2022 Annual Self-Monitoring Report
Don Edwards San Francisco Bay National Wildlife Refuge
Fremont, California

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Introduction

The South Bay Salt Pond Restoration Project (Project) 2022 Annual Self-monitoring Report on Water Quality has been prepared to provide an overview of the Projects effects on water quality and habitat suitability of managed ponds due to management and restoration activities. This report includes: 1) Water quality results from the U.S. Fish and Wildlife Service (Service) Site Specific Protocol for Monitoring of South Bay Ponds (in draft), 2) A summary of the Project's Phase 2 progress during 2022 and 3) A summary of 2022 Refuge Operations and Maintenance activities, and 4) Update on research happening on managed ponds.

This annual report is designed to meet California Regional Water Quality Control Board (RWQCB) permitting requirements for a water quality self-monitoring plan as described in R2-2018-0020, Findings 9, & 111-113, as well as South Bay Salt Pond Restoration Project Phase 2 Monitoring Plan and Water Quality Self-monitoring Program for Refuge Lands (C. Strong & Underwood 2018), which was prepared as part of the compliance with RWQCB's permitting requirements. This Report will also be submitted to NOAA's National Marine Fisheries Service (NMFS) per the Project's Phase 2 Biological Opinion, WCR-2017-6803.

It is anticipated that both water quality and fisheries information will help the RWQCB and NMFS: 1) understand the status of the Project; 2) provide feedback and guidance to the Project Management Team on current and future applied studies and monitoring; and 3) assist in identifying emerging key uncertainties and management decisions required to keep the Project on track toward its restoration objectives as we implement Phase 2.

Background

The South Bay, before industrialization, was a rich mosaic of habitats that supported vast amounts of wildlife. The marshes, natural salt pannes, sloughs, and mudflats that made up the tidal zone were diked and flooded to concentrate the salty bay water into evaporation ponds where the salt was then harvested. By the middle of the last century, over 90% of the South Bay had been converted into commercial salt production ponds. The South Bay has always been an important place for wildlife and while the drastic reduction in marsh coverage led to the decline of many species that rely on it, the now large open expanses of water had a beneficial effect on many water bird species. The South Bay hosts over one million shorebirds annually and is a key stop for migratory bird species along the Pacific flyway.

In the present day, tens of thousands of acres of decommissioned commercial salt ponds have been purchased and are managed by the Service as part of the Don Edwards San Francisco Bay National Wildlife Refuge (Refuge). The Refuge, working as a partner in the collaborative South Bay Salt Pond Restoration Project, aim to restore 15,100 acres of the ponds in the South Bay to a mix of wetland habitats. While many of the former salt pond will be restored to tidal marsh, some will be managed as ponds and enhanced for waterfowl and shorebirds. To ensure these managed ponds remain beneficial habitat, the Service monitors, among other things, the water quality in the ponds.

Site Specific Protocol for Monitoring of South Bay Ponds (Service 2021, in draft)

Objectives

The **management objectives** for the ponds at the Refuge, as identified in the Natural Resource Management Plan for the San Francisco Bay National Wildlife Refuge Complex (NRMP, USFWS 2019) and draft Managed Pond and Managed Wetland Operation Plan (USFWS 2022) are:

- Most ponds managed to circulate bay waters while maintaining discharge salinities (permit requirement) to the Bay at less than 40 parts per thousand (ppt).
- Maintain a mix of shallow (0-0.4 meter) and deep (0.4-1.5 meter) water levels in ponds to support dabbling ducks, diving ducks, eared grebes, terns, and shorebirds that allow for a variety of foraging depths across ponds while still maintaining the integrity of the levees to prevent erosion and over-topping.
- Maintain pond A15 at higher salinity level to promote brine shrimp and brine fly production for foraging waterbirds such as eared grebes.
- Regulate water levels in some ponds (including A22, SF2 Unit 3, R3) as seasonal ponds to reduce vegetation by flooding and drying to provide for nesting habitat on the pond bottom, exposed islands, and interior levees.

In addition to these management objectives outlined in the NRMP, the California RWQCB has implemented requirements for the discharge of pond waters into adjacent creeks and sloughs that lead to the bay. The main parameters of concern for pond discharge are salinity, metals, dissolved oxygen, pH, and temperature. Water Quality Standards for each parameter are outlined in RWQCB permit R2-2018-0020 Sections 67-79.

The **sampling objectives** for the ponds at the Refuge are:

- Detect with 95% Confidence that the discharges of ponds A8, A14, A16, A2W, A3W, SF2, & R5/S5 do not exceed water quality standards as outlined in RWQCB permit R2-2018-0020 and Basin Water Plan objectives.

- Detect that surface pond levels are being maintained per the pond operations plan to meet habitat requirements for dabbling ducks, diving ducks, eared grebes, terns, and shorebirds.

