FINAL

2012 Willard Spur Sampling and Analysis Plan

Development of Water Quality Standards for Willard Spur

JUNE 2012

Prepared by

CH2MHILL®

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Appendix

A Quality Assurance Project Plan

Acronyms and Abbreviations

BRMBR	Bear River Migratory Bird Refuge
DQO	Data Quality Objective
DWQ	Utah Department of Environmental Quality, Division of Water Quality
DWR	Utah Department of Natural Resources, Division of Wildlife Resources
EPA	United States Environmental Protection Agency
GSL	Great Salt Lake
QA	Quality Assurance
QAPP	Quality Analysis Project Plan
QC	Quality Control
SAV	Submerged Aquatic Vegetation
UPDES	Utah Pollution Discharge Elimination System
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WMA	Wildlife Management Area

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1.0 Introduction

This Sampling and Analysis Plan (SAP) was prepared on behalf of the Utah Department of Environmental Quality, Division of Water Quality (DWQ) for the collection of environmental samples required to support ongoing research of Willard Spur (see Figure 1-1) for the year 2012. The information that will be obtained from the implementation of this SAP will be used by the Willard Spur Science Panel and researchers to achieve program objectives.

1.1 Background

Construction of the Perry/Willard Regional Wastewater Treatment Plant (Plant) was completed in 2010. The DWQ received numerous comments as part of the public notice process for the Plant's Utah Pollution Discharge Elimination System (UPDES) discharge permit to Willard Spur. Many of these comments expressed concern over the potential impact the effluent could have on the water body and petitioned the DWQ to prohibit all wastewater discharges to Willard Spur or to alternatively reclassify Willard Spur to protect the wetlands and current uses of the water. Although the Utah Water Quality Board denied the petition made, they directed the DWQ to develop a study to establish defensible protections (e.g., numeric criteria, antidegradation protection clauses, beneficial use changes, etc.) for the water body. The Water Quality Board also directed the DWQ to pay for phosphorus reductions at the Plant while the study is conducted. This path forward, developed in conjunction with stakeholders, allows the Plant to operate while the studies are underway, with reasonable assurances that the effluent will not harm the ecosystem.

Very little information describing Willard Spur existed at the outset of the project in 2011. The hydrology and dynamics of flow, water depth, and how they influenced the wetted area and habitat were relatively unknown. There were only a few data points describing the chemistry of the water in Willard Spur and there were no known data describing the chemistry of its sediments. The condition and abundance of emergent and submerged vegetation was relatively unknown. Furthermore, very little was known about the populations of macroinvertebrates, fish, and birds who use Willard Spur. Forming a baseline of understanding of this ecosystem was critical to developing an effective research program and establishing defensible protections for Willard Spur. Thus, DWQ developed and implemented the 2011 Sampling Plan (CH2M HILL, 2011a) for the Willard Spur program.

While results from the 2011 monitoring season have been incorporated into a database, evaluation of those data is still ongoing. Initial observations indicate that water flows in 2011 were uncharacteristically high and long in duration. The year 2011 represented the fourth wettest 12-month period on record for the State of Utah with a total of 23.67 inches of precipitation (National Weather Station data at SLC International Airport). This, with the corresponding above average winter snowpack and spring snowmelt, resulted in high flows to Willard Spur and Great Salt Lake (GSL). Almost a five foot rise in GSL's elevation was observed. While flows in 2011 were uncharacteristically high, projections for spring runoff

in 2012 are considerably different. The snowpack in March 2011 was estimated by the National Weather Service (NWS) to be heading from 143 percent of normal to 185 percent of normal, while at this same point in time (March 2012) the NWS estimates the snowpack at only 65 percent of normal (Trentelman, 2012). The lower flows this could generate have the potential of creating vastly different conditions in Willard Spur. The 2012 Willard Spur SAP was developed to capture data that could help understand the conditions in and response of Willard Spur to this potentially more typical or dry condition. Understanding this new condition will be an important part of determining the impact of the Plant and developing defensible protections for Willard Spur.

1.2 Objectives

This 2012 SAP was written as an integral part of Research Area No. 2 in the Willard Spur Research Plan (CH2M HILL, 2011b). The objective of the 2012 SAP is to collect environmental data that accomplish the following:

1. Provide background information describing the overall condition and function of Willard Spur that can serve as the basis for the Science Panel to make recommendations requested by the Water Quality Board. Data from 2012 will allow for a comparison of the overall condition of Willard Spur between the years 2011 and 2012 and better understand the dynamics of the ecosystem related to hydrology.
2. Infer if the Willard/Perry WWTP's discharge to Willard Spur has any greater impact on the beneficial uses of Willard Spur on a normal to dry water year compared to an above average water year.
3. Augment experiments being completed in 2012 to understand the nutrient cycling process within Willard Spur. These experiments will be examining effects on localized test plots. Data from this SAP will enable the Science Panel to better understand conditions throughout Willard Spur in relation to these test plots.

This Plan defines the data quality objectives, sampling and analytical procedures, safety considerations, documentation and reporting requirements to be implemented by the DWQ for the collection of environmental samples (e.g., water, sediment, macroinvertebrates, etc.) in 2012 in Willard Spur. Further, this Plan identifies special studies to be completed in 2012 to address the stated objective.

1.3 Site Description

Willard Spur is a unique and dynamic ecosystem located in the eastern part of the Bear River Bay of GSL (see Figure 1-1). Willard Spur encompasses over 11,780 hectares (ha) (equivalent to approximately 29,100 acres or almost 45.5 square miles) of wetlands with almost 20 percent of that area contained within the Bear River Migratory Bird Refuge (BRMBR). Its waters are generally bounded on the north by the southern dike of the BRMBR (also known as the D-line dike), on the east by the natural rise of topography and Interstate 15, and on the south by the northern dikes of Willard Bay Reservoir, the Harold S. Crane Wildlife Management Area (WMA), and Great Salt Lake Minerals. The waters and mudflats of Bear River Bay stretch to the west of Willard Spur. The open waters

MAP SOURCE: GOOGLE EARTH PRO, JUNE 18, 2010.

\\snowbird\proj\NorthDavisCountySewe\341055\WillardSpur\Hydrology\WillardSpur Study Area_v2.ai APR-11 ckm

FIGURE 1-1
Map of Study Area and Vicinity

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of GSL are located south of Bear River Bay. This study will focus only on the open waters of Willard Spur as shown in Figure 1-1.

The unique habitat of Willard Spur varies dynamically throughout any given year and is directly linked to the hydrologic cycle of GSL's watershed. Willard Spur is where GSL's saline waters and freshwater entering from the Bear River and Weber River basins begin to mix when lake levels exceed approximately 4201.5 feet (per bathymetry developed by Hansen and Associates in 2010). Freshwater entering Willard Spur from the Bear River and Weber River basins typically make up over 40 percent of the annual inflow to GSL (Arnow and Stephens, 1987). When lake levels fall below an elevation of approximately 4201.5 feet, Willard Spur no longer mingles with GSL's saline waters, and its habitat is then controlled largely by the freshwater inflows. GSL was last at an elevation of 4201.5 feet in August 2001; Willard Spur has since been transitioning into freshwater dominated wetlands (U.S. Geological Survey, National Water Information System, accessed Mar 29, 2011, http: //waterdata.usgs.gov/nwis.). As inflows dissipate and water levels in Willard Spur drop, a natural rise in the lake bottom on the western boundary of Willard Spur (locally known as the "sandbar") disconnects the waters of Willard Spur from Bear River Bay and the waterbody becomes a natural impoundment. This can happen on an annual basis depending on available inflows. This condition was not observed in 2011.

While a detailed classification of the wetlands habitat of Willard Spur has not been completed, the United States Fish and Wildlife Service (USFWS) include five management categories for Willard Spur wetlands within the boundaries of the BRMBR (USFWS, 2004). The areal extent of each of these categories is largely dependent on the hydrology in a given growing season:

- Deep submergent wetlands (18-24 inches of water, dominated by sago pondweed [*Stuckenia pectinata*] with very little emergent vegetation)
- Shallow submergent wetlands (4-18 inches of water, dominated by sago pondweed with sparse emergent vegetation)
- Mid-depth emergent wetlands (8-12 inches of water, 50 percent emergent vegetation with alkali bulrush [*Schoenoplectus maritimus*] largely in shallower areas and hardstem bulrush [*Schoenoplectus acutus*] in deeper areas, large stands of cattails [*Typha latifolia and T. angustifolia*] and phragmites [*Phragmites australis*] possible)
- Shallow emergent wetlands (2-8 inches of water, predominantly alkali bulrush, some stands of cattails, and phragmites)
- Vegetated mudflats (0-2 inches of surface water during high-inflow periods or large precipitation events, highly saline soils, often unvegetated, can support shallow-rooted vegetation such as pickleweed [*Salicornia rubra* and *S. utahensis*], saltgrass [*Distichlis spicata*], and seepweed [*Suaeda calceoliformis* and *S. moquinii*])

The varied habitat that Willard Spur provides is a haven for birds and fish; the immense populations of birds being perhaps what Willard Spur is most well known for. USFWS has documented over 210 bird species that regularly use the adjacent BRMBR, at least 67 of which nest in the area. The vegetation, macroinvertebrates, and fish the wetlands of BRMBR and Willard Spur provide are ideally suited for these migrating populations of

waterfowl, shorebirds, and other waterbirds from the Pacific Flyway and Central Flyway. These waters, in conjunction with other waters of GSL, were recognized for their importance to shorebirds as a Western Hemisphere Shorebird Reserve Network Site in 1992 (USFWS, 2004).

The waters of Willard Spur have been protected for their beneficial uses through the use of numeric and narrative criteria (R317-2-7). The beneficial uses of Willard Spur vary depending upon location. Areas within the BRMBR are currently classified as 2B, 3B, and 3D while areas outside of BRMBR are currently classified as 5C and 5E. Table 1-1 provides a summary of the beneficial uses associated with these classes (R317-2-6).

Understanding the dynamics and complexity of the Willard Spur food web, how it interweaves with the varying and unique habitat and hydrology, and the role water quality serves as a critical linkage is a challenge that this SAP will help to address.

TABLE 1-1
Water Classification and Beneficial Uses of Willard Spur

Classification	Beneficial Uses
2B – Recreation and Aesthetics	Infrequent primary contact recreation, secondary contact recreation
3B – Aquatic Wildlife	Warm water species of game fish and other warm water aquatic life, including the necessary aquatic organisms in their food chain
3D – Aquatic Wildlife	Waterfowl, shore birds and other water-oriented wildlife not included in Classes 3A, 3B, or 3C, including the necessary aquatic organisms in their food chain
5C – Bear River Bay	Infrequent primary and secondary contact recreation, waterfowl, shore birds and other water-oriented wildlife including their necessary food chain
5E – GSL Transitional Waters < 4208 feet elevation	Infrequent primary and secondary contact recreation, waterfowl, shore birds and other water-oriented wildlife including their necessary food chain

2.0 Data Quality Objectives

The United States Environmental Protection Agency's (EPA's) seven-step data quality objective (DQO) process (EPA, 2006) is being used to guide the requirements and design rationale for Willard Spur sampling in 2012. The DQOs define the type, quantity, and quality of data and establish performance and acceptance criteria so that data collected support the goals of the study.

2.1 Problem Statement

2.1.1 Problem

Before 2011, there was very little existing environmental data describing the hydrology, water quality, and environmental condition of Willard Spur. DWQ implemented the 2011 Willard Spur Sampling Plan (CH2M HILL, 2011a) to collect detailed background information that described the condition and function of Willard Spur. This data was used as a basis for defining the work included in the 2011 Research Plan (CH2M HILL, 2011b).

