EXECUTIVE SUMMARY

Studies of the Food Web of Willard Spur, Great Salt Lake, 2011–2013: Development of Water Quality Standards for Willard Spur

Prepared for

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Acknowledgements

This executive summary provides a brief overview of several studies and literature reviews undertaken by various principal investigators with the funding, support, and assistance of the Utah Department of Environmental Quality, Division of Water Quality (UDWQ) as part of UDWQ's Development of Water Quality Standards for Willard Spur project. The reader is encouraged to review the source literature for further detail and discussion provided by the principal investigators.

Collaboration among the numerous stakeholders and project partners was also critical to project success. The Willard Spur Science Panel and Steering Committee provided review and important input to the design and completion of this work.

SECTION 1

Introduction

The ecosystem of Willard Spur, located within Great Salt Lake's (GSL) Bear River Bay was relatively unknown at the outset of this project. Central to determining the impact of the Perry Willard Regional Wastewater Treatment Plant (Plant) upon Willard Spur was understanding the current health of the ecosystem, what the components are, and how resilient the ecosystem as a whole is. Would the effluent from the Plant contribute flows or nutrients that would upset the current balance of the ecology? The studies summarized by this document were designed with the objective of understanding the food web of Willard Spur.

Overall Objectives

The Science Panel was charged with the responsibility to identify and oversee the studies required to address the question: "*What water quality standards are fully protective of beneficial uses of Willard Spur waters as they relate to the proposed POTW (publicly owned treatment works) discharge?"* This question represents the overall program objective.

Two questions were identified that follow from the program objective, i.e., these questions must be answered for the program objective to be achieved. The questions are as follows:

1. What are the potential impacts of the Perry Willard Regional Wastewater Treatment Plant on Willard Spur?

2. What changes to water quality standards will be required to provide long term protection of Willard Spur as they relate to the proposed POTW discharge?

To provide answers to these questions, the three following key research areas were agreed upon:

1. Define and understand the food web of Willard Spur

2. Define the water and nutrient budget for Willard Spur

3. Define responses to eutrophication within Willard Spur

This document provides an overview of the numerous studies and literature reviews that were completed to define and understand the food web of Willard Spur (Research Area 1). Key beneficial uses of Willard Spur are tied to the fishery and bird populations and other uses they support. At the outset of this project, very little was known about any of the populations inhabiting Willard Spur. Research area 1 was intended to help understand these populations and also, through a review of literature, identify how changes in flow and nutrients might impact them (CH2M HILL, 2011).

Findings

Several studies and literature reviews were undertaken in an effort to better understand the ecosystem of Willard Spur. This section summarizes the key findings, the methods utilized and the results of these methods for each category. The reader is encouraged to review the source literature for further detail and discussion.

3.1 Bird Use

Dr. John Cavitt and his team at Weber State University reviewed the literature to investigate bird use and diet in Willard Spur and better understand the linkage between habitats, diet and bird utilization of Willard Spur (Cavitt 2013, Barber and Cavitt 2012).

3.1.1 Key Findings

A detailed review of Utah Division of Wildlife Resources' avian population database for 1999-2012 was completed by Dr. Cavitt to determine which species were using Willard Spur, an estimate of how many birds of each species were present throughout different seasons, and how these numbers fluctuated depending on various conditions, in particular, water level and inflows. Fifty-six species were recorded in the database and their populations illustrate how critical the Willard Spur habitat is within the GSL ecosystem. Most key bird species populations appear to be correlated with water elevations and flows. Birds that prefer mudflats and shallow waters increase when flows are low into Willard Spur. Birds that prefer deeper waters, more submerged aquatic vegetation, and possibly birds who have been pushed out of other areas of the GSL by rising water levels tend to increase in quantity in Willard Spur during times of high flows and corresponding high water levels. This finding showcases how dynamic the Spur's ecology is throughout different seasons and conditions and why it attracts such a diversity of birds.

A detailed literature review was completed to develop a summary of dietary information for fifty-two bird species found to utilize Willard Spur. Diets included fish, invertebrates, and vegetation sources and were found to vary by bird species, preferred habitat, and season.

A more focused analysis of the diets of ducks feeding in Willard Spur was also completed to establish which food sources were most critical to support the waterfowl populations. While the diets of the various bird species varied as widely as the habitat they prefer, the diet of the ducks sampled in the BRMBR area in 2009-2010 and the ducks sampled in Willard Spur in November 2011 was almost entirely vegetarian. This could be because the selection and quantity of vegetation in Willard Spur exceeded other locations on the GSL, the vegetation was predominant during the periods of deeper water preferred by waterfowl, or it could be the result of a lack of macroinvertebrates within the Spur during the sampling time period. Diets from birds sampled in other parts of the GSL provided a more complete picture of the range of food items consumed by ducks in the area, and how their diets changed depending on season.

