		
Submit Draft Literature Review (7/6)							X					
Status Update /Attend Qtrly SP Mtg (7/19)							X					
Final Literature Review (10/5)										X		
Status Update / Attend Quarterly SP Mtg (10/11)										X		
2013												
Draft Task 3 Interim Report (1/18)	X											
Final Task 3 Interim Report (30 days after comments)			X									
Status Update / Attend Quarterly SP Mtg	X			X			X			X		
Construct Research Plots				X								
Begin Treatment Applications and Adaptation				X								
Monitoring and Analysis				X	X	X	X	X	X	X		
2014												
Draft Task 4 Interim Report (1/17)	X											
Final Task 3 Interim Report (30 days after comments)			X									
Status Update / Attend Quarterly SP Mtg	X			X			X			X		
Draft Final Report (4/30)					X							
Final Report and Data (6/30)						X						
2015												
1-day Workshop re: Findings			X	X								
Project Complete					X							

III. Cost proposal

The cost of each task and the overall project is provided below. Funds are requested for salary and benefits for senior investigators (professional) and graduate students to conduct the proposed work. Funds are also requested for materials and supplies, and travel to execute the proposed work. Note that salary for University of Utah professionals is matched for particular tasks. The overhead rate at the University of Utah is 10% for State-funded projects, and is applied to only the first \$25,000 of a subcontract.

Due to the cost of fertilizer and plot set up already incurred outside of contract (\$5180), \$5180 and related student hours has been reduced from Dr. Hoven's student labor under Task 4. Since the level of effort for Task 4 is projected and not known at this time, we propose to reconcile the difference if the requested workplan for 2013 should require it.

Budget Willard Spur											Overhead Rate
											0.1
Task 1: Coordination and Reporting											
PI	Grad Student	Professional	Materials/Supplies	Travel	Analyses	Benefits	Total	Overhead	Total with overhead	PI hours	Student hours
Johnson		\$2,100	\$0	\$0	\$0	\$777	\$2,877	\$287.70	\$3,165	30	
Goel							\$0	\$0.00	\$0	30 - match	
Hoven		\$6,045	\$100	\$825	\$0	\$753	\$7,723	\$0.00	\$7,723	65	
Rushforth		\$4,800		\$440			\$5,240	\$524.00	\$5,764	40	
Richards		\$400					\$400	\$40.00	\$440	4	
subtotal	\$0	\$13,345	\$100	\$1,265	\$0	\$1,530	\$16,240	\$852	\$17,092		Total cost of task
Task 2: Literature Review											
PI	Grad Student	Professional	Materials/Supplies	Travel	Analyses	Benefits	Total	Overhead	Total with overhead	PI hours	Student hours
Johnson	\$1,500	\$2,100				\$987	\$4,587	\$458.70	\$5,046	30	60
Goel						\$0	\$0	\$0.00	\$0	30 - match	70
Hoven		\$6,510				\$811	\$7,321	\$0.00	\$7,321	70	
Rushforth						\$0	\$0	\$0.00	\$0	10	
Richards		\$100					\$100	\$10.00	\$110	1	
subtotal	\$1,500	\$8,710	\$0	\$0	\$0	\$1,798	\$12,008	\$469	\$12,477		Total cost of task
Task 3: Baseline Understanding											
PI	Grad Student	Professional	Materials/Supplies	Travel	Analyses	Benefits	Total	Overhead	Total with overhead	PI hours	Student hours
Johnson	\$14,250	\$8,400	\$2,500	\$1,000	\$2,500	\$5,103	\$33,753	\$3,375.30	\$37,128	130	620
Goel	\$8,150		\$500	\$500	\$2,400	\$1,141	\$12,691	\$1,269.10	\$13,960	50 - match	420
Hoven	\$8,384	\$23,529	\$2,524.8	\$2,426	\$3,240	\$2,931	\$43,034	\$1,250	\$44,284	285	524
Rushforth					\$450		\$450	\$45.00	\$495	10	
Richards		\$4,500					\$4,500	\$450.00	\$4,950	45	
subtotal	\$30,784	\$36,429	\$5,525	\$3,926	\$8,590	\$9,175	\$94,428	\$6,389	\$100,818		Total cost of task
Task 4: Defining Threshold Values											
PI	Grad Student	Professional	Materials/Supplies	Travel	Analyses	Benefits	Total	Overhead	Total with overhead	PI hours	Student hours
Johnson	\$14,250	\$8,400	\$2,500	\$1,000	\$2,500	\$5,103	\$33,753	\$3,375.30	\$37,128	130	620
Goel	\$8,134		\$500	\$500	\$2,400	\$1,139	\$12,673	\$1,267.28	\$13,940	30 - match	420
Hoven	\$3,204	\$28,599	\$2,200	\$2,426	\$3,240	\$2,815	\$42,483	\$1,250	\$43,733	257	200.25
Rushforth						\$0	\$0	\$0.00	\$0	10	
Richards		\$5,000					\$5,000	\$500.00	\$5,500	45	
subtotal	\$25,588	\$41,999	\$5,200	\$3,926	\$8,140	\$9,057	\$93,909	\$6,393	\$100,302		Total cost of task
Task 5: Final Report											
PI	Grad Student	Professional	Materials/Supplies	Travel	Analyses	Benefits	Total	Overhead	Total with overhead	PI hours	Student hours
Johnson							\$0		\$0	60 match	
Goel							\$0		\$0	60 match	
Hoven		\$8,370				\$1,043	\$9,413		\$9,413	90	
Rushforth						\$0	\$0		\$0	10	
Richards		\$4,000					\$4,000	\$400.00	\$4,400	45	
subtotal	\$0	\$12,370.00	\$0	\$0	\$0	\$1,043	\$13,413		\$13,813		Total cost of task
Total Project											
PI	Grad Student	Professional	Materials/Supplies	Travel	Analyses	Benefits	Total	Overhead	Total with overhead	PI hours	Student hours
Johnson	\$30,000	\$21,000	\$5,000	\$2,000	\$5,000	\$11,970	\$74,970	\$7,497.00	\$82,467	380	1300
Goel	\$16,284		\$1,000	\$1,000	\$4,800	\$2,280	\$25,364	\$2,536.38	\$27,900	200	910
Hoven	\$11,588	\$73,053	\$4,825	\$5,676	\$6,480	\$8,352	\$109,974	\$2,500.00	\$112,474	767	724.25
Rushforth		\$4,800		\$440	\$450		\$5,690	\$569.00	\$6,259	80	
Richards		\$14,000					\$14,000	\$1,400.00	\$15,400	140	
subtotal	\$57,872	\$112,853	\$10,825	\$9,116	\$16,730	\$22,602	\$229,998	\$14,502	\$244,500		Total cost of project

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