While results from the 2011 monitoring season have been incorporated into a database, evaluation of those data is still ongoing. Initial observations indicate that water flows in 2011 were uncharacteristically high and long in duration. Thus, observed conditions may not be representative of what would be considered a more typical condition or even a critical condition where flows are low and nutrients may be more concentrated. This is an important factor that must be considered as the 2011 data are evaluated.

The year 2012 presents an opportunity to not only extend the record of data describing Willard Spur but also to capture conditions during a more typical or dry year. The available snowpack is currently estimated by the NWS to be at 65 percent of normal, thus lower inflows from streams are anticipated (Trentelman, 2012). Information gathered in such a normal or dry condition will be useful and will help inform future discussions regarding the presence and significance of impacts to Willard Spur from the Plant's discharge. Further, this information will help the Science Panel identify means to monitor and protect Willard Spur during what is considered a more critical condition.

2.1.2 Project Team

Implementation of the SAP will require an interdisciplinary effort. The team who will implement the SAP consists of various members from the following organizations:

- The DWQ (collection of water, sediment, diatom, macro-invertebrate, zooplankton, and phytoplankton samples, flow and vegetation monitoring)
- United States Geological Survey (USGS) (flow, water level, and meteorological monitoring)
- CH2M HILL (coordination)

Efforts will be coordinated closely with other ongoing research under the oversight of the Science Panel.

2.1.3 Available Resources

The DWQ will use existing staff and resources to begin to collect samples in April 2012 and continue at a monthly interval through November 2012. The DWQ will contract with the USGS to complete flow, water level, and meteorological monitoring through April 2013. CH2M HILL will assist with sampling and flow monitoring design and coordinate the requisite agreements with various parties. Costs for 2012 will be covered under monies provided by the Water Quality Board.

2.1.4 Relevant Deadlines

This Plan, comprising the DWQ's strategy (i.e., methods, frequency, locations, etc.) for 2012 sampling events and monitoring, will be reviewed and approved by the Science Panel before implementation.

Spring runoff typically begins in force in April. It is critical to start continuous flow monitoring using the equipments already installed at the sampling sites to collect as much information as possible about the 2012 spring runoff.

The proposed approach includes an end-of-year report of analytical results in March 2013.

2.2 Goal of the Study/Decision Statements

2.2.1 Objectives

The objective of this SAP is to collect environmental data that accomplish the following:

- Provide background information describing the overall condition and function of Willard Spur that can serve as the basis for the Science Panel to make recommendations requested by the Water Quality Board. Data from 2012 will allow for a comparison of the overall condition of Willard Spur between the years 2011 and 2012 and better understand the dynamics of the ecosystem related to hydrology.
- Infer if the Willard/Perry WWTP's discharge to Willard Spur have any greater impact on the beneficial uses of Willard Spur on a normal to dry water year compared to an above average water year.
- Augment experiments being completed in 2012 to understand the nutrient cycling process within Willard Spur. These experiments will be examining effects on localized test plots. Data from this SAP will enable the Science Panel to better understand conditions throughout Willard Spur in relation to these test plots.

2.2.2 Key Questions

The overall objective of the Willard Spur research program is to answer the question posed by the Water Quality Board:

> *What water quality standards are appropriately protective of beneficial uses of Willard Spur waters as they relate to the proposed POTW discharge?*

Many questions will need to be answered to answer this question; most of which will be addressed in specific research studies to be completed in the years 2012–2014. Flow monitoring and sampling efforts in 2011 and 2012 and possibly in the following years until 2014, will work toward gaining an understanding of and answering the following question:

What is the current condition of Willard Spur?

Toward that end, this SAP identifies investigations that will work to answer the following research questions:

- What are the hydraulic/hydrologic characteristics of Willard Spur?
  - Where are the inputs/outputs of flow and what is their timing?
  - What is the annual hydrograph (mass balance) for water entering/leaving Willard Spur?
  - How does the water surface elevation change in relation to inputs/outputs?
  - How does the volume and residence time of water change in relation to inputs/outputs?
  - Are wind seiche events a predominant feature in Willard Spur?
- What are the sources of waterborne contaminants entering Willard Spur, and what is the relative significance of the various sources?
  - What potential contaminants are of concern for Willard Spur (i.e., nutrients, selenium, mercury, etc.)?
  - What are the contaminant concentrations and loads in water entering Willard Spur? In water leaving Willard Spur to Bear River Bay?
  - What is the mass balance for contaminants in Willard Spur?
- What are the relative concentrations of potential contaminants in water, sediment, and macroinvertebrates in Willard Spur?
  - How do concentrations vary spatially in comparison to sources of water?
  - Where in Willard Spur are sediments deposited?
  - How do concentrations vary throughout the year for different seasons/hydroperiods?
  - What is the relative contribution of nutrients to the water column (i.e., between nonpoint sources, point sources and sediment fluxes)? Does the sediment surface currently reach anaerobic conditions?
  - How do concentrations vary per other collocated variables sampled?
- What are the current vegetation, macroinvertebrate, phytoplankton compositions in Willard Spur?

  - How predominant are invasive species (i.e., phragmites) in Willard Spur? Where are they located and to what extent? What drives the distribution of phragmites? (i.e., water or sediment salinity, duration of sediment inundation/saturation, concentrations of water or sediment nutrient concentrations, etc.)
  - How do water column and sediment nutrient concentrations affect algal mat, submerged aquatic vegetation (SAV), and macroinvertebrate population characteristics (i.e., densities, distribution, etc.)?
- What are the current bird and fish compositions in Willard Spur?
  - What species of birds and fish currently rely upon Willard Spur? What are their population numbers?
  - What habitat do these birds and fish rely upon? What is the timing of their use?

It is assumed that results will only be reflective of conditions in 2012. It is presumed that 2012 will represent a normal to dry hydrologic cycle where Willard Spur will experience lower flow rates and longer residence times. This will be very different from 2011 which was an extremely wet year. This will allow comparison of conditions in Willard Spur over a wet and a normal to dry hydrologic cycle.

2.2.3 Possible Outcomes

- Successfully collect all required samples, monitor flow at all locations, and measure water level and meteorological changes at least at one location.
- Weather conditions (i.e., ice, electrical storms) or property access limitations preclude or limit the ability to collect samples.
- Resources (i.e., boats, equipment, staff, contracts, funding, etc.) are not available or in place to complete required sampling, monitoring, and analysis.
- Information is adequate to quantify the condition of Willard Spur and to conclude that current contaminant loadings to Willard Spur have a measurable adverse effect on beneficial uses of Willard Spur. The Science Panel will evaluate results and provide recommendations for the Willard Spur Research Program.
- Information is adequate to quantify the condition of Willard Spur and to conclude that current contaminant loadings to Willard Spur have no measurable adverse effect on beneficial uses of Willard Spur. The Science Panel will evaluate results and provide a recommendation as to whether the Willard Spur Research Program should continue and if so, how.
- Information is not adequate to quantify the condition of Willard Spur or to determine whether current contaminant loadings to Willard Spur have a measurable adverse effect on beneficial uses of Willard Spur. The Science Panel will evaluate results and provide recommendations for the Willard Spur Research Program.

2.3 Inputs to the Decision

2.3.1 Informational Inputs

Seasonal Conditions:

- Incoming flow rates will be monitored on a continuous basis at 32 sites and on a monthly basis at two sites (overlap at the outfall ditch site), and water samples will be collected on a minimum monthly basis from inflow points to Willard Spur (33 sites). Water samples will be collected biweekly during spring runoff at high-priority inflow sites (at least 14 sites depending on whether the sites have flow or not). These data will allow for estimation of nutrient loads.
- Water samples will be collected on a monthly basis at the confluence of the old Plant discharge location with Willard Spur, at the outfall's mixing zone and at another site in the Willard Bay tailrace, at the confluence of the Willard Bay tailrace with Willard Spur, at the confluence of the WMA bypass drain and Willard Spur, and along the transect extending the length of Willard Spur (a total of 11 sites).
- Sediment samples will be collected in summer and fall at the confluence of the old Plant discharge location with Willard Spur, in the Willard Bay tailrace, at the confluence of the Willard Bay tailrace with Willard Spur, at the confluence of the WMA bypass drain and Willard Spur, and along the transect extending the length of Willard Spur (11 sites). These samples will be analyzed for chemistry in the summer and diatoms in the fall. Diatom samples will be preserved and stored. The project team will discuss the value of analyzing these samples with the Science Panel.
- Samples of macroinvertebrates, phytoplankton and zooplankton will be collected on a monthly basis at the confluence of the old Plant discharge location with Willard Spur, in the Willard Bay tailrace, at the confluence of the Willard Bay tailrace with Willard Spur, at the confluence of the WMA bypass drain and Willard Spur, and along the transect extending the length of Willard Spur (11 sites).
- Vegetation (SAV and emergent vegetation) will be characterized on a monthly basis at the confluence of the old Plant discharge location with Willard Spur, in the Willard Bay tailrace, at the confluence of the Willard Bay tailrace with Willard Spur, at the confluence of the WMA bypass drain and Willard Spur, and along the transect extending the length of Willard Spur (11 sites).
- Standard suites of field measurements and analytical suites will be completed to characterize the chemistry of mediums sampled. These are summarized in Tables 3-1 and 3-2.

2.3.2 Special Studies

Hydrology/Hydraulic Characteristics. Four continuous flow gauges five inflow points at BRMBR will be operated by the USGS. The DWQ will operate seven additional flow gauges at BRMBR to augment the USGS's primary sites. The DWQ will operate one flow gauge in the bypass drain at the WMA and two lake stage gauges at the WMA to measure inflow through the 16 weirs in the south dike. It is assumed that flow through the south dike is comparable to flow through the north dike into Willard Spur. Inflow from Willard Bay into

the tailrace is gauged by the United States Bureau of Reclamation. Inflow from the Plant into the old outfall ditch and through the new outfall pipeline will be gauged by the Plant. Inflow from the irrigation return canal near the Plant will be measured by DWQ intermittently. The DWQ will measure the outflow from Willard Spur on three occasions.

The water surface elevation and local meteorological conditions will be monitored by the USGS at one site in Willard Spur. The DWQ will additionally attempt to monitor the water surface elevation at two additional sites on Willard Spur to characterize seiche events.

2.3.3 Site-Wide Intensive Sampling Event

DWQ will sample water, sediment, phytoplankton, zooplankton and macroinvertebrates and monitor vegetation at 18 sites in addition to the routine 11 open water sites.

2.3.4 Macroinvertebrates

Two special studies are identified to evaluate macroinvertebrate use in Willard Spur. The stable isotope analysis requires sampling of macroinvertebrates at two sites in the months of July and October. The life history analysis will include three sampling events (July – September) at three routine sites. These sampling events will be completed at 2-week intervals between routine monthly sampling events at these sites.

2.3.5 Nutrient Assimilation in Harold Crane WMA

DWQ will collect water samples at five sites on two separate events along the south dike of the WMA. These two sampling events will coincide with the routine monthly sampling events along the north dike of the WMA.

2.3.6 Support of Nutrient Cycling Research

DWQ will collect water samples at six sites on six different occasions coordinated with the nutrient cycling research team. This work is intended to augment routine sampling completed by the research team.

