Monitoring and Research Performed in the Impounded Wetlands and Outflows Of Farmington Bay Waterfowl Management Area

2018 Update and Summary

Summary Report to
Utah Division of Wildlife Resources

By

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Introduction and Background

In 1998, the Utah Division of Water Quality listed the Lower Jordan River on the 303(d) list as impaired for dissolved oxygen. Elevated nutrients were initially suspected to be the cause. Shortly thereafter, members of the conservation and environmental communities complained to DWQ management that nutrients could be impairing Farmington Bay and its wetlands. However, neither Farmington Bay or the wetlands were being assessed for beneficial use support. These beneficial uses include support for waterfowl and shorebirds and the aquatic life in their foodchain. Concern about the support status prompted the initiation of a long-term program to understand the ecological health of impounded wetlands within the WMA and many duck club impoundments and more importantly, identify an assessment methodology with which to perform a beneficial use assessment. With sparse information on wetlands assessments methods, the focus for the first several years was on developing appropriate methodology that is both sensitive and reflective to meaningful measures that can assess the level of support for the beneficial uses of these impoundments.

One of the central concerns for these wetlands was the relatively high concentrations of nutrients delivered to the impoundments from the Jordan River and State Canal. As such, one of the visible concerns and focus of our initial studies was the frequent surface mats of *Chladophora*, a filamentous green alga, or *Lemna minor* (duckweed), a floating macrophyte that occasionally develop on the impoundments during midsummer. Other observations of concern were that the submerged aquatic vegetation (SAV; mostly comprised of *Stuckenia sp.* or sego pondweed), began to senesce earlier in the fall (late August), in some ponds than in others. We initially postulated that these surface mats and situations of early senescence may be tied to excess nutrients and much of our research for the first several years focused on testing this hypothesis. A large part of testing this hypothesis, however, required the development and testing quantitative metrics that are sensitive to excess nutrients or other potential stressors such as elevated pH, low dissolved oxygen or sediment metal concentrations. This included testing several measures of plant health and basic impoundment characteristics and comparing these measures to possible environmental stressors. These metrics initially included Percent cover (to the nearest 1%; visual aerial estimates at mid-canopy of the SAV), presence of epiphytes, and/or macroalgae on the SAV, percentage of impoundment surface covered by duckweed or *Chladophora*, species composition, biomass of tubers and drupelets were also determined as a measure of reproductive potential, Light penetration and attenuation through the water column and SAV canopy and branch density of SAV shoots as a measure of plant health and growth and as an early indicator of the onset of senescence.

In addition to these measures of biological condition or health, Dr. Hoven, Currently with The Audubon Society assessed several physical variables across 15 different impoundments including average pond depth, rate of pond filling during spring, length of period the impoundment was allowed to dry, if any, the previous year, hydraulic residence time, location or order of the impoundment relative to other impoundments in the series or landscape and length of the inflow channel if any, and whether this channel is populated with emergent of submerged vegetation.

In brief, with one exception for one impoundment, none of these sensitive biological metrics were statistically related to nutrient concentrations. The one exception included a slight reduction in drupelet biomass that was correlated with elevated phosphorus concentrations. However, this reduction also covaried with elevated metal concentrations in the sediments – indicating that the exact cause of the reduction in drupelet biomass density could not be determined. In many other cases, sediment concentrations of one or more toxic metals were associated with decline in drupelet density, branch density, early senescence and tuber density. Overall, these data suggest that legacy sediment metal concentrations, likely as a result of historic smelters located along the Jordan River, pose the greatest risk for decline in SAV plant health.

This research also found that the occasional surface mats observed on impoundments within the Farmington Bay WMA and other duck club impoundments were not statistically related to higher nutrient concentrations. Moreover, these mats were not found to impede the underlying SAV, even though dissolved oxygen concentrations were often lower underneath these mats than at similar depths in mat-free areas of the respective impoundments. Further, these surface mats were not found to negatively impact macroinvertebrate communities. Rather, in many cases, densities of phytophilus macroinvertebrates (waterfowl and shorebird food) were actually greater because of the additional habitat offered by the surface mats.

The first 12 years of this program culminated in a report by Hoven and Richards (2015) that suggests management strategies based on plant metrics and pond configuration which is widely used by WMA and duck club managers alike.

Current Monitoring Objectives

Since 2015, the monitoring effort by the WFWQC has focused on two primary objectives:

1. Understanding and quantifying nutrient dynamics and diel patterns of dissolved oxygen (DO) and pH and nutrient fluxes from sediments
2. Quantifying outflow nutrient concentrations and flows in order to improve the overall nutrient budget for Farmington Bay.