- Detect that Water Control Structures (WCS) are functioning as intended to circulate bay waters through the ponds in a way that maintains nominal water quality conditions.

- Detect any adverse environmental conditions such as Harmful Algal Blooms (HAB), anoxic events leading to fish mortality, avian influenza, and avian botulism.

This set of sampling objectives will help Refuge staff understand the effectiveness of management strategies used to meet pond management objectives identified in the NRMP, as well as meeting RWQCB permit standards.

Methods

Water quality measurements are taken monthly, from approximately June-October, at pre-determined locations (blue icons on map) throughout the pond complexes (Figure 1), using a YSI proDSS multimeter. The YSI ProDSS records barometric pressure, pH, dissolved oxygen, salinity, and temperature. Data on the Multimeter is timestamped and matched to sampling locations. Each measurement is taken twice and results are averaged.

Results

Water quality measurement data and pond function information is presented below for each pond/pond system and compared to RWQCB standards. References to "permit requirements" refer to RWQCB standards. Measurements were taken at Water Control Structures (WCS) as well as Collection Points (CP) on the pond perimeter. Results for discharge locations at A8, A14, A16, A2W, A3W, and SF2 are included in Figure 2 and Table 1. All data collected during monthly water quality monitoring sampling, including discharge locations and pond CPs, can be found in Appendix 1.

Alviso Unit: Pond A8 Complex

The Pond A8 Complex consists of Ponds A5, A7, A8N, and A8S (Figure 3). This complex is operated to maintain muted tidal circulation through the ponds while maintaining discharge salinities to the Bay at less than 40 ppt. As part of the Phase 1 initial actions, a 40-foot armored notch with multiple bays that can be opened and closed independently at A8 and Alviso Slough was installed. In May of 2017 all 8 bays were opened year round. Ponds A5, A7 and A8 are identified as tidal habitat in the long-term programmatic restoration of the Project. The water control structures at both A7 and A5 from Alviso Slough and Guadalupe Slough respectively, have failed and intake water at high tides (cannot be fully closed). These structures are in need of repair; however, the Service has not identified funds to repair them at this time. Valley Water and partners (including the Service) are in the scoping phase for the Calabazas/San Tomas Aquino Marsh-Creek Connection Project which include several potential alternatives that will breach Pond A8 Complex to restore full-tidal exchange.

Salinity and pH levels in the Pond A8 Complex were below 40 ppt and 8.5 threshold, respectively, set for pond discharges by the RWQCB and DO fluctuated between 3.4 and 8.0mg/L throughout the 4 month sampling window (Figure 2a and Table 1).

Alviso Unit: A14 Pond Complex

The Pond A14 system consists of Ponds A9, A10, A11, A14, and Ponds A12, A13, and A15 (Figure 3). The objectives of the Alviso Pond A14 systems are to: 1) maintain full tidal circulation through ponds A9, A10, A11 and A14, while maintaining discharge salinities to Coyote Creek at less than 40 ppt; 2) maintain ponds A12, A13 and A15 as higher salinity ponds and operate at 80 – 120 ppt salinity during summer to favor brine shrimp development, as possible. Ponds A10, A11 and A14 all have significant internal levee breaches allowing the water to mix, while Pond A9 has an intake structure and a WCS into A10. In addition to discharge measurements, several Collection Points were established in the A9-A14 (Appendix 1 and Figure 3). The A9 WCS was replaced in 2021 and is functioning properly. The A14 WCS remains inoperable, allowing 2 way flow and is scheduled for repairs in 2023. Due to construction for the South Bay Shoreline Project, ponds A12 and A13 batch ponds were managed for shallow water, while A15 was managed dry for snowy plovers. In 2022, salinity and pH levels at the Pond A14 discharge were below 40 ppt and 8.5 threshold, respectively, set for pond discharges by the RWQCB (Figure 2b and Table 1) and water quality parameters within Ponds A9, A10 and A11 varied (Appendix 1).

Alviso Unit: Pond A16

Pond A16 provides 243 acres of managed shallow pond habitat with 16 nesting islands (along with 4 existing islands) (Figure 3). Objectives for this pond include discharge salinities to Artesian Slough at less than 40 ppt, and a discharge maximum of 180 cfs. The intake WCS brings water from tidal Pond A17 into Pond A16. Pond A16 water can either be discharged into Artesian Slough or moved into New Chicago Marsh through a siphon. In 2022, salinity and pH levels at the Pond A16 WCS were below 40 ppt and just above the 8.5 threshold, respectively, set for pond discharges by the RWQCB (Figure 2c and Table 3). Dissolved oxygen varied amongst the sampling periods. Construction in 2022 for the South Bay Shoreline Project included the addition of a sheet pile coffer dam along the entire southern levee and removal and replacement of the existing A16 siphon with a temporary siphon to move water into New Chicago Marsh. During the dewatering of the coffer dam, water quality measurements were taken from within the coffer dam and outside the dam within Pond A16. While the Refuge's low DO reading in August was worrisome, water samples taken during the dewatering process demonstrated the daily variation of DO throughout the day (FISHBIO unpublished data). Samples taken on August 5, 2022 at 0830 had a low DO of 1.2 mg/L, increased to 5.1mg/L at 1130 and reached 11.8mg/L by the late afternoon reading at 1645.