2.3.7 Fish Sampling Study

Fish abundance will be characterized and samples will be collected during a one-time event along a transect extending the length of Willard Spur (6 sites). This sampling event will be coordinated with the sampling of water and macroinvertebrates at the same time so that water, fish, and macroinvertebrates may be analyzed for selenium and mercury. Both selenium and mercury have been identified as contaminants of concern elsewhere in GSL, thus this information will help establish a baseline for Willard Spur.

2.3.8 Variables/Characteristics to Be Measured

- Flow rates (cubic feet per second) at inflow and outflow points
- Water surface elevation (feet) of Willard Spur pool
- Meteorological conditions at Willard Spur (short- and long-wave radiation, temperature, humidity, wind, precipitation, barometric pressure)
- Water chemistry

- Chemistry and diatom characterization of sediments
- Diversity and numbers of macroinvertebrates
- Diversity and numbers of phytoplankton and zooplankton
- Percent cover of SAV and emergent vegetation
- Numbers and contaminant concentrations of fish

2.4 Study Boundaries

The study area, shown in Figure 1-1, includes the wetlands, open waters, and drainage of Willard Spur as bounded by dikes/berms of the BRMBR, Harold S. Crane WMA, Willard Bay Reservoir, and GSLM, the natural "weir" (a.k.a., sand bar) separating Willard Spur from Bear River Bay on the west and Interstate-15 on the east.

2.4.1 Temporal

Hydrology will be monitored for a minimum of 1 year. Environmental samples will be collected, and supplemental studies will be completed throughout 2012. A final report summarizing results from 2012 including all data finalized should be prepared by March 2013.

2.4.2 Practical Constraints on Data Collection

- Property access agreements will need to be negotiated and confirmed.
- Availability of boats and other field equipment, as well as equipment functionality, may limit some activities.
- Staff and funding availability will need to be confirmed.
- Weather is a major constraint for all sampling and monitoring activities, because storms can limit the ability to safely conduct sampling and measurement activities at the study area.
- The presence of ice and/or lack of water could limit the ability to collect samples.

2.5 Decision Rules

- If information is adequate to quantify the condition of Willard Spur and to conclude that current contaminant loadings to Willard Spur have a measurable adverse effect on beneficial uses of Willard Spur, then the Science Panel will provide recommendations for the Willard Spur Research Program.
- If information is adequate to quantify the condition of Willard Spur and to conclude that current contaminant loadings to Willard Spur have no measurable adverse effect on beneficial uses of Willard Spur, then the Science Panel will evaluate results and provide a recommendation as to whether the Willard Spur Research Program should continue and, if so, how.

- If information is not adequate to quantify the condition of Willard Spur or to determine whether current contaminant loadings to Willard Spur have a measurable adverse effect on beneficial uses of Willard Spur, then the Science Panel will evaluate results and provide recommendations for the Willard Spur Research Program.

2.6 Tolerable Limits on Decision Rules

Tolerance limits for laboratory analysis data quality are defined in the Quality Analysis Project Plan (QAPP) (see Appendix B), in terms of acceptability criteria. The QAPP defines procedures that specify all quality assurance (QA)/quality control (QC) objectives for sample measurement based on each matrix.

The Science Panel will provide the Steering Committee and the DWQ with its recommendation regarding the suitability and adequacy of the available information with regard to the decision rules. The Water Quality Board will make the final decision of whether and how the Willard Spur Research Program should continue.

2.7 Optimization of the Sampling Design

After detailed consideration of reasonable alternatives and scheduling constraints, the following design is the most resource effective:

- Use available and trained DWQ personnel to collect environmental samples and complete the supplemental studies.
- Use established, existing, and local sampling infrastructure (sampling equipment, sampling protocol, vehicles, and laboratories) to execute the SAP.
- Use the DWQ's airboat to facilitate collection of samples. The USFWS has also offered the use of its airboats if and when needed.
- Collaborate with USFWS, Utah Department of Natural Resources, Division of Wildlife Resources (DWR), and other researchers where possible.
- Use trained USGS stream gauging technicians that are locally available for gauge installation, gauge servicing, and periodic direct flow measurement.
- Use established USGS methods, discharge equipment, and software for gauge operation, data transmission, and data archiving.
- Use existing technical, database, and publication resources for data QA/QC, data archiving, and publication and distribution of results to interested parties.

It is assumed that these DQOs and all sampling, gauging, analytical, and QA/QC methods will be reviewed on an ongoing basis, discussed with representatives of the Steering Committee, revised as required, and eventually accepted by the Science Panel before the data are used for decision rules or publication.

3.0 Sampling Work Plan

This section summarizes a sampling work plan that incorporates concepts to achieve the objectives of the DQOs for this study. Work to be completed as part of this study in 2012 can be characterized into two categories:

- Environmental sample collection: These activities will work toward understanding the temporal and spatial condition of Willard Spur.
- Supplemental studies: These are studies that will be completed to address specific questions that are critical to meeting the objectives of this Plan.

3.1 Environmental Sample Collection

The majority of the DWQ's resources for this effort will be dedicated to collecting environmental samples that describe conditions at inflow and outflow points of Willard Spur as well as within the open waters of Willard Spur. This data will be critical in benchmarking the present condition and understanding what studies may be required to meet the Water Quality Board's objectives for Willard Spur. This section provides a summary of the approach the DWQ will use for sampling in 2012.

3.1.1 Sampling of Inflows

During the 2011 sampling and monitoring efforts, 32 inflow sources were located for the Willard Spur. These included points from the BRMBR, the east side drainage area, and the WMA area (see Figure 3-1). The same sources will be monitored and sampled for 2012. Table 3-1 summarizes the chemical parameters that water samples will be analyzed for and Table 3-2 summarizes the parameters that sediment samples will be analyzed for. Note that different chemical parameters for water samples will be analyzed depending upon the site and month sampled. Table 3-3 provides a summary of site locations and activities to be completed at those locations. Figure 3-2 illustrates these locations throughout Willard Spur. Figure 3-3 provides a larger scale illustration of sampling locations in the East Drainage Area. Sampling procedures, analytical methods, and quality assurance requirements are found in the QAPP in Appendix A.

Water samples will be collected at a minimum monthly interval at all inflow locations identified in Table 3-3. Biweekly water samples will be collected at the five primary discharge sites from the BRMBR, two locations near the old Plant outfall, the new Plant outfall, and six locations at the WMA to improve estimates of loading during the spring runoff in the months of May and June.

Inflow from the WMA is largely dominated by local spring runoff and stormwater runoff and can be very dynamic. Although DWQ sampled water along the south dike of the WMA in 2011, apparent significant assimilation of nutrients in the impoundments makes it important that flows be sampled where they enter Willard Spur along the north dike. DWQ will continue to monitor flows along the south dike of the WMA but will sample water at 16 culverts located along the north dike of the WMA. DWQ will confirm north dike

culverts that are conveying flow, measure flow entering the culverts, and collect a water sample at each culvert at a minimum monthly interval as identified in Table 3-2.

FIGURE 3-1
Drainage Areas of Willard Spur

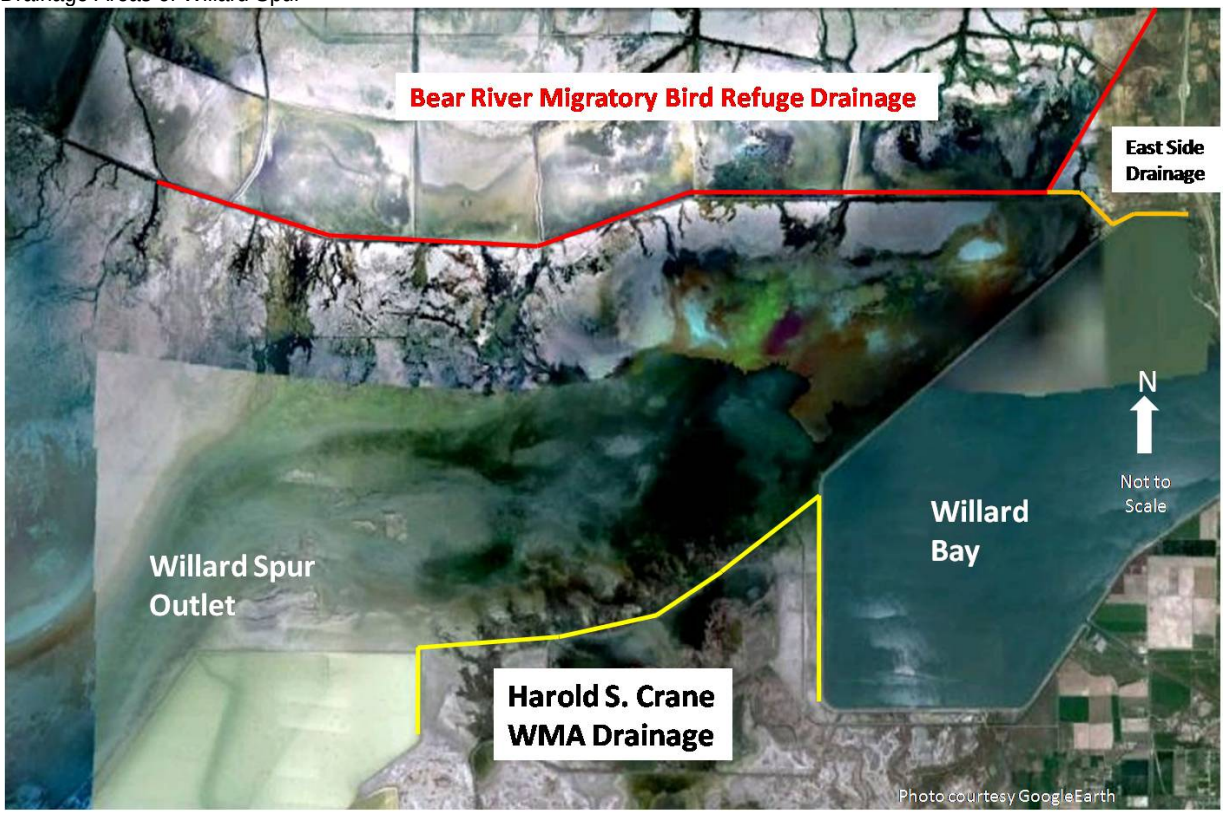

FIGURE 3-2
Sampling and Monitoring Sites

NOTE: Not all open water sites shown in this Figure will be sampled. Please see Table 3-3 and Section 3.1.2 for details