Methods

Nutrient Dynamics

Unit 2 of the FBWFMA, Pond 47 and Pond 1 in Ambassador Duck Club were sampled each month from May to October throughout the summer. The focus was on monitoring diel patterns of nutrients, temperature, pH, DO and EC. Temperature, pH, DO and EC were measured using an In-Situ multi-probe data recording sonde. Measurements were recorded every 3 hours. Concurrent water samples for ortho-P, ammonia, nitrate sulphate, and hydrogen sulfide were analyzed using Chemetrics field spectrophotometric methods. This system utilizes an adaptation of appropriate EPA Standard Methods for analysis.

Farmington Bay Nutrient Budget

Flows and nutrient concentrations have been measured in all important outfalls and tributaries to Farmington Bay on a monthly schedule. This has included all Turpin Unit culverts, the bypass canal, both outfalls from Unit 1 and the Northwest Oil Drain. Each sampling event included measuring flows and the nutrients, ortho-P, nitrate and ammonia.

Results

Farmington Bay Nutrient Budget

Releases from Unit 1, the Turpin Unit and the NW Oil Drain constitute a significant contribution to the water and nutrient budgets of Farmington Bay. The following tables include a summary of flow and nutrient concentrations and estimated loadings to Farmington Bay for 2018. This data constitutes three years of nutrient loading data to Farmington Bay. Of key interest are1) the ultimate fate of nutrients with respect to water column concentrations duration/distance travelled through the Bay, 2) sediment concentrations dynamics of nutrient ratios and their relationship to phytoplankton species relative abundance,3) cyanobacteria blooms and zooplankton species relative abundance and benthic macroinvertebrate species presence and relative abundance. The state of these conditions will receive considerable analyses and assessment in a forthcoming document.

Table 1. Summary of flow and nutrient concentrations discharged from the Turpin Unit, Unit 1, the Bypass Canal and the Oil Drain within Farmington Bay Waterfowl Management Area during 2018.

Turpin Unit Total				
	Flow (m^3)	Ammonia (mg/L)	Nitrate mg/L)	ortho-P mg/L
Average Flow/concentrations	1.65	1.126666667	0.15	0.1287
Annual Volume (m^3)	42816559.07	32073970.39	32073970.39	32073970.39
Total Load		36136673.3	4811095.55	4127919.98
Load (kg)		36136.67	4811.09	4127.91
Metric tons		36.13	4.81	4.12

Table 1. Cont.

Unit 1 North Outfall

Date	Flow (m^3/s)	Ammonia (mg/L)	Nitrate (mg/L)	Phosphate (mg/L)
	0.237	1.98	0.02	0.21
6/11/2018	0.311	1.01	0.03	0.12
7/19/2018	0.095	0.65	0.02	0.10
8/20/2018	0.152	0.53	0.03	0.01
9/5/2018	0.309	0.53	0.03	0.01
10/3/2018	0.109	0.71	0.01	0.07
Mean Flow/Concentration	0.20	0.90	0.02	0.08
Annual Volume	5247956.47	5247956.47	5247956	5247956.47
Load		4731907.42	122452.3	440536.79
Load (kg)		4731.91	122.45	440.54
metric tons		4.73	0.12	0.44

Unit 1 South Outfall

Date	Flow (m^3/s)	Ammonia (mg/L)	Nitrate (mg/L)	Phosphate (mg/L)
5/22/2018	1.05	5.98	0.05	0.07
6/11/2018	0.31	1.32	0.03	0.03
7/19/2018	0.26	0.92	0.03	0.01
8/20/2018	0.14	0.63	0.03	0.00
9/5/2018	0.12	0.59	0.03	0.00
10/3/2018	0.78	1.33	0.03	0.06
Mean Flow/Concentration	0.44	1.80	0.03	0.03
Annual Volume (m^3)	11492247.14	11492247.14	11492247.14	11492247.14
Load (g m^{-3})		20628583.61	383074.90	335820.70
Load (kg)		20628.58	383.07	335.82
Metric Tons		20.63	0.38	0.34

Table 1. Cont.

