Farmington Bay Wetlands Progress Report:
Summary of Results and Additional Data needs

Introduction

There has been growing concern by waterfowl managers, scientists and citizen groups that the nutrient load from wastewater discharges along the Wasatch front may be exceeding the assimilatory capacity of the wetland and Farmington Bay ecosystems. This culminated in public comments on Utah's 303(d) list of impaired waters and questions as to why the DWQ had not included Farmington Bay on this list. This raised two important issues: 1) Historically, DWQ had not performed assessments on Farmington Bay and particularly on Farmington Bay wetlands; 2) Unlike the toxics program, there are no EPA-recommended water quality criteria for nutrients. Moreover, although EPA has suggested probably-based nutrient criteria for the nation's streams, there are no such recommendations for wetlands.

Nevertheless, in response to stakeholder comments DWQ applied for and received EPA grant money to begin developing assessment methods for wetlands. These methods are to be used for setting site-specific water quality standards for nutrients as well as perform 30(b)/303(d) assessments of Farmington Bay wetlands.

Notably, similar concern for the open-water portion of Farmington Bay has been expressed by stakeholders and EPA Region 8. Therefore, concurrent research focusing on understanding the open-water ecosystem has also been underway. For clarification, this report only focuses on Farmington Bay wetlands.

Study Design

This study focused exclusively on the fringe wetlands (i.e. impoundments and sheetflow wetlands that develop across the mudflats). These sheetflow wetlands are located near and below the meander line and are considered intermittent at average or above-average lake elevations. Much of the mudflats are inundated with salt water. This restricts wetland plant communities to a much narrower zone immediately surrounding freshwater inflows. Nevertheless, these two wetland types constitute the great majority of fringe wetlands.

Impoundments were created for the purpose of attracting and supporting waterfowl and are located in the delta of the major tributaries, including the Jordan, Bear and Weber rivers. These impoundments are shallow and generally occur in series where water is systematically "stepped" down from one pond to the next. Therefore, sampling sites were established along the successive ponds with the objective of measuring and assessing the biological response to the expected assimilation/decline in nutrients as water progressed from pond to pond. Accordingly, sampling sites were established in FB Wildlife management Area (FBWMA), Newstate Duck Club, Ambassador Duck Club and the Inland Sea Shorebird Reserve (ISSR) operated by Kennecott Utah Copper. Reference (control) impoundments were located in the Public Shooting Grounds Wildlife Management Area (PSG) located on the fringe of Bear Rive Bay. This included both impounded wetlands and sheetflow sites identified downstream in water that is released by these impoundments.

Similarly, sheetflow sampling sites were established along longitudinal transects leading from the discharges of Central Davis and North Davis Sewer Districts and along the flows leading from the final impoundment (Turpin Unit) of FBWMA. Again, we hypothesized that, as the nutrient-rich water passed across the mudflats, there would be measurable attenuation of nutrients.

In addition to measuring water column nutrients, we measured pH, dissolved oxygen, conductance, temperature and sediment nutrients pH, organic carbon, and conductance. Biological parameters included plant species composition, native vs. non-native, density, stem height and tissue CNP ratios; Macroinvertebrate species composition and classification as to tolerance to organic/nutrient enrichment, pH, DO and salinity; Measures of shorebird population health including nesting habitat, nesting success, hatching success, diet and dietary preference (food item availability vs. actual stomach contents) for American avocets and black-necked stilts.

Results − Nutrient Dynamics

There were two major observations concerning water quality:

1. Except for stations very near the POTW discharges, all sampling sites exhibited severe nitrogen limitation. (i.e. phosphorus was in great abundance for plant growth relative to nitrogen and carbon). Indeed, in many of the impoundments, N was undetectable (<0.05 mg L^{-1}).

2. Contrary to our hypothesis, a nutrient gradient only occurred in the Ambassador Duck Club complex and to a lesser extent, in the Newstate Duck Club complex. Attenuation in these ponds is attributed to relatively much longer retention times than other impoundment systems. Throughout the other locations, there was only a slight decrease in water column phosphorus. Among the sheetflow sites, there was rapid attenuation in nitrogen but virtually no attenuation in P. P concentrations remained within about 20% of those found in the upstream locations. This lack of nutrient attenuation is attributed to saturation of nutrient uptake potential by wetland vegetation and to saturation of binding sites in the sediments. Our sediment samples contained 400 to 1200 mg kg^{-1} total P. Most notably, biologically available (soluble) P ranged from 10 to 80 mg kg^{-1} in the sediments. This readily available supply of P indicates that P concentrations between water and sediments are at equilibrium and explains why water column concentrations remained elevated (0.4 to 4 mg L^{-1}) throughout the transects.

Results − Macroinvertebrates

Macroinvertebrate community structure aligned very well with observations described in the scientific literature. Tolerant taxa were dominant in the nutrient-rich sites (both impoundments and sheetflow sites) while sensitive taxa were found in the reference impounded and sheetflow sites. The distribution of these taxa was aligned with gradients in pH and to a lesser extent to the dissolved oxygen gradient. Several species of invertebrates and one of the reference site plant species responded negatively to pH > 9 to 9.5, suggesting that our freshwater pH standard of 9.0 may be applicable in wetland systems.