FIGURE 3-3
Sampling and Monitoring Sites in East Drainage Area

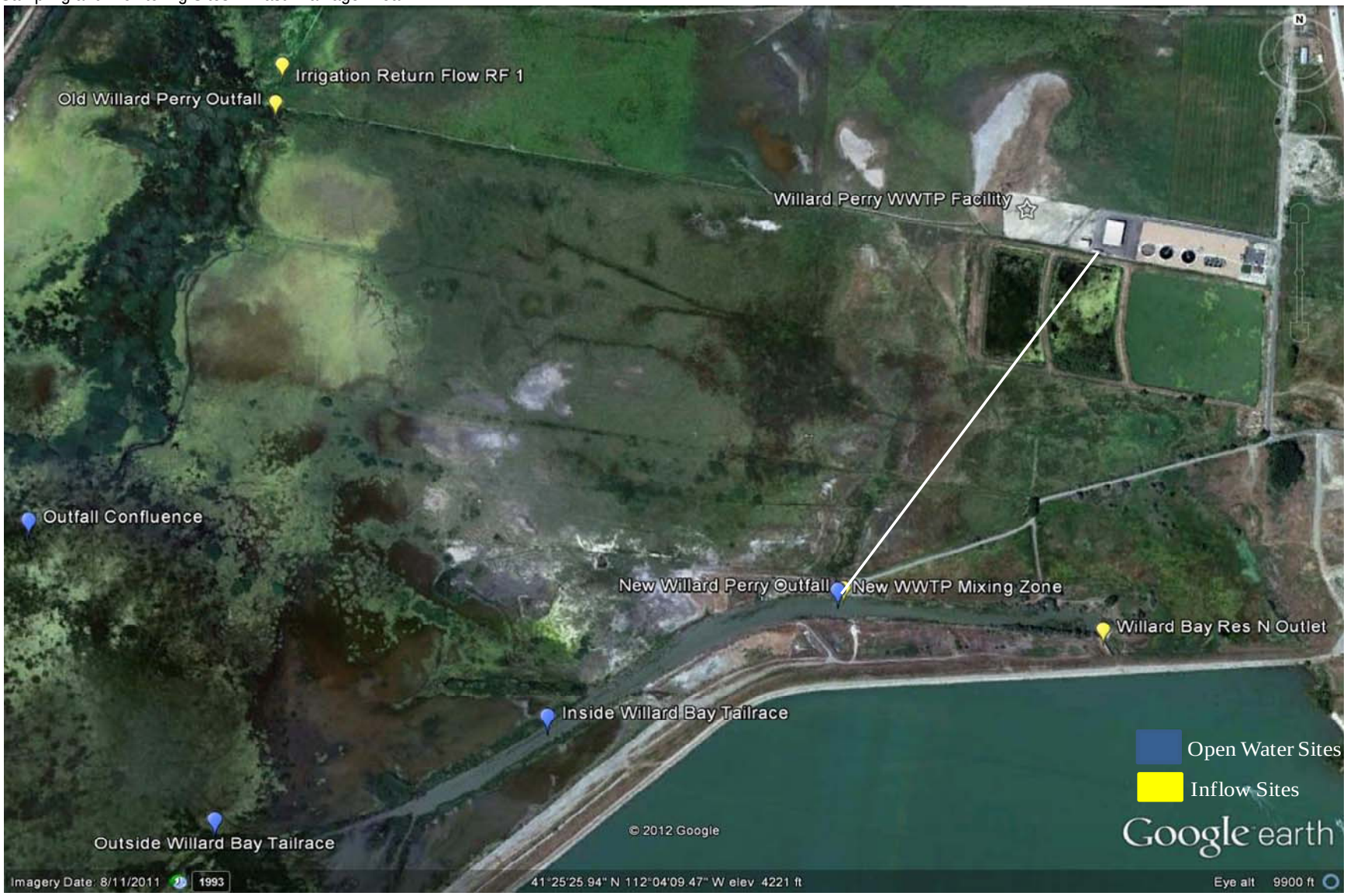

TABLE 3-1
Water Chemistry Parameters to be Analyzed for Inflow and Open Water Sites

Description	Parameters
Standard Water Chemistry Parameters to be Analyzed during Inflow Monthly Monitoring	
Field Parameters	Temperature, specific conductance, pH, dissolved oxygen,
General Chemistry	Total suspended solids, total volatile solids, total dissolved solids
Total (Nonfiltered) Nutrients	Nitrate/Nitrite, Total Phosphorus, TKN
Other	Chlorophyll-a
Standard Water Chemistry Parameters to be Analyzed during Open Water Monthly Monitoring	
Field Parameters	Temperature, specific conductance, pH, dissolved oxygen,
Biochemical Oxygen Demand (BOD)	Carbonaceous BOD_5
Total (Nonfiltered) Nutrients	Ammonia, Nitrate/Nitrite, Total Phosphorus, TKN
Dissolved (Filtered) Nutrients	Nitrate/Nitrite, Total Nitrogen, Dissolved Phosphorus
General Chemistry	Sulfate, total suspended solids, total volatile solids, total dissolved solids
Dissolved (filtered) Metals	Iron, Manganese and Hardness
Other	Chlorophyll-a
Extensive Water Chemistry Parameters to be Analyzed for both Open Water and Inflow Sampling Sites for May and August	
Field Parameters	Temperature, specific conductance, pH, dissolved oxygen
Biochemical Oxygen Demand (BOD)	Carbonaceous BOD_5
Total (Nonfiltered) Nutrients	Ammonia, Nitrate/Nitrite, Total Phosphorus, TKN
Dissolved (Filtered) Nutrients	Nitrate/Nitrite and Total Nitrogen, Dissolved P
General Chemistry	Sulfate, alkalinity, turbidity, specific conductance, total suspended solids, total volatile solids, total dissolved solids
Total (Nonfiltered) Metals	Total Selenium, Total Mercury
Dissolved (filtered) Metals	Aluminum, arsenic, barium, boron, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, nickel, potassium and hardness
Other	Chlorophyll-a, Ash Free Dry Mass

NOTE:
TKN = Total Kjeldahl Nitrogen

TABLE 3-2
Sediment Chemistry Parameters

Description	Parameters
General Parameters	pH, Salinity
Sediment Nutrients	Phosphorus, Ammonia-Nitrogen, Nitrate-Nitrogen, Total Nitrogen
Sediment Elements	Aluminum, Boron, Calcium, Cadmium, Cobalt, Chromium, Copper, Iron, Potassium, Manganese, magnesium, Molybdenum, Sodium, Nickel, Phosphorus, Lead, Sulfur, Strontium and Zinc
Other	Sulfate-Sulfur, Total Organic Carbon

TABLE 3-3
Summary of Sampling Locations, Activities, and Frequency

Sample Location						Flow Measurement		Water Sampling (Chemistry)				Sediment Sampling		Macro-invertebrate Sampling				Phytoplankton and Zooplankton Sampling		Vegetation Monitoring		Fish Sampling
No	STORET ID	Inflow Site or Open Water (OW) Site	Site Description	Latitude	Longitude	Continuous (Transducers)	Intermittent (water depth and velocity check)	Biweekly in May, June [4]	Monthly (May and Aug with extended parameters list. All other months reduced parameters list)	Six events (nutrient cycling project)	Site-wide Intensive Event (July) [1]	One-time Event (July–chemistry, October - diatoms) [1]	Site-wide Intensive Event (July) [2]	Monthly	Site-wide Intensive Event (July) [2]	Stable Isotope Analysis (July & October)	Life History Analysis (3 events, July-Sept)	Monthly	Site-wide Intensive Event (July) [2]	Monthly	Site-wide Intensive Event (July) [2]	One-time Event (anytime Sep thru Oct)[3]
Bear River Migratory Bird Refuge																						
1	4984710	Inflow	BRR-1	**41°25'25.17"N**	**112°15'51.60"W**	X	USGS	X	X													
2	4984715	Inflow	BRR-2	**41°25'18.07"N**	**112°15'23.70"W**	X	USGS	X	X													
3	4985659	Inflow	BRR-3	**41°24'59.69"N**	**112°14'3.98"W**	X	USGS	X	X													
4	4984720	Inflow	BRR-4 O-Line	**41°24'58.10"N**	**112°13'5.50"W**	X	USGS	X	X													
5	4984717	Inflow	BRR-5	**41°24'57.22"N**	**112°12'30.16"W**	X	USGS	X	X													
6	4984725	Inflow	BRR-6 4's Drain (USGS)	**41°24'56.90"N**	**112°11'28.60"W**	USGS	USGS	X	X													
7	4985653	Inflow	BRR-7	**41°25'14.46"N**	**112°10'11.75"W**	X	USGS	X	X													
8	4984750	Inflow	BRR-8 Whistler (USGS)	**41°25'22.49"N**	**112° 9'32.59"W**	USGS	USGS	X	X													
9	4984752	Inflow	BRR-9	**41°25'22.30"N**	**112° 8'36.70"W**	X	USGS	X	X													
10	4984755	Inflow	BRR-10 Unit 5 (USGS)	**41°25'22.30"N**	**112° 7'39.50"W**	USGS	USGS	X	X													
11	4984758	Inflow	BRR-11 5C (USGS)	**41°25'22.41"N**	**112° 5'39.50"W**	USGS	USGS	X	X													
East Side Drainage																						
12	4984760	Inflow	Irrigation RF1	**41°25'45.1"N**	**112°04'34.8"W**		X	X	X													
13	4984762	Inflow	WP-OUTFALL (end of old outfall ditch)	**41°25'43.7"N**	**112° 4'34.1"W**	WWTP	X	X	X													
14	5984644	Inflow	New Outfall Pipeline Effluent (measure & sample at plant, Plant to do this)	**41°25'18.28"N**	**112°3'58.76"W**	WWTP		WWTP	WWTP													
15	5984641	Inflow	New Outfall Mixing Zone (in OW of tailrace, downstream of pipe outfall)	**112°3'58.76"W**	**112°3'58.76"W**				X													
16	4920420	Inflow	WB-RES-N-OUTLET	**41°25'17.40"N**	**112° 3'41.52"W**	USBR		X	X													
17	5984643	OW	Inside Willard Bay Tailrace	**41°25'11.50"N**	**112°04'17.80"W**				X			X		X				X		X		
18	5984645	OW	Outside Willard Bay Tailrace	**41°25'02.06"N**	**112° 4'35.1"W**				X			X		X				X		X		
19	5984640	OW	OUTFALL-CNFL (confluence w/ WS)	**41°25'21.36"N**	**112°4'51.12"W**				X			X		X				X		X		
Harold C. Crane Wildlife Management Area																						
20	WMA 1	Inflow	Weir 1	**41°20' 25.8"N**	**112°11' 23.9"W**	X																
21	4984610	Inflow	HC-WMA-1	**41°20'26.2"N**	**112°11'23.8"W**	X	X															
22	WMA 3	Inflow	Weir 3	**41°20' 26.2"N**	**112°11'13.3"W**	X																
23	WMA 4	Inflow	Weir 4	**41°20' 26.2"N**	**112°11'02.2"W**	X																