Bypass Canal

	Flow (m^3/s)	Ammonia (mg/L)	Nitrate (mg/L)	Phosphate (mg/L)
43242.00	0.22	1.12	0.14	1.06
43262.00	0.21	1.19	0.45	0.42
43300.00	0.19	0.84	0.54	0.27
43332.00	0.27	0.93	0.34	0.34
43348.00	0.30	1.10	0.59	0.44
43376.00	0.09	0.65	0.03	0.04
Average Flow/concentrations	0.21	0.97	0.35	0.43
Annual Volume	6668187.76	6668187.76	6668187.76	6668187.76
Total Load		6479255.77	2322752.07	2856207.09
Total Load (kg)		6479.26	2322.75	2856.21
Metric Tons		6.48	2.32	2.86

Oil Drain

Date	Flow (m^3/s)	Ammonia (mg/L)	Nitrate (mg/L)	Phosphate (mg/L)
5/22/19	2.45	1.97	7.50	1.69
6/22/18	2.24	0.84	4.92	1.86
7/7/18	2.61	5.13	6.75	1.99
8/20/18	2.50	8.41	2.25	1.94
9/5/18	2.44	3.99	14.76	2.03
10/3/18	2.82	5.53	13.24	1.45
Average Flow/concentrations	2.61	4.31	8.24	0.55
Annual volume	82327145.76	79173545.76	79173545.76	79173545.76
Total Load		214921325.75	341369938.14	43545450.17
Total Load (kg)		214921.33	341369.94	43545.45
metric tons		214.92	341.37	43.55

Diel Patterns of Nutrient Concentrations in the Impoundments

During 2018, diel measurements of nutrients (ammonia, nitrate, ortho-P), and field parameters (DO, pH, temperature and conductance) were performed on a monthly schedule. The dynamics of these parameters reveals important aspects of environmental stressors such as DO, pH and temperature. Similarly, the more-subtle aspects of nutrient dynamics can be connected to plant health, as well as the presence and ability of important microbial communities to process or assimilate P and particularly N. In short, microbial communities are known to be sensitive to various toxics such as heavy metals, low DO, high or low pH and H_2S. Therefore, transformations and attenuation of nutrients that are mediated by microbes can be an important measure of the condition and functionality of the impoundments as influenced by potential contaminants in the water column. Toward this end, we have measured nutrients and other important chemical parameters in the lower Jordan River, the State Canal and the impoundments that directly receive this water. This included measuring diel patterns of nutrient concentrations. Variations might occur as a result of sediment releases due to diel patterns of DO or pH. For example, as DO approaches 0.0 mg/L at the sediment surface, ortho-P^{---} can be released to the water column from iron as Fe is reduced from Fe^{+++} to Fe^{++}. In addition, denitrification of NO_3 to N_2 can occur in a reducing environment, which would result in removal of NO_3 from the water column. Yet such sediment releases of ortho-P were not apparent as DO approached zero mg/L (Figure 1, 2, 3 and 4) for Ambassador 1 and Figures 5, 6, 7 and 8 for FBWMA Unit 1. Perhaps more notable, nitrate concentrations always remained extremely low indicating continual denitrification and loss of N_2 to the atmosphere.

Ammonia, a product of decomposition of amino acids and other nitrogen-containing organic molecules such as urea, did increase concurrently with the decrease in DO in Ambassador 1 during the June sampling effort; however, ammonification can occur anaerobically or aerobically. Moreover, as a gas, ammonia can be released slowly, by simple diffusion or by ebullition from “pockets” of high concentrations of ammonia in the sediments. In addition, ammonification occurs at higher rates than nitrification (Kadlec and Knight 1996). Treatment Wetlands. CRC 893 pp), which does require the consumption of oxygen. Hence, the very low concentrations of nitrate, an oxygen-consuming process, that suggests a healthy community of denitrifiers as well as overall adequate supplies of free oxygen to feed aerobic processes. Abundant communities of both nitrifiers and denitrifiers has been documented by DNA analyses in Dr. Ramesh Goel’s lab at the University of Utah.

Overall, and over the years of monitoring nutrient concentrations in the water column and in water discharged from Turpin Unit, ammonia consistently remained between 0.4 to 0.7 mg/L while nitrate remained between 0.01 to 0.08 mg/L, despite the ammonia concentrations in the source water. For example, ammonia concentrations at Burnham Dam and other sites upstream in the Jordan River are consistently 0.2 to 0.5 mg/L, while ammonia at the end of the State

Canal, is consistently between 1.5 and 3 mg/L (Table 2). Yet concentrations in the water column between Ambassador 1 and FBWFA Unit 1 are quite similar, generally in the range of 0.6 to 1 mg/L (Figures 1, 2, 5, 6). This data suggests a large rate of ammonification, from internal decomposition of organic matter (e.g. higher ammonia in Ambassador 1 than at river sites; and yet additional nitrification and denitrification in FBWMA Unit 1, which brings ammonia levels down to the 0.6 to 1.0 mg/L, as well as an overall loss of nitrogen by denitrification (e.g. nitrate in both impoundments is very near 0.0 mg/L). Denitrification led to an overall large loss in total inorganic nitrogen as the controlling process in the nitrogen dynamics of these impoundments. Finally, the internal production of ammonia sustains a normal (Redfield) N:P ratio in the impoundments. In turn, this explains why, over more than a decade of monitoring, no blooms of nitrogen-fixing or toxin-producing cyanobacteria have been observed in the impoundments. These measurements and responses indicate that the microbial, as well as the macrophyte communities, remain healthy and productive and continue to perform favorable ecological processes.