3.1.2 Conclusions

While a direct linkage to nutrient concentrations in Willard Spur was not identified in this work, the studies did illustrate important linkages between

1. water level and habitat dynamics in Willard Spur,
2. habitat dynamics and food sources for bird populations utilizing Willard Spur, and
3. vegetation communities and the bird populations utilizing Willard Spur.

3.2 Fish Use

Chris Penne at the Utah Division of Wildlife Resources completed a review of the available literature and conducted field studies to ascertain the presence, composition, and diversity of the fishery in Willard Spur (Penne 2012a, Penne 2012b).

3.2.1 Key Findings

Although no investigations describing Willard Spur's fishery prior to 2011 were found, observational studies of migratory birds and reports from anglers suggested that there was a fishery dominated by common carp.

Two field studies (Moore 2011, Penne 2012b) confirmed that a warm water fishery does exist in Willard Spur. The fish species found consisted of common carp, gizzard chad, Utah chub, channel catfish, black bullhead, hybrid striped bass (also known as wiper), yellow perch, black crappie, and channel catfish. Although there is some recreational use of the fishery, the primary value of the fishery in the Willard Spur is thought to be as a food source for migratory birds such as the white pelican.

The two fisheries that are also a source of water to Willard Spur, the Bear River and Willard Bay Reservoir, have been extensively studied. The primary fish species found in these two fisheries were found in Willard Spur, indicating a strong link between the fisheries of Bear River, Willard Bay Reservoir and Willard Spur.

The fish present in Willard Spur are capable of surviving and reproducing in varied and challenging conditions. The dominant fish species found in Willard Spur (common carp, gizzard shad, Utah chub, and black bullhead) are all able to spawn in the ecology of Willard Spur and are generalist feeders capable of eating detritus, benthic invertebrates, plant material, and plankton, all of which are found in abundance within Willard Spur. Each of these four species are also more tolerant of the warm temperatures, low dissolved oxygen, and higher salinities found in shallow, fluctuating ecosystems like Willard Spur.

The greatest threat to the Willard Spur fishery is thought to be the elimination of habitat through the absence of water. A significant loss of fish was observed in 2012 and 2013 as the open water in Willard Spur receded and eventually dried up in 2013. In systems such as in Willard Spur that have high densities of common carp, the collective feeding activity of these fish can degrade water quality and reduce habitat for other fish species. This becomes more important as water levels decrease and carp are concentrated in smaller areas. Thus, inflows to and water levels in Willard Spur are currently the primary limiting factors for Willard Spur's warm water fishery.

3.2.2 Conclusions

Willard Spur supports a warm water fishery that is tolerant of the wide variety of conditions observed in Willard Spur with the obvious exception of when water was limited.

3.3 Macroinvertebrate and Zooplankton Communities

Dr. Larry Gray evaluated the macroinvertebrate communities of Willard Spur as represented by the samples collected by UDWQ in 2011 – 2013 (Gray 2012, Gray 2013, Gray 2015a, Gray 2015b) and completed a review of the literature to understand the composition, characteristics, and tolerance of macroinvertebrates in Willard Spur.

3.3.1 Key Findings

Gray found that the macroinvertebrate taxa present in Willard Spur are representative of what are commonly found in other GSL wetlands. Abundance of major taxa shifted seasonally and likely in response to changing conditions in Willard Spur. Community composition appeared to be most sensitive to water level and the health of submerged aquatic vegetation (SAV). This was confirmed both through a comparison of results among years but also a comparison of central and peripheral sample sites. A literature review completed by Gray (Gray 2012) provided an important summary of major macroinvertebrate taxa found in Willard Spur, effects of salinity, water level, and nutrient enrichment on individual taxa, and community metrics and community responses to nutrient enrichment.

The abundance of macroinvertebrates and zooplankton was found to be lowest in 2011, the year when flow rates were highest and water temperatures were lowest (Gray 2012). Community metrics were similar to other GSL wetlands, even declining in response to a decrease in SAV within Willard Spur. Perimeter and channel sites were found to contain a greater abundance of more tolerant species such as snails, hemipterans, and aquatic beetles.

Gray reported that the year 2012 presented with similar taxa as 2011, however the relative abundance of taxa shifted to a greater abundance of midges vs mayflies and damselfies (Gray 2013). Lower water levels and rapidly declining SAV condition in 2012 resulted in declining community metrics and a shift to a community of taxa adapted to stagnant conditions and low dissolved oxygen concentrations. Gray also completed an evaluation of the life cycles and trophic position of common macroinvertebrate taxa found in Willard Spur and noted the impact of low water levels on the number of generations produced in a given year.