TABLE 3-3
Summary of Sampling Locations, Activities, and Frequency

Sample Location						Flow Measurement		Water Sampling (Chemistry)				Sediment Sampling		Macro-invertebrate Sampling				Phytoplankton and Zooplankton Sampling		Vegetation Monitoring		Fish Sampling
No	STORET ID	Inflow Site or Open Water (OW) Site	Site Description	Latitude	Longitude	Continuous (Transducers)	Intermittent (water depth and velocity check)	Biweekly in May, June [4]	Monthly (May and Aug with extended parameters list. All other months reduced parameters list)	Six events (nutrient cycling project)	Site-wide Intensive Event (July) [1]	One-time Event (July–chemistry, October - diatoms) [1]	Site-wide Intensive Event (July) [2]	Monthly	Site-wide Intensive Event (July) [2]	Stable Isotope Analysis (July & October)	Life History Analysis (3 events, July-Sept)	Monthly	Site-wide Intensive Event (July) [2]	Monthly	Site-wide Intensive Event (July) [2]	One-time Event (anytime Sep thru Oct)[3]
24	WMA 5	Inflow	Weir 5	41°20'26.2"N	112° 10'47.1"W	X																
25	WMA6	Inflow	Weir 6	41°20' 26.2"N	112°10'32.2"W	X																
26	WMA7	Inflow	Weir 7	41°20'28.3"N	112°10'17.3"W	X																
27	WMA8	Inflow	Weir 8	41°20'31.1"N	112°10'03.0"W	X																
28	WMA9	Inflow	Weir 9	41°20'33.8"N	112°09'47.9"W	X																
28	4984620	Inflow	HC-WMA-2	41°20'35.1"N	112°09'41.3"W	X	X															
30	4984630	Inflow	HC-WMA-3	41°20'35.5"N	112°09'39.5"W	X	X															
31	WMA12	Inflow	Weir 12	41°20' 36.6" N	112°09' 33.4"W	X																
32	WMA13	Inflow	Weir 13	41°20' 41.0" N	112°09' 19.4"W	X																
33	WMA14	Inflow	Weir 14	41°20' 46.5" N	112°09' 06.5"W	X																
34	WMA 15	Inflow	Weir 15	41°20'53.3"N	112°08'50.2"W	X																
35	4984650	Inflow	HC-WMA-5	41°20'57.79"N	112°08'40.37"W	X	X															
36	4984655	Inflow	WMA Bypass Drain	41°20'38.2"N	112° 8'11.1"W	X	X															
37	4984657	Inflow	HC-WMA-Bypass-N	41°21'49.80"N	112°08'11.60"W			X	X													
38	WMA18	Inflow	Water level in pond			X																
39	5984770	Inflow	HC-WMA-1N	41 21' 55.3"N	112 8' 44.8"W		X	X	X													
40	5984775	Inflow	HC-WMA-2N	41 21' 53.9"N	112 8' 54.5"W		X	X	X													
41	5984780	Inflow	HC-WMA-3N	41 21' 51.9"N	112 9' 08.2"W		X	X	X													
42	5984785	Inflow	HC-WMA-4N	41 21' 47.0"N	112 9' 19.3"W		X	X	X													
43	5984790	Inflow	HC-WMA-5N	41 21' 41.4"N	112 9' 29.6"W		X	X	X													
44	5984800	Inflow	HC-WMA-6N	41 21' 35.3"N	112 9' 40.7"W		X	X	X													
45	5984805	Inflow	HC-WMA-7N	41 21' 30.4"N	112 9' 52.2"W		X	X	X													
46	5984810	Inflow	HC-WMA-8N	41 21' 26.0"N	112 10' 04.4"W		X	X	X													
47	5984815	Inflow	HC-WMA-9N	41 21' 21.7"N	112 10' 15.9"W		X	X	X													
48	5984820	Inflow	HC-WMA-10N	41 21' 17.5"N	112 10' 28.0"W		X	X	X													
49	5984825	Inflow	HC-WMA-11N	41 21' 14.7"N	112 10' 40.1"W		X	X	X													
50	5984830	Inflow	HC-WMA-12N	41 21' 14.0"N	112 10' 52.5"W		X	X	X													

TABLE 3-3
Summary of Sampling Locations, Activities, and Frequency

Sample Location						Flow Measurement		Water Sampling (Chemistry)				Sediment Sampling		Macro-invertebrate Sampling				Phytoplankton and Zooplankton Sampling		Vegetation Monitoring		Fish Sampling
No	STORET ID	Inflow Site or Open Water (OW) Site	Site Description	Latitude	Longitude	Continuous (Transducers)	Intermittent (water depth and velocity check)	Biweekly in May, June (4)	Monthly (May and Aug with extended parameters list. All other months reduced parameters list)	Six events (nutrient cycling project)	Site-wide Intensive Event (July) (1)	One-time Event (July–chemistry, October - diatoms) (1)	Site-wide Intensive Event (July) (2)	Monthly	Site-wide Intensive Event (July) (2)	Stable Isotope Analysis (July & October)	Life History Analysis (3 events, July-Sept)	Monthly	Site-wide Intensive Event (July) (2)	Monthly	Site-wide Intensive Event (July) (2)	One-time Event (anytime Sep thru Oct)(3)
51	5984835	Inflow	HC-WMA-13N	**41 21' 14.0"N**	**112 11' 05.6"W**		X	X	X													
52	5984840	Inflow	HC-WMA-14N	**41 21' 14.0"N**	**112 11' 16.3"W**		X	X	X													
53	5984845	Inflow	HC-WMA-15N	**41 21' 08.1"N**	**112 11' 24.2"W**		X	X	X													
54	5984850	Inflow	HC-WMA-16N	**41 21' 02.9"N**	**112 11' 24.1"W**		X	X	X													
Willard Spur																						
55	WSLVL1	OW	Lake stage (WS2)	**41°24'40.57"N**	**112° 5'25.45"W**	X																
56	WSLVL2	OW	Lake stage/MET (USGS)			**USGS**																
57	WSLVL3	OW	Lake stage (WS12)	**41°22'10.66"N**	**112°15'59.07"W**	X																
58	WSLVL4	OW	Lake stage (WS6)			X																
59	5984650	OW	WS-1	**41°25'12.06"N**	**112° 5'13.98"W**				X			X		X				X		X		X
60	5984654	OW	WS1c (new northern mid OW site)	**41°25'14.54"N**	**112° 5'26.97"W**						X		X		X				X		X	
61	5984656	OW	WS1d(new southern mid OW site)	**41°25'8.49"N**	**112° 4'57.22"W**						X		X		X				X		X	
62	5984660	OW	WS-2	**41°24'40.57"N**	**112° 5'25.45"W**				X			X		X		X	X	X		X		
63	5984664	OW	WS2c (new northern mid OW site)	**41°24'51.61"N**	**112° 5'49.33"W**						X		X		X				X		X	
64	5984666	OW	WS2d (new southern mid OW site)	**41°24'37.68"N**	**112° 5'16.99"W**						X		X		X				X		X	
65	TBD	OW	OWNCSED1 (nutrient cycling project site)							X												
66	TBD	OW	OWNCSED2(nutrient cycling project site)							X												
67	TBD	OW	OWNCSED3 (nutrient cycling project site)							X												
68	TBD	OW	OWNCWAT1 (nutrient cycling project site)							X												
69	TBD	OW	OWNCWAT2 (nutrient cycling project site)							X												
70	TBD	OW	OWNCWAT3 (nutrient cycling project site)							X												
71	5984670	OW	WS-3	**41°24'24.66"N**	**112° 5'55.44"W**				X			X		X				X		X		X
72	5984674	OW	WS3c (new northern mid OW site)	**41°24'38.95"N**	**112° 6'35.37"W**						X		X		X				X		X	
73	5984676	OW	WS3d (new southern mid OW site)	**41°24'5.11"N**	**112° 6'17.71"W**						X		X		X				X		X	
74	5984680	OW	WS-4	**41°24'06.15"N**	**112° 7'37.72"W**																	X

TABLE 3-3
Summary of Sampling Locations, Activities, and Frequency

Sample Location						Flow Measurement		Water Sampling (Chemistry)				Sediment Sampling		Macro-invertebrate Sampling				Phytoplankton and Zooplankton Sampling		Vegetation Monitoring		Fish Sampling
No	STORET ID	Inflow Site or Open Water (OW) Site	Site Description	Latitude	Longitude	Continuous (Transducers)	Intermittent (water depth and velocity check)	Biweekly in May, June [4]	Monthly (May and Aug with extended parameters list. All other months reduced parameters list)	Six events (nutrient cycling project)	Site-wide Intensive Event (July) [1]	One-time Event (July–chemistry, October - diatoms) [1]	Site-wide Intensive Event (July) [2]	Monthly	Site-wide Intensive Event (July) [2]	Stable Isotope Analysis (July & October)	Life History Analysis (3 events, July-Sept)	Monthly	Site-wide Intensive Event (July) [2]	Monthly	Site-wide Intensive Event (July) [2]	One-time Event (anytime Sep thru Oct)[3]
75	5984695	OW	OUT-HC-WMA-DD	41°22'20.51"N	112° 8'22.92"W				X			X		X				X		X		
76	5984690	OW	WS-5	41°23'43.01"N	112° 8'39.71"W																	
77	5984700	OW	WS-6	41°23'13.38"N	112° 9'39.80"W				X			X		X		X	X	X		X		X
78	5984704	OW	WS6c (new northern mid OW site)	41°23'52.00"N	112° 9'57.33"W						X		X		X				X		X	
79	5984706	OW	WS6d (new southern mid OW site)	41°22'35.69"N	112° 9'11.31"W						X		X		X				X		X	
80	5984710	OW	WS-7	41°22'44.31"N	112°10'31.98"W																	
81	5984720	OW	WS-8	41°22'39.17"N	112°11'39.58"W				X			X		X				X		X		X
82	5984722	OW	WS8a (old 2011 northern edge site)	41°23'40.38"N	112°12'7.77"W						X		X		X				X		X	
83	5984728	OW	WS8b (old 2011 southern edge site)	41°21'8.57"N	112°11'43.46"W						X		X		X				X		X	
84	5984724	OW	WS8c (new northern mid OW site)	41°23'3.95"N	112°11'50.85"W						X		X		X				X		X	
85	5984726	OW	WS8d (new southern mid OW site)	41°21'55.76"N	112°11'40.90"W						X		X		X				X		X	
86	5984723	OW	WS8e (new northern fringe channel site)								X		X		X				X		X	
87	5984725	OW	WS8f (new northern fringe channel site)								X		X		X				X		X	
88	5984730	OW	WS-9	41°22'56.02"N	112°12'46.86"W																	
89	5984740	OW	WS-10	41°22'56.78"N	112°13'56.36"W				X			X		X			X	X		X		X
90	5984744	OW	WS10c (new northern mid OW site)	41°23'22.45"N	112°13'58.50"W						X		X		X				X		X	
91	5984746	OW	WS10d (new southern mid OW site)	41°22'9.99"N	112°13'59.52"W						X		X		X				X		X	
92	5984750	OW	WS-11	41°22'47.10"N	112°15'07.71"W																	
93	5984760	OW	WS-12	41°22'10.66"N	112°15'59.07"W		X		X			X		X				X		X		
94	5984764	OW	WS12c (new northern mid OW site)	41°22'19.67"N	112°16'31.42"W						X		X		X				X		X	
95	5984766	OW	WS12d (new southern mid OW site)	41°21'53.78"N	112°15'32.62"W						X		X		X				X		X	

NOTES:
[1] Samples collected at same time as routine monthly samples.
[2] One-time intensive sampling event includes the other open water sites as well.
[3] Special study to characterize fish population and determine Se and Hg concentrations.
[4] Biweekly samples will be collected at all inflows that has flow

3.1.2 Sampling of Conditions within Open Waters of Willard Spur

Sampling sites within Willard Spur will be located along a longitudinal transect that extends the length of Willard Spur. This transect was defined in 2011 by a review of available historical aerial photography to identify the likely primary flow path through Willard Spur for a wide range of flow conditions (see Figure 3-5). A review of 2011 data determined that the number of sites could be reduced, thus only sites WS1, WS2, WS3, WS6, WS8, WS10, and WS12 along this longitudinal transect will be sampled in 2012. If Willard Spur recedes to the east and a regular site is found to be "dry" (i.e., no water above ground surface), then the "dry"site condition will be photographed/documented and the site will be replaced with the odd-numbered site to the east and nearest to the "dry" site. For example, if site WS12 is "dry" then site WS11 should be sampled. If WS12 and WS11 are "dry", then WS9 should be sampled in addition to WS10. A total of number of 7 open waters sites should be maintained along this longitudinal transect during 2012.

Additional open water sites are located within the Willard Bay tailrace, at the confluence of the old Plant outfall and Willard Spur, the confluence of the Willard Bay tailrace and Willard Spur, and the confluence of the WMA bypass drain and Willard Spur. Every attempt should be made to keep these sampling sites at the same physical location, however if the site is "dry" or access is not possible, samples should be collected as close as possible to the regular station and the project team notified.