In addition, comparison of ortho-P measurements between Ambassador 1 and FBWMA Unit 1, and the river sites, indicate a dramatic reduction in the reactive form of P in the impoundments. Together with the nitrogen transformation data, this is strong evidence that these wetlands continue to perform one of the most important functions of any healthy wetland -the cycling and removal of nutrients and support of higher trophic levels.

Figure 1. Diel patterns of various nutrient concentrations in Pond 1 of Ambassador Duck Club, June, 2018.

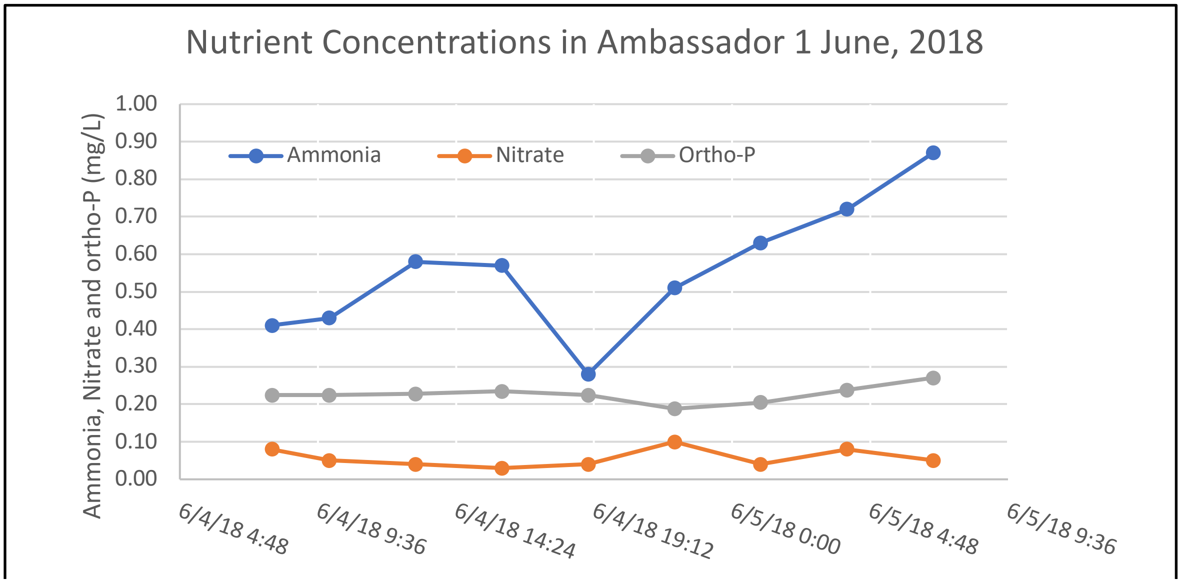


Figure 2. Diel patterns of various nutrient concentrations in pond 1 of Ambassador Duck Club, July, 2018.