Alviso Unit: Mountain View Ponds A1 and A2W

The main water quality objective for Ponds A1 (intake) and A2W (outlet) is to maintain full tidal circulation while maintaining discharge salinities to the Bay at less than 40 ppt (Figure 4). The A1 WCS and A1/A2W siphon are fully functional, while the A2W WCS and A2W/A2E siphon are non-functional. In 2022, salinity and pH levels at the Pond A2W discharge were below 40 ppt and 8.5 threshold, respectively, set for pond discharges by the RWQCB (Figure 2d and Table 1) and above the 5.0 mg/L threshold for DO in the Basin Plan. These ponds are part of Phase 2 of the Project and are likely to be breached in the next 3-5 years to restore the ponds to tidal marsh.

Alviso Unit: Moffett Ponds AB1, AB2, A2E, A3N, and A3W

The Alviso Pond System A3W consists of Ponds AB1, AB2, A3W, A2E, and A3N (Figure 4). The objectives for the Alviso Pond A3W system are to: 1) maintain full tidal circulation through ponds AB1, AB2, A2E, and A3W while maintaining discharge salinities to Guadalupe Slough at less than 40 ppt; 2) maintain water levels in Pond A3N to cover the pond bottom due to mercury "hotspots" by leaving the A3N / A3W gate fully open, year round; and 3) maintain water surface levels lower in winter to reduce potential overtopping of A3W and A2E levee adjacent to Moffett Field.

In 2021 and 2022, several WCSs were replaced and several external and internal berms were raised (see Refuge O&M update). Water quality sampling throughout the Moffett Pond Complex were mixed (Figure 2e, Table 1 and Appendix 1). In 2022, salinity and pH levels at the Pond A3W discharge were below 40 ppt and at or just above the 8.5 threshold, respectively, set for pond discharges by the RWQCB. DO measurements at the AB1 inlet were low, between 1 and 2 mg/L, in June, July and August sampling periods before increasing in September. Unlike A16, these low DO readings were not associated with morning sampling. DO measurements at A3W discharge ranged from 6 to 14mg/L from June thru August, before dropping to 1mg/L in September.

Ravenswood Unit: Ponds R3-SF2, Ravenswood Slough and Flood Slough

The objectives of the Pond SF2 System are to manage a 155-acre pond with 30 nesting islands for nesting and roosting birds and an 85-acre seasonal wetland for western snowy plover nesting (Figure 5). The water level in SF2 is designed to maintain shallow water to provide foraging habitat for shorebirds and waterfowl. Water control structures are used to manage water levels, flows into and out of Pond SF2 from the Bay, and flows between cells. The goal of this water management is to create shorebird foraging habitat and to meet water quality objectives. In 2022, salinity and pH levels at the Pond SF2 discharge were below 40 ppt and 8.5 threshold, respectively, set for pond discharges by the RWQCB (Figure 2f and Table 1). DO measurements at the SF2 discharge ranged from 4.8 to 8.6mg/L from June thru August, before dropping to 3.2mg/L in September.

Construction is ongoing at Ponds R3, R4, and R5/S5 and no discharges from the SBSP Restoration Project occurred in 2022 (See Project updates below). However, per the upcoming fish community monitoring that will begin in 2023, pre-construction continuous water quality monitoring in Ravenswood Slough and Flood Slough were collected from October 2022 to December 2022. Water quality parameters collected included water temperature, DO concentration and percent saturation, salinity, pH, chlorophyll-a (chl-a) and turbidity. This data will be processed and included in the annual Interim Data Summaries produced by Helix, as well as the final report. Once R5/S5 pond and Pond R3 come online, presumably in 2023/24, water quality sampling in R5/S5 will also begin. In preparation for these ponds to discharge into receiving water, the Refuge submitted the Salinity-Metals Analysis and Monitoring Plan to RWQCB in July 2022.

Problems Encountered in 2022

A few different issues influenced water monitoring in 2022. Management of the recently added AB1 WCS continues to be difficult. The A14 WCS has been identified as a high priority WCS in need of replacement and due to supply chain issues, construction has been pushed to 2023. In addition, WCS at the end of their life continue to fail. WCS are replaced as funding becomes available.

Fish Kills and Harmful Algal Bloom

No large fish kills <u>within</u> managed ponds were detected