Sampling and characterization of water, sediment, macroinvertebrates, phytoplankton, zooplankton, vegetation and fish will be completed at the open water locations and intervals indicated in Table 3-2. The DWQ will also document observations of water depth and discernable flow direction, flow velocity, light penetration (turbidity and secchi depth), and presence of algal mats whenever samples are collected in the open water. Sampling procedures, analytical methods, and quality assurance requirements are found in the QAPP in Appendix A.

FIGURE 3-5
Transect Locations in Willard Spur

3.2 Special Studies

The DQOs include a number of questions that build on and extend beyond the understanding that environmental samples can provide. This section summarizes studies that will be completed in 2012 to augment the environmental sample collection efforts described in the previous section and meet the objectives described in the DQOs.

3.2.1 Hydrology Study

The objective of the hydrologic study is to better understand the sources and timing of how water is conveyed into and through the water body. This study will identify where the sources of inflow are located, estimate the timing and volume of inflow and outflow of Willard Spur, and evaluate how the volume (i.e., water level and areal extent of water surface) and residence time of water in Willard Spur respond to these characteristics. Much of this data will be used to estimate nutrient loads as well as evaluate changes in habitat and condition/response of Willard Spur.

Early indications of snow accumulated in the watershed during the 2011–2012 winter as well as underlying hydrologic conditions point toward 2011 being a year with normal to dry flows entering Willard Spur. It is recognized that these flows are different than what was observed in 2011 and may or may not be representative of a "typical" hydrologic cycle for this watershed. The working hypothesis presented in 2011 was that a high runoff year as observed in 2011 will dilute and flush contaminants in the water column out of Willard Spur (better case scenario) versus a low runoff year, as may occur in 2012, will cause possible contaminants to concentrate and stay within Willard Spur (worst case scenario). The objective for this year is to understand the condition in 2012 so as to compare conditions during different hydrologic regimes and better inform evaluations and decisions to be made in subsequent years.

The hydrologic study will focus on collecting data in three areas:

- Measurement of flows
- Water level measurement
- Meteorological monitoring

Measurement of Flows. While continuous measurement of every inflow point is not feasible, a significant effort will be undertaken to characterize the timing and volume of the vast majority of the surface water inflows. There are three basins contributing surface water to Willard Spur: the Bear River basin to the north (i.e., BRMBR drainage), the east side drainage, and the Weber River basin to the south (WMA drainage) (see Figure 3-2). This study does not address groundwater inflows or outflows. Groundwater hydrology may be addressed by the Science Panel at a later time.

Bear River Basin. There are 11 possible inflow points contributing surface water from the Bear River into Willard Spur through the BRMBR. CH2M HILL met with the USFWS to identify the 4 points contributing the most significant quantities of inflow (see Table 3-3). The USGS will maintain a gauging station at each of these 4 points. Each of these stations will include telemetry that will allow remote monitoring of data and equipment performance to minimize the risk of loss of flow data at these critical points. The DWQ will install a gauging station at each of the remaining seven points. These seven gage stations will not include

telemetry and will be visited on a monthly basis to confirm operation and download data. The USGS will manually measure flow at all 11 sites on a monthly basis for use in calibrating and confirming these gauges. Standard operating procedures for these gauging stations will follow the methods as described in Cartern and Davidian (1968) and Buchanan and Somers (1968 and 1969). Assuming these gauge stations operate as intended, they will provide near-continuous monitoring of surface water inflows to Willard Spur.

East Drainage Area. The drainage area contributing surface water to Willard Spur from the east is largely dominated by local runoff and irrigation return flows and includes flows from the Perry/Willard Regional Wastewater Treatment Plant (see Figure 3-2). Flows from the Plant, whether through the old outfall ditch or through the new outfall pipelines, will be measured and reported by the Plant. Inflows from an irrigation return flow ditch will be measured on a monthly basis by DWQ when water samples are collected. Inflows from Willard Bay via the tailrace will be estimated from United States Bureau of Reclamation records.

Weber River Basin. The majority of surface water entering Willard Spur from the Weber River basin enters through the Harold S. Crane Wildlife Management Area, an area located between Willard Bay and Great Salt Lake Minerals (see Figure 3-2). Much of this flow represents urban runoff and irrigation return flows. There are a number of challenges to measuring and sampling these inflows, including access and dynamic flow conditions. These challenges were discussed in detail in the 2011 Sampling Plan (CH2M HILL, 2011a).

The proposed plan is to maintain a water level sensor in the large wetland pool south of the WMA's Main Unit's south dike. CH2M HILL developed a rating curve for each of the 16 weirs in the south dike that describes their flow characteristics and coupling that with near-continuous water level measurements. Using these rating curves, the DWQ will be able to characterize the dynamics of water flowing into the WMA. These flows will be assumed to be representative of flows entering Willard Spur. The DWQ will likewise install a gauging station on the Bypass Drain east of the WMA to measure flow through this ditch to Willard Spur. Estimates of flow through the bypass drain may be confounded by backwater conditions in the channel. Flow entering Willard Spur in the area between Great Salt Lake Minerals and the WMA will not be monitored but is expected to be insignificant in 2012. It is acknowledged that groundwater inflow, precipitation, and evaporation will have some effect on the actual flow from the WMA to Willard Spur, but it is assumed that this will be negligible.

Outflow. Surface water flowing out of Willard Spur into Bear River Bay flows over a wide expanse locally known as the "sand bar." Continuous measurement of outflow through this area is not considered feasible at this time. The DWQ will measure flow depth and velocity at discrete locations along the width of the outflow and integrate these values to estimate the flow rate two to three times during 2012.

Water Level Measurement. The dynamics of how Willard Spur responds to inflows is important to understanding the areal extent of the water body and its habitat. Four lake stage sensors will be installed in Willard Spur to understand how the water body responds to inflows and wind events. The USGS will maintain one lake stage sensor that is equipped with telemetry to allow for remote monitoring of data and equipment performance. The DWQ will install three lake stage sensors, at sites WS2, WS6, and WS12, to better understand how wind

events affect the movement of water within the water body and how that affects the areal extent of water within Willard Spur.

Meteorological Monitoring. Understanding local weather conditions is essential to understanding evaporative losses, precipitation inflows, effects of wind on water movement, and how weather may impact water quality conditions. The USGS will install a meteorological station on its lake stage platform to measure short and long-wave radiation, temperature, humidity, wind, precipitation, and barometric pressure.

3.2.2 Site-wide Intensive Sampling Event

The objective of this special study is to investigate spatial patterns within the open waters of Willard Spur and how nutrients are being assimilated within an existing fringe wetland that extends from a discrete outfall location to the open waters of Willard Spur. This information will help determine the location and distribution of future monitoring sites and understand how a long term nutrient source may impact the ecosystem.

Samples of water, sediment, macroinvertebrates, zooplankton, and phytoplankton will be collected in a one-time sampling event from an additional 18 sites throughout the open waters of Willard Spur. Further, the project team will also monitor vegetation conditions at these same locations during this one-time sampling event using established protocol.

Sample sites will be located along transects perpendicular to the longitudinal transect at the following locations: WS1, WS2, WS3, WS6, WS8, WS10, and WS12 (see Figure 3-6). Each of these perpendicular transects were sampled in 2011 with samples generally collected at the edge of water (sample sites were designated as WSXa and WSXb, with WSX representing the sample site on the longitudinal transect, WSXa located at the northern edge of water, and WSXb at the southern edge of water). New sample sites will be established in 2012 along the same perpendicular transects, however sites will now be established at points approximately halfway between the edge of water (e.g., WSXa and WSXb) and the longitudinal transect (e.g., WSX). These new sites will be designated as WSXc (located north of the longitudinal transect) and WSXd (located south of the longitudinal transect). Samples will be collected at WSXc, WSX, and WSXd (i.e., not WSXa or WSXb). Standard protocol should be observed for adjusting sites if sites are found to be dry.

An additional 4 sites will be sampled/monitored along transect WS8. Three additional sites, including WS8a and two further to the north, will span along the fringe wetland created by outflow from the BRMBR's O-Line Canal. DWQ will also collect include the site WS8b. These four sites will provide a transect spanning the entire width of Willard Spur providing insight into how these fringe wetlands may assimilate nutrients over long periods of time.

FIGURE 3-6
Proposed Halfway Sampling Locations between Longitudinal Transect and Edge of Water in Willard Spur *(sites 8e and 8f are not shown in this map)*

3.2.3 Sonde Deployment

The objective of this special study is to characterize diurnal variations in temperature, pH, specific conductance, and dissolved oxygen in the open waters of Willard Spur. DWQ will deploy sondes at least once, preferably twice, for a period of 7 days along the longitudinal transect (3 sites) (see Figure 3-5). Deployments should occur during the critical times of July and August.

3.2.4 Nutrient Uptake Capacity of Willard Bay Tailrace

Some studies have suggested that flowing water bodies may be responsible for nutrient removal depending upon the transport distances that might result in increased water residence time. The Plant is currently constructing a new pipeline to discharge its effluent to the Willard Bay tailrace. The objective of this special study is to estimate the nutrient uptake capacity of the Willard Bay tailrace. This will be accomplished along a predetermined length of the channel through the use of a nutrient pulse addition approach (Tank et al., 2008). This approach has been shown to be uniquely suited to quantifying how much of the nutrients from the channel, including effluent from the Plant, may be taken up by biological activity in this channel. This approach will help better understand the relative role of biology vs. hydrology in nutrient uptake at least under two different flow events. Experimental protocols can be adapted from Tank et al., 2008 and Covino et al., 2010.

3.2.5 Macroinvertebrates

As described above, sampling of macroinvertebrates on a regular monthly basis at open water sites will inform an understanding of how macroinvertebrate populations change spatially and temporally. Two special studies will be completed to augment routine sampling for 2012 (1) the Stable Isotope Analysis of the Food Web, and (2) a Life History Analysis of Common Macroinvertebrates.

Stable Isotope Analysis of the Food Web. This special study, using stable isotope (^{15}N and ^{13}C) analysis, will be completed to better understand the lower food web (macroinvertebrates, algae, detritus and plants) and the trophic interaction in the ecosystem. ^{15}N is useful in determining food web and predator-prey relationships as it shows significant differences between producers (algae and SAV), herbivores, and carnivores. ^{13}C is useful in determining the source of detritus for detritivores and can provide insight into the relative importance of autochthonous detritus, such as that derived from SAV, algae, and emergent aquatic plants within Willard Spur, and allochthonous detritus derived from treatment plant effluent and agricultural/upland runoff.

Samples for this study will be collected at two locations, once in late July (at or near peak SAV growth) and once in October (after SAV senescence). Samples should be collected in conjunction with the Life History Study described below. Dr. Larry Gray will participate in the July sampling event.

One site will be at the open water site WS2 in the upper reach of Willard Spur and the other at open water site WS6 in the middle reach of Willard Spur. Samples for this study should be taken at a slight distance away from the usual sampling sites to avoid too much disruption with routine sampling. The total number of sweep samples for this study is 4 (2 in July and 2 in October). It should be noted that because the goal is to collect sufficient biomass for the isotope analysis, each net sweep sample should consist of 10 sweeps rather than the usual 5.

The samples will be collected "fresh" (i.e., not preserved with ethanol), placed on ice, and sent to Dr Larry Gray's lab immediately for further processing. Stable isotope analysis will be carried out by the lab at the University of Utah.