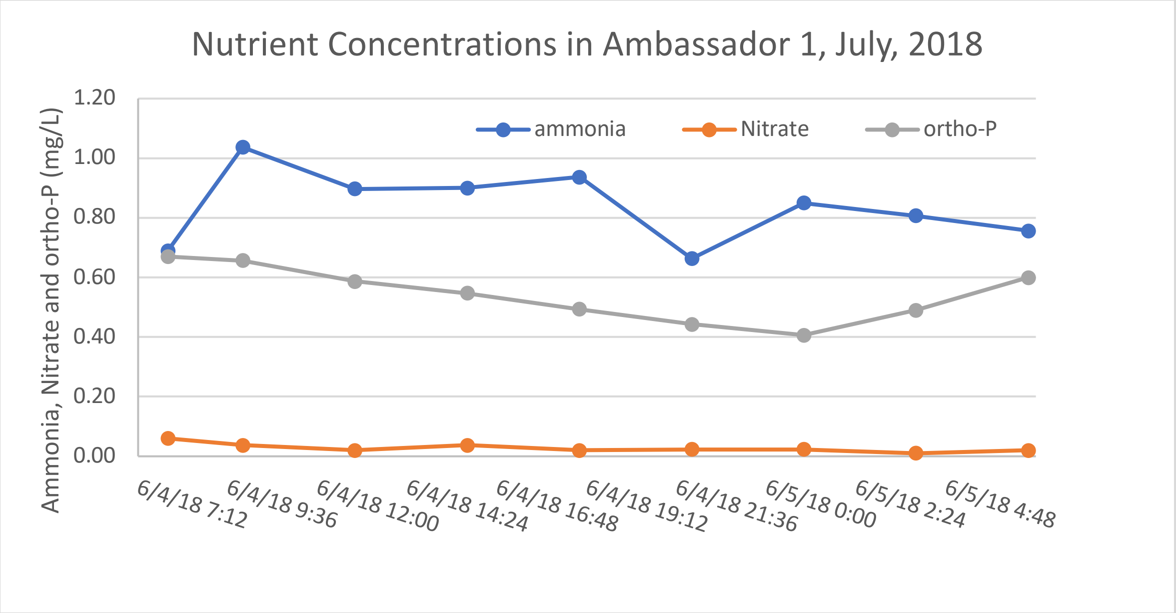


Figure 3. Diel patterns of DO, temperature, and pH in pond 1 of Ambassador Duck Club, June, 2018.

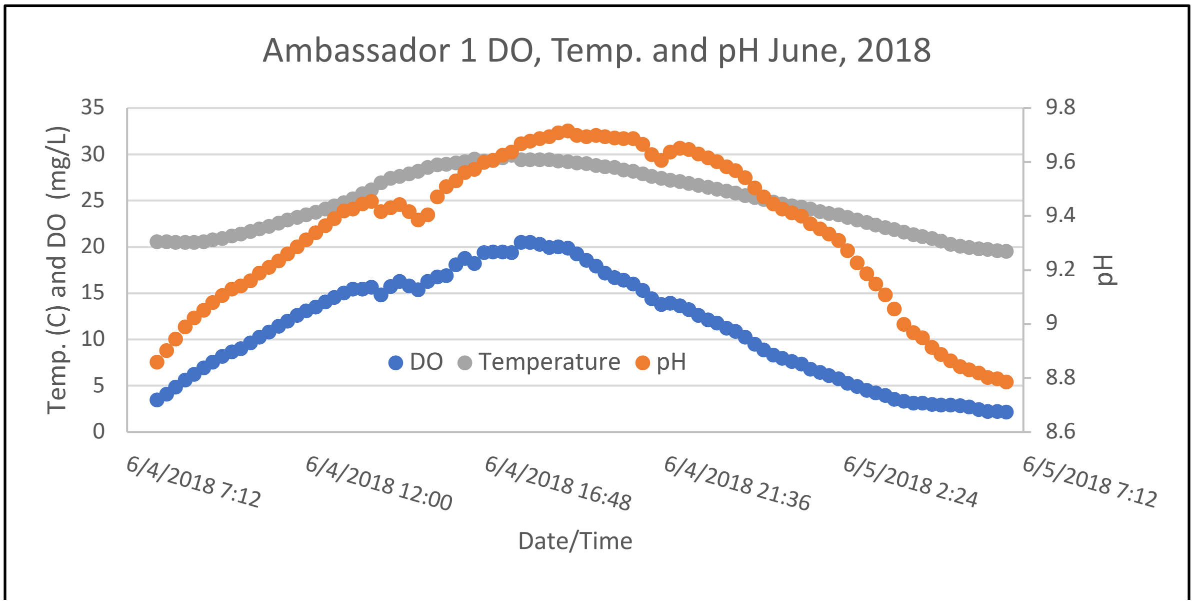


Figure 4. Diel patterns of DO, temperature, and pH in pond 1 of Ambassador Duck Club, July, 2018.