Gray found that the community composition and response to low water levels and SAV condition were similar in 2013 as observed in 2012. The macroinvertebrate communities appeared to rebound even after the low water conditions observed in 2012. The abundance of macroinvertebrates were found to exhibit a high degree of resilience with sample counts actually higher in the spring of 2013 than the spring of 2012. Fall abundance was, however, lower in the fall of 2013 than in the fall of 2012.

3.3.2 Conclusions

Gray found macroinvertebrate and zooplankton communities in Willard Spur to be similar in composition and response to other communities in GSL wetlands. Abundance and community composition varied seasonally and appear to be most responsive to water levels and the condition of SAV. Gray found the macroinvertebrate and zooplankton communities to exhibit a high degree of resiliency even after drought. While a direct link to nutrient enrichment in Willard Spur was not found, a summary of chemical and physical characteristics that could possibly impact the macroinvertebrate and zooplankton communities was presented.

3.4 Assessment of Emergent Wetland Vegetation

Dr. Karin Kettenring and her team at Utah State University completed a detailed review of the literature to understand the vegetation, invasive plants, and nutrients as a driver of vegetation dynamics in Willard Spur (Downard et al 2013).

3.4.1 Key Findings

Detailed studies of the vegetation and habitat of Willard Spur do not exist within the literature, however the literature did confirm the important role that vegetation plays as part of the habitat and food web in ecosystems adjacent to and similar to Willard Spur. The literature indicates that Willard Spur may have a higher diversity of plant species than other GSL locations due to freshwater inflows. Inflow and water level fluctuations are important in determining the location, extent, condition, and expansion of vegetation in systems similar to Willard Spur. Extreme fluctuations in water levels can stress vegetation by changing the salinity and other aspects of chemistry of water and sediments and create conditions opportune for invasive species. Numerous invasive plant species are likely located within Willard Spur, however *Phragmites australis* is the most widespread. Monotypic stands of these invasive species displace native vegetation and the food sources they provide particularly to migratory birds, fragment the marshes, affect nesting habitat, and generally reduce the quality of the habitat and ecosystem services provided by the wetlands.

Several sources of GSL vegetation mapping were identified, however only the 2007 Ducks Unlimited and 2011 Utah State University GSL vegetation mapping projects provided readily useful data for Willard Spur. A consistent difference between datasets was simply an observed increase in *Phragmites* distribution between 2007 and 2011. The more recent 2011 USU dataset is provided at a one meter resolution, whereas the 2007 Ducks Unlimited dataset was done at a much more coarse resolution, making it difficult to precisely quantify the actual increase in *Phragmites* during this time period.

At the outset of this project there was concern voiced that the stand of *Phragmites* located adjacent to the old Outfall Ditch was a result of discharge from the Plant. Through analysis of historical data in the form of

satellite images of the site and first person accounts it was determined that the *Phragmites* stand was present in that location before the Plant began discharging to the Outfall Ditch in April of 2011. Nonetheless, the literature indicates that *Phragmites* is a high nutrient specialist and as such, performs particularly well in areas with elevated anthropogenic nutrient inputs that allow it to outcompete native species and spread more rapidly. There are findings that link nutrients to changes in the distribution of invasive species, however there are also other modifying factors that need to be better understand that also could impact the spread of invasive species, such as salinity, pH, natural inflows, temperature, etc.

3.4.2 Conclusions

Vegetation is a critical element that provides habitat and other ecosystem services in wetlands similar to Willard Spur. There are many factors that influence the condition and distribution of vegetation in Willard Spur, however freshwater sources, water level fluctuations, salinity, nutrients, and water depth likely play the most influential role. An observed increase in the distribution of invasive species such as *Phragmites australis* in Willard Spur is of concern. Further work is needed to determine the role water levels and nutrients play in the distribution of invasive and native plant species in Willard Spur.

Conclusions

The Willard Spur ecosystem appears to be a highly dynamic, complex, and resilient ecosystem. It contains a wide variety of habitat that changes significantly throughout the year, yet supports a very diverse population of flora and fauna. The habitat, flora and fauna found in Willard Spur are representative of, exhibit similar characteristics and responses, and face similar challenges as is found in other GSL wetlands.

Water inflows to and thus the water levels within Willard Spur are consistently observed as key drivers in the dynamics and composition of the communities observed in Willard Spur. Even while inflows result in significant seasonal changes and extremes in the ecosystem, the ecosystem exhibits a remarkable resiliency to these changes. Nutrient enrichment too is of concern, however these studies identified no direct link to the conditions observed as part of this project.

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