Life History Analysis of Common Macroinvertebrates. In addition to routine monthly sampling, 3 sites representing the upper, middle, and lower Spur areas will be selected in which additional sweep samples will be taken at 2-week intervals (i.e., in between regular sampling) from July to September (weather and equipment permitting) to gain additional detail into the life cycles of the common macroinvertebrates, including mayflies, damselflies, corixids, chironomids, amphipods, and snails. All samples collected at these sites will be treated as regular samples, except that size-frequency histograms will be constructed to determine periods of emergence and recruitment and number of generations occurring during the summer/early fall season. This knowledge will assist in separating normal life cycle changes in abundance with changes in populations that may be caused by other physical/chemical factors.

The additional biweekly samples will be completed in the months of July, August, and September and will occur in the period between normally scheduled, monthly sampling events at these sites (total of 3 additional sampling events). The 9 additional samples will be

collected at the open water sites WS2, WS6, and WS10. If site WS10 becomes dry, samples should be collected at the site corresponding to protocol defined in this document. A total of 9 extra samples will be collected. Dr. Larry Gray will participate in the July sampling event.

3.2.6 Nutrient Assimilation in Harold Crane WMA

As previously described in this SAP, DWQ will routinely monitor flows going through the Harold Crane WMA to estimate the nutrient load to Willard Spur from the Weber River watershed. These activities include measuring the quantity of water flowing through the south dike and sampling the water flowing through the north dike to evaluate the water quality entering Willard Spur. It is understood that the wetland impoundments of the WMA may provide significant water quality benefits to Willard Spur as the water is detained and natural biological activity enhances the quality of the water before entering Willard Spur. The objective of this study is to collect water samples along the south dike of the WMA to evaluate how the water quality entering the WMA through the south dike differs from the water quality leaving the WMA through the north dike. This data will be used to estimate the assimilation of nutrients in the WMA impoundments.

DWQ will collect water samples on two separate sampling events at a maximum of five weirs or at least three weirs along the south dike, depending on whether there is flow through the weirs. The samples will be collected once during spring runoff in June and a second time during September. The five weirs to be sampled are 2, 10, 11, 15, and 16. DWQ will photo-document each of these weirs, measure the flow rate, and obtain a water sample at each weir.

Note that these sampling events should be coordinated with DWQ's impounded wetlands study so as to gain the maximum benefit for both projects.

3.2.7 Sampling Support for Nutrient Cycling Study

DWQ is funding a research study in 2012-2013 with the goal of observing how open water wetlands in Willard Spur naturally change throughout the year and with increased nutrients from a water source and from a sediment source. The research team will be monitoring these sites intensively and sampling on a monthly basis. DWQ will collect water samples at the six study sites on six different sampling events. These six sampling events will be coordinated closely with the research team and will generally occur once per month during the months of June through October (5 months) with a sixth sampling event to occur in August or September. The goal is to closely monitor changes in water chemistry with an emphasis upon changes that are known to occur in August/September.

3.2.8 Fish Sampling Study

A fish sampling study completed in 2011 by Hannah Moore (Moore, 2012) identified a diverse population of fish existing in Willard Spur. The objective of this study is to sample six locations along the longitudinal transect of Willard Spur to confirm the presence of fish and species present. Sample sites should be adjacent to established DWQ sites along this transect and work should be coordinated with DWR. DWQ will collect representative tissue samples from fish collected and send to the EPA for analysis (selenium and mercury).

3.3 Supplemental Studies

Additional studies were identified that may be completed by the DWQ or others if resources are available or may be postponed until additional funds are available and input is received from the Science Panel. These supplemental studies are identified in this document not as requirements for 2012 but to foster cooperation with other agencies and provide guidance if funds become available. These studies include the following:

- Residence time experiment in Willard Spur
- Mapping the existing distribution of phragmites in Willard Spur
- Bird surveys
- Detailed evaluation of mixing patterns in the Plant's mixing zone

3.3.1 Residence Time of Water in Willard Spur

A key factor in how Willard Spur assimilates contaminants is the time that water resides within the water body. To that end, the DWQ will attempt to complete dye studies on two separate occasions to better understand the residence time of water in the Plant outfall's mixing zone and the overall Willard Spur during different flow regimes: June (spring runoff) and August (dry season).

3.3.2 Mapping of Existing Distribution of Phragmites

The USFWS has completed extensive investigations of invasive species such as phragmites within the BRMBR (USFWS, 2007; Kettenring and Mock, 2009; Zaman and McKee, 2010). Mapping the presence and extent of phragmites within Willard Spur would serve as a benchmark that defines the extent of the current problem but also a means to begin to evaluate whether water quality standards may improve the present condition. DWQ is currently participating in a study, led by Dr. Karin Kettenring, to map invasive species along the eastern side of GSL. Continuing this work will provide a useful baseline map identifying how the distribution of invasive species is changing.

3.3.3 Bird Surveys

The Utah Division of Wildlife Resources (DWR) completed extensive surveys of GSL bird populations from 1997 to 2001 that served as a basis for designating the Bear River Bay, including Willard Spur, as a Globally Important Bird Area and a part of the Western Hemisphere Shorebird Reserve Network. Surveys of Willard Spur identified a rich diversity of bird species and vast numbers. The area, however, is immense, and the study notes that due to the aerial methods used and the highly variable habitat, the survey accuracy in this area is likely understated (Paul and Manning, 2002). The DWR still completes routine bird surveys of Bear River Bay (Anderson, 2010) and Willard Spur (personal communication with John Luft). The USFWS and DWR routinely complete bird surveys at their wildlife management areas on the periphery of Willard Spur (per communication with John Isanhart and Val Bachman).

While birds adapt their feeding habits to the available condition and thus make it difficult to assess whether this beneficial use is impaired, bird surveys would still provide a benefit in addressing the objectives of this study. Understanding the diversity and populations of birds using Willard Spur will help determine how this water body resource is being used

and what needs to be protected. Understanding bird use could, at a minimum, provide anecdotal data that could be linked to other collocated environmental data collected as part of this study and that, in turn, could provide beneficial information that could help guide further research into how GSL wetlands water quality affects this beneficial use.

This study, if completed in 2012, would provide an updated survey of water birds utilizing Willard Spur. The study will identify the bird species utilizing Willard Spur and estimate their populations. Surveys will be timed to coincide with sampling efforts in a way that survey results could be linked to environmental data collected in 2012. Surveys will be coordinated with USFWS and DWR to utilize their avian biologists. Alternatively, DWQ's field teams could stop at a good vantage point for each sampling site, observe for 10 minutes, and document bird use at the sampling site. Protocol could be simplified by grouping birds into guilds, such as waterfowl, waders, shorebirds, or other waterbirds so that even inexperienced birders can capture this important information. At a minimum, the DWQ will provide anecdotal observations regarding bird use at sites where environmental samples are collected.

3.3.4 Evaluation of Plant's Mixing Zone

The existing mixing zone for the Plant's outfall is located in a back-eddy area on the east side of Willard Spur. Little is currently known about how the Plant's effluent actually mixes with the open waters of Willard Spur (i.e., where the effluent mixes). Other unknowns include the extent of the dilution effect of flow from BRMBR's 5C Outlet and the residence time of the effluent in the vicinity of the outfall. Some of these unknowns will be addressed by water quality samples to be collected by the DWQ (see Section 3.1) and by the proposed residence time experiment (see Section 3.2.1).

The objective of this study, if resources are available, is to collect water quality samples in a radial pattern from the outfall site to specifically quantify the dilution of effluent and determine how nutrient concentrations are dissipated in the mixing zone. This should be completed at a minimum for two hydrologic regimes, a high-flow scenario (spring runoff) and low-flow scenario (August to September).

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4.0 Data Analysis

As described above, this SAP was developed as one component in Research Area No. 2 of the overall Willard Spur Research Plan (CH2M HILL, 2011b). Figure 4-1 illustrates how the work defined in this SAP helps address the overall questions of the program and links to the other work. Section 2.2.2 of this SAP identifies numerous questions that the SAP is intended to answer. While it is not possible to predict exactly all the analyses that will be conducted until the data are available, the following discussion is meant to provide a description of how expected results will be analyzed to achieve each objective. This discussion, in combination with the linkages illustrated in Figure 4-1, provide an overview of the planned analyses for this project.

4.1 What are the hydraulic/hydrologic characteristics of Willard Spur?

- Where are the inputs/outputs of flow and what is their timing?
- DWQ will collect, compile, and convert raw flow measurements into useable flow data. Flow data will be compiled so as to create a hydrograph for each flow monitoring site.
- What is the annual hydrograph (mass balance) for water entering/leaving Willard Spur?
- Flow hydrographs for the various flow monitoring sites will be combined into one overall hydrograph for Willard Spur. Measured outflow data from Willard Spur will be used to understand how inflow varies with outflow and compared against residence time estimates.
- How does the water surface elevation change in relation to inputs/outputs?
- DWQ will collect, compile, and convert raw data from pressure transducers into water depth data for each site. If DWQ is able to survey each site, these water depths will be translated into actual water surface elevations. If no survey data is available, water depth data will be normalized and compared to the USGS lake stage data. Water elevation measurements will be used to evaluate whether wind events created significant seiche activity, evaluate the water storage volume (i.e., stage versus storage curve), estimate the residence time of water, and potentially complete hydraulic calculations (e.g., flow rates and velocities) for flow in Willard Spur.
- How does the volume and residence time of water change in relation to inputs/outputs?
- DWQ will compare inflow hydrographs to estimated stage versus storage curve to evaluate the volume, residence time and likely flow velocities in Willard Spur. Data will be used as part of the nutrient cycling evaluation to determine if and how system hydrology may be a factor.
- Are wind seiche events a predominant feature in Willard Spur?

- DWQ will use available meteorological data and the water surface elevation data to determine if wind seiche events are occurring and if they might have a significant impact on habitat and flow. These data will be compared with field observations to confirm trends.

4.2 What are the sources of waterborne contaminants entering Willard Spur, and what is the relative significance of the various sources?

- What potential contaminants are of concern for Willard Spur (i.e., nutrients, selenium, mercury, etc.)?
- DWQ will compile water chemistry data and analyze the dataset to look for spatial and temporal trends of potential contaminants. Contaminant concentrations will be benchmarked against common thresholds for concern obtained from the literature to identify sources of concern, if present.
- What are the contaminant concentrations and loads in water entering Willard Spur? In water leaving Willard Spur to Bear River Bay?
- The water chemistry evaluation described above will be augmented by an evaluation of water chemistry by inflow monitoring site to evaluate if any specific inflow sites may require further evaluation in the future.
- What is the mass balance for contaminants in Willard Spur?
- Only nutrients will be addressed in 2012. Nutrient loads for all inflow sites will be estimated from the available dataset. These incoming loads will be compared with the estimated export of nutrients via the Willard Spur outlet. It is noted that only minimal outflow data will be available. This nutrient budget, i.e., mass balance, will be used in conjunction with observations from the remaining dataset to evaluate how and when nutrients may be cycled within Willard Spur. Data from other studies will also be used to inform this evaluation as described below.

4.3 What are the relative concentrations of potential contaminants in water, sediment, and macroinvertebrates in Willard Spur?

- How do concentrations vary spatially in comparison to sources of water?
- Where in Willard Spur are sediments deposited?
- DWQ will compile water and sediment chemistry data from routine sampling and the site-wide intensive sampling event and analyze the dataset to look for spatial and temporal trends of potential contaminants. Sediment chemistry will only be evaluated for one sampling event. Macroinvertebrates will only be analyzed for selenium and mercury. Contaminant concentrations will be benchmarked against common thresholds for concern obtained from the literature to identify sources of concern, if present.