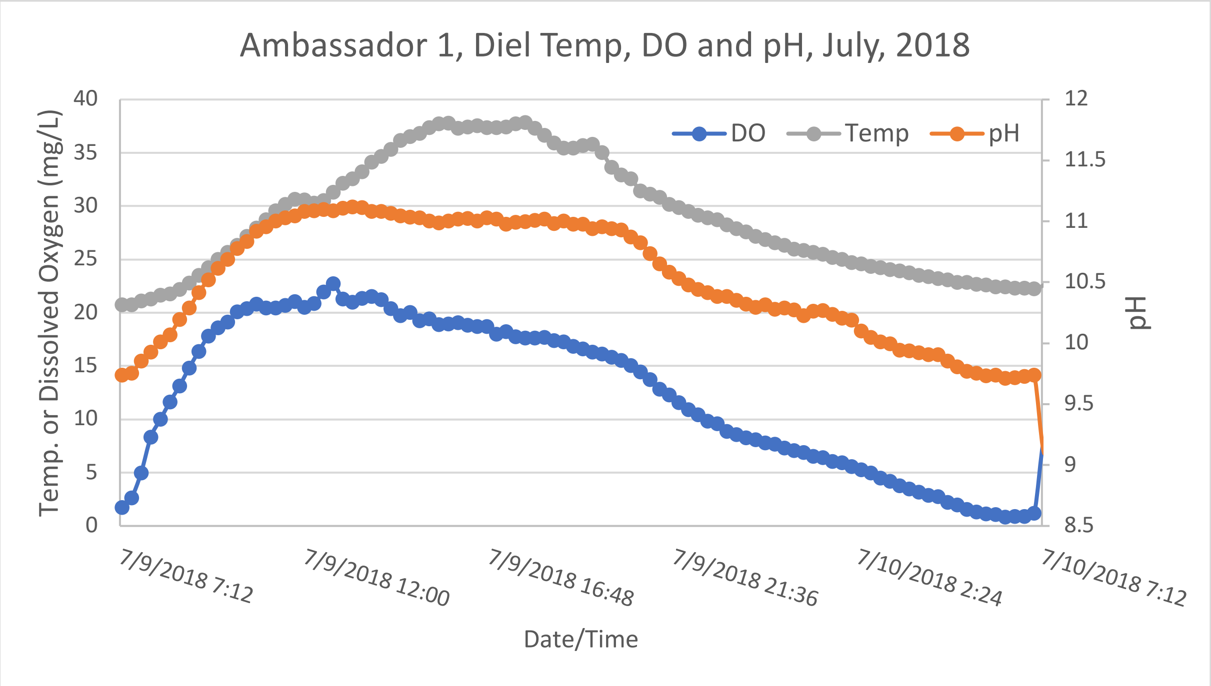


Figure 5. Diel patterns of various nutrient concentrations in Unit 1 of FBWMA, June, 2018.

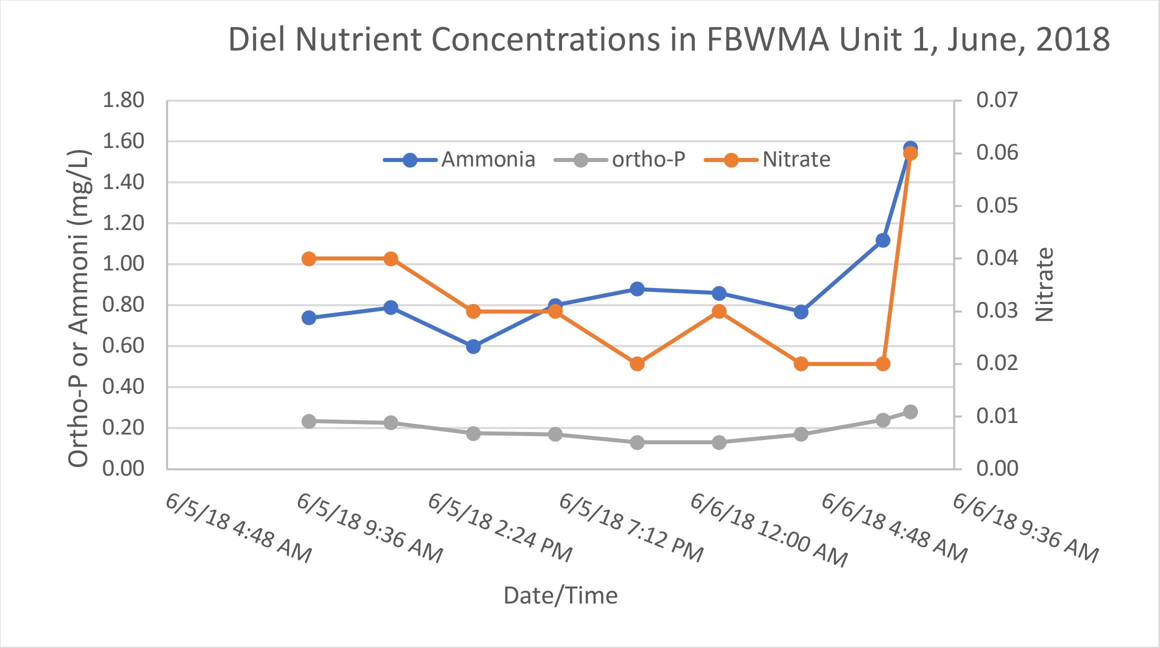


Figure 6. Diel patterns of various nutrient concentrations in Unit 1 of FBWMA, July, 2018.