Results − Plant Communities

In the sheetflow sites, the two major metrics, species richness and number of invasive species were opposite of traditional wetland ecological dogma. The lowest plant diversity occurred in the most nutrient-enriched sites and also in the reference sites. Similarly, the number of invasive species was lowest in the most nutrient-enriched sites and in the reference sites. This would suggest that the moderate nutrient levels (0.08 to 0.3 mg L^{-1} P) are optimal for plant diversity, but these conditions are the most conducive to invasive species as well. There was also substantial evidence that the degree of "invasion" is also dependant upon other factors such as physical disturbance from grazing or hydrologic interruptions.

Because the impoundments are intensively (and successfully) managed to grow sego pond weed (*Stuckenia filiformes*), there was very little plant diversity in these ponds. However, although these ponds are dominated by this single species, there was notable variability between ponds and particularly between seasons. Early-season sampling revealed a high percentage (>75%) of bottom was covered at all of the targeted (nutrient-enriched) sites, with the notable exception of unit 1 of the FBWMA. Yet, by August, percent coverage generally dropped to about 40% and by November, percent coverage dropped to < 15%. For comparison, the upper reference pond in PSG remained near or above 80% coverage throughout all three sampling seasons and the middle and lower ponds of PSG retained about 50% coverage by November.

There are three possible explanations for the observed decline in the targeted (nutrient-enriched) sites: (1) There was observed surface mats of filamentous algae or duckweed that rapidly developed during mid-summer and these mats effectively shaded the submerged aquatic vegetation; (2) There may be sufficient P in the water column to actually stress the Stuckenia and impede growth; and (3) Early arrival of sufficient numbers of waterfowl and their subsequent foraging on Stuckenia reduces the biomass and density.

Because the reference ponds and PSG did not experience similar declines, we believe that waterfowl foraging is the least important factor in this observed decline. However, careful bird counts across reference and target sites are necessary to confirm this hypothesis. Alternatively, the greatest density of algae and duckweed surface mats appeared to be associated with ponds that contained the highest nutrient concentrations. Similarly, through extensive literature review we have discovered two papers that address P-induced stress on submerged vegetation. This stress includes increased phosphotase (an enzyme involved in the metabolic control of P) activity and concomitant reductions in stem height. The onset of this stress response occurred at 0.2 to 0.4 mg L^{-1} total P. Ultimately, it appears likely that a large quantity of this essential forage species may be lost before the majority of waterfowl populations arrive at Farmington Bay. This brings into question whether these impoundments are excessively enriched (causing premature senescence) and whether Stuckenia biomass could be improved during the critical fall staging period.

Results − Shorebird Studies

Shorebird studies were performed to provide a direct assessment of the designated beneficial use for Great Salt Lake of "Support for Waterfowl and Shorebirds and the aquatic life in their food

chain". Study objectives included a description of nesting habitat and measurement of nesting success, hatching success and prey item selection. These studies were performed in the sheetflow environments.

Results indicate that nest site preference included early stage (low stem height with generally <75% ground cover) communities of pickle weed (*Salicornia sp.*), or alkali bulrush (*Schoenplectus maritimus)* and close proximity (generally < 30 m) to surface water. These conditions were common in the sheet flow sites at the outfall of the Turpin Unit of FBWMA and even in the vicinity of Central and North Davis SD discharges. Nesting and hatching success were consistently between 93% and 96%. These are similar values to those measured in Bear River National Bird Refuge, and both of which are among the highest success rates ever measured in the US.

Equally notable, preferred forage items for both American Avocets and black-necked stilts are midge larvae and water boatmen (family Corixidae). These taxa are tolerant of organic/nutrient-enriched waters and were the most ubiquitous among all of our sampling sites. Conclusions from this study, thus far, indicate that shorebird populations and the aquatic life in their food chain, in these sheetflow wetlands, are being fully supported.

However, a final study to complete this effort is warranted. This study would include tracking the survival of hatchlings through the period to where they achieve flight and thereby can avoid predators. The sensitivity of this period in their life history is second only to hatching success as it requires the additional unique habitat of taller and denser stands of emergent vegetation, as compared to nesting habitat, for essential cover. This cover also needs to be adjacent to surface water that supplies the macroinvertebrate populations for their diet. This would complete a thorough assessment of all of the life history stages of these shorebirds that occur in Great Salt Lake wetlands.

Summary of Additional Research Needs

In order to complete the wetlands assessment methods development program, leading to site-specific nutrient standards for Farmington Bay sheetflow and impounded wetlands, the following studies are recommended:

1. **Plants/sediments and macroinvertebrates analyses** to measure and clarify the relative importance of shading, waterfowl foraging and potential stress from excess P in the impounded wetlands.

2. **Nesting habitat quality study** to quantify nesting habitat characteristics in relation to plant communities and proximity to surface water.

3. **Shorebird juvenile survival study** to quantify shorebird juvenile survivability and link this to habitat and food resource requirements.