- How do concentrations vary throughout the year for different seasons/hydroperiods?

See above.

- What is the relative contribution of nutrients to the water column (i.e., between nonpoint sources, point sources and sediment fluxes)? Does the sediment surface currently reach anaerobic conditions?
  - Results from the sonde deployment, measurements made as part of this SAP, and measurements made as part of the nutrient cycling study will be used to determine if Willard Spur approaches anaerobic conditions and when.
  - Results from the nutrient uptake study will be used to determine how much of the nutrient load from the Plant is assimilated before reaching Willard Spur. This information will be incorporated into the nutrient budget for Willard Spur.
  - Results from the site-wide intensive sampling event, routine sampling, the nutrient uptake study, the nutrient cycling study, and the nutrient assimilation study at Harold Crane WMA will be used to evaluate if and how much nutrient assimilation is taking place in fringe and open water wetlands and how future nutrient inflows may impact Willard Spur.
  - The nutrient cycling study will be used to determine the relative contribution of sediment and water sources of nutrients and the ecosystem's response to these contributions. Nutrient loading estimates as described above will be combined with estimates of sediment flux from the nutrient cycling study to prepare a nutrient budget for Willard Spur. A nutrient budget will be estimated for 2011 and 2012 to evaluate how different hydrologic conditions may affect nutrient cycling and how the Plant may impact Willard Spur.
- How do concentrations vary per other collocated variables sampled?

See above.

4.4 What are the current vegetation, macroinvertebrate, phytoplankton compositions in Willard Spur?

- How predominant are invasive species (i.e., phragmites) in Willard Spur? Where are they located and to what extent? What drives the distribution of phragmites? (i.e., water or sediment salinity, duration of sediment inundation/saturation, concentrations of water or sediment nutrient concentrations, etc.)
- The Vegetation/Habitat Mapping and Literature Review project will be addressing these questions.
- How do water column and sediment nutrient concentrations affect algal mat, submerged aquatic vegetation (SAV), and macroinvertebrate population characteristics (i.e., densities, distribution, etc.)?
- DWQ will evaluate the available dataset to identify meaningful trends between water and sediment chemistry and primary and secondary producers. The macroinvertebrate

stable isotope analysis and macroinvertebrate life stage analysis will be used to evaluate how nutrients are moving through and impacting the food web.

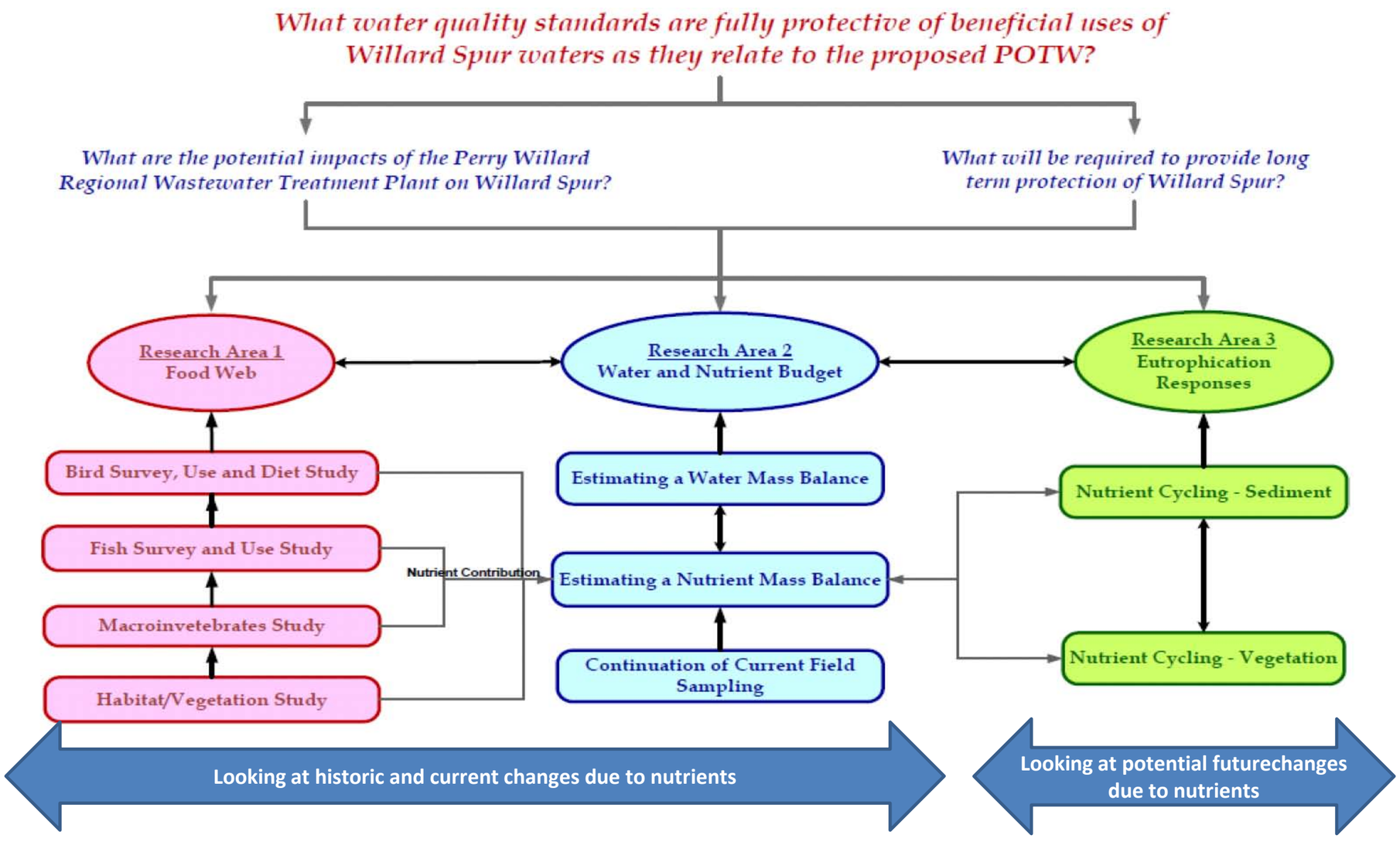
4.5 What are the current bird and fish compositions in Willard Spur?

- What species of birds and fish currently rely upon Willard Spur? What are their population numbers?
- The Avian Use Literature Review and Fish Use Literature Review studies will address these questions.
- What habitat do these birds and fish rely upon? What is the timing of their use?

See above.

Linking Objectives & Questions to Answers & Solutions

Development of Water Quality Standards for Willard Spur



Study Question	Research Area that will address question	Specific Study/Task to address question	Possible Management Solutions
1. What are the potential impacts of the Plant on Willard Spur?			
1.1 What characteristics of the effluent are of concern?			
1.1.1 Is alteration of site hydrology a concern?	2	Hydrology monitoring	
1.1.2 Are the chemical constituents of concern?	2	2011 and 2012 Sampling Plan	Maintain Discharge Monitoring Reporting
1.2 What are the nutrient loads in the effluent with and without nutrient removal?	2	2011 and 2012 Sampling Plan, Nutrient Budget	Maintain Discharge Monitoring Reporting
1.3 What are the sources of nutrients entering Willard Spur and what is the relative significance of these sources?	2	2011 and 2012 Sampling Plan, Nutrient Budget	
1.4 How much of that load will reach Willard Spur accounting for nutrient assimilation by the wetland channel?	2	Nutrient Uptake Capacity Analysis - Special Study	
1.5 How will the wetland channel respond to the effluent's nutrient load?	2	2011 and 2012 Sampling Plan	
1.5.1 How will it respond in the long term?	2	Sampling Study, Nutrient assimilation of Harold Crane WMA	Long term monitoring plan with assessment framework
1.6 Under what conditions does the effluent reach and not reach Willard Spur?	2	Hydrology study	
1.7 Of the nutrients that reach Willard Spur, how might they change the ecosystem?	2 3 1	Site-wide Intensive Sampling Study Nutrient cycling study Vegetation/habitat mapping & lit review, Avian use lit review, Fish use lit review, Macroinvertebrate evaluation & lit review	
1.7.1 Do these changes have a deleterious effect on Willard Spur?	3	Nutrient cycling study	Change UPDES permit conditions, permanent nutrient removal
2. What will be required to provide long term protection of Willard Spur?			
2.1 What are the beneficial uses of Willard Spur?	2	2011 and 2012 Sampling Plan	Change beneficial use designation
2.2 What is the present condition of Willard Spur?	2	2011 and 2012 Sampling Plan	
2.2.1 What are the hydraulic/hydrologic characteristics of Willard Spur?	2	2011 and 2012 Sampling Plan, Hydrologic monitoring	
2.2.2 What are the sources of contaminants entering Willard Spur and what is the relative significance of these sources?	2	2011 and 2012 Sampling Plan, Nutrient Budget	
2.2.3 What are the relative concentrations of potential contaminants in water, sediment, macroinvertebrates, and fish in Willard Spur?	2	2011 and 2012 Sampling Plan	
2.2.4 What are the current vegetation, macroinvertebrate, and phytoplankton compositions in Willard Spur?	1 2	Vegetation/habitat mapping & lit review, Macroinvertebrate evaluation & lit review 2011 and 2012 Sampling Plan	
2.2.5 What are the current bird and fish componsitions in Willard Spur?	1 2 external	Avian use lit review, Fish use lit review 2011 and 2012 Sampling Plan DWR bird surveys	Address the petitioners request to reclassify Willard Spur as Category 1 Waters Assessment of beneficial use support
2.3 What are "natural" responses vs. responses to the Plant?			
2.3.1 How has Willard Spur changed over time to what we see today? What factors may have caused that change? How could nutrients affect change?			
2.3.1.1 How have hydrologic conditions changed?	2	Hydrology monitoring	
2.3.1.2 How have vegetation/habitat changed?	1	Vegetation/habitat study mapping & lit review	
2.3.1.3 How has bird use changed?	1 1	Avian use lit review 2011 Waterfowl diet study	
2.3.1.4 How has fish use changed?	1	Fish use lit review	
2.3.1.5 How has macroinvertebrate (lower food chain) use changed?	1	Macroinvertebrate evaluation & lit review	
2.3.1.5.1 What is influencing lower numbers of 2011 macroinvertebrates? Pattern doesn't match other GSL wetlands.	2	Macroinvertebrate life history analysis	
2.3.1.5.2 Where do macroinvertebrates get their food? Is food source impacted by nutrients?	2 3	Macroinvertebrate stable isotope analysis Nutrient cycling study	
2.3.2 How does the Willard Spur ecosystem respond to conditions in 2011 vs 2012 - a wet year representing optimal conditions vs dry/normal year representing critical conditions?	2 1 external external	2011 and 2012 Sampling Plan, Sonde deployment, Site-wide intensive sampling study Vegetation/habitat mapping & lit review, Avian use lit review, Fish use lit review, Macroinvertebrate evaluation & lit review Dr. Kettenring study of GSL invasive species DWR bird surveys	Long term monitoring plan with assessment framework
2.4 How is Willard Spur cycling nutrients? How does it respond to nutrients?	3	Nutrient cycling study	
2.5 What factors influence how Willard Spur is responding to nutrients?	3 2	Nutrient cycling study 2011 and 2012 Sampling Plan	
2.6 How might Willard Spur respond to increased nutrients? In short term? In long term?	3	Nutrient cycling study	Triggers for use in long term monitoring, Numeric indicators with narrative criteria, Site-specific numeric criteria

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5.0 References

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APPENDIX A

Quality Assurance Project Plan