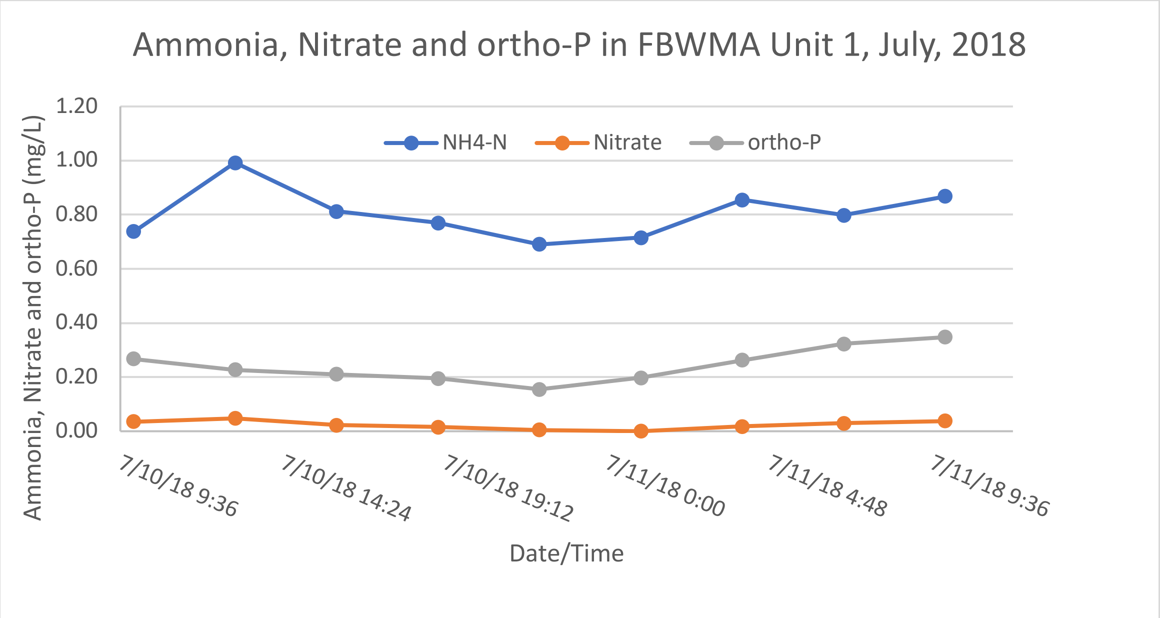


Figure 7. Diel patterns of DO, temperature, and pH in Unit 1 of FBWMA, June, 2018.

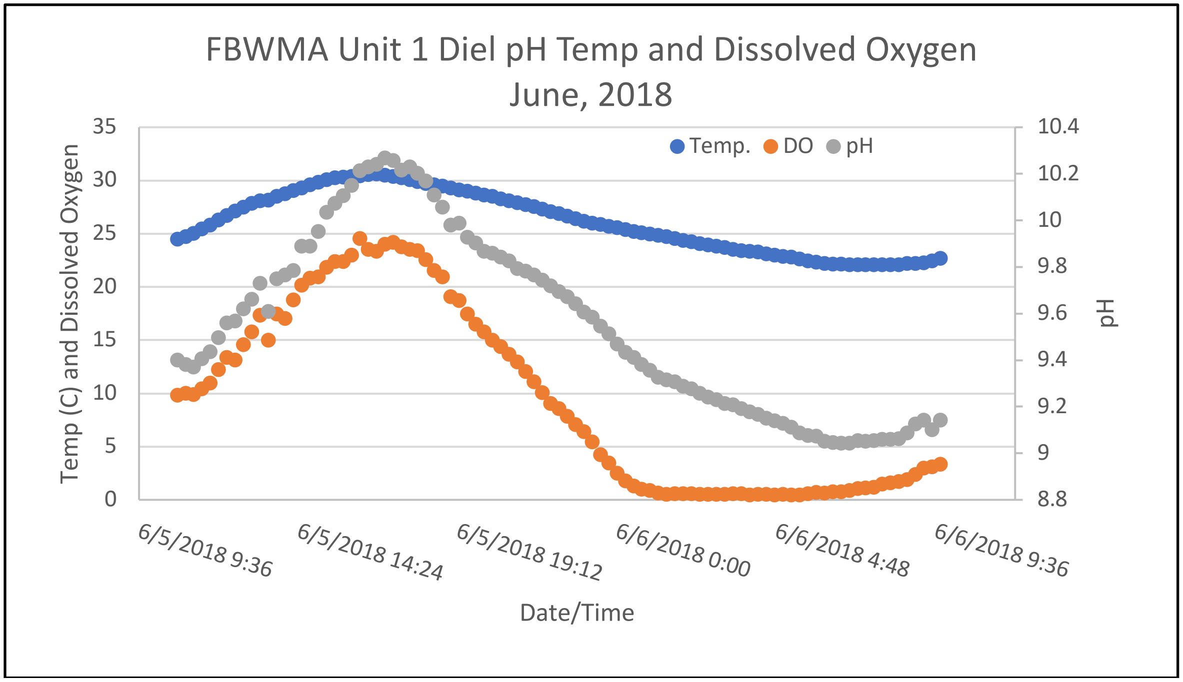
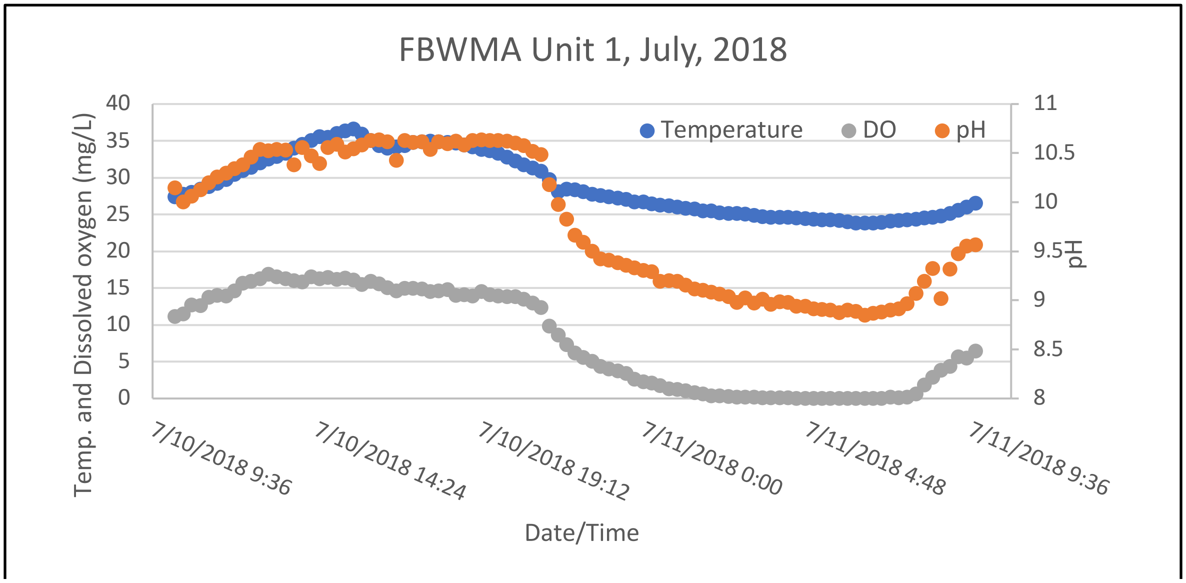


Figure 8. Diel patterns of DO, temperature, and pH in Unit 1 of FBWMA, July, 2018.



Average Annual Nutrient concentrations at Burnham Dam, 2017			
Ammonia	Nitrate	0rth-P	Total P
0.31	3.82	0.64	0.69

Average Annual Nutrient concentrations at End of State Canal, 2017			
Ammonia	Nitrate	0rth-P	Total P
2.72	4.17	0.65	0.89

Future Research and Monitoring

The 2019 field season will include continued monitoring of the flows and nutrient loads entering Farmington Bay from the various sources within the FBWMA. Additional monitoring is essential in order to understand seasonal as well as annual variability in these important parameters and how their dynamics influence the phytoplankton community, including the cyanobacterial blooms in the open water of Farmington Bay. In addition, we will continue to monitor the physical/chemical conditions of the impoundments, both in the interest of knowing nutrient concentrations in addition to assuring the long-term health and function of the wetlands in the context of meeting beneficial uses.

Literature Cited

Hoven, HM and DC Richards. 2015. Plant metric-based management strategies that can improve beneficial uses of Great Salt Lake impounded wetlands. Report to Wasatch Front Water Quality Council.

Kadlec RH and RL Knight. 1996. Treatment Wetlands. CRC 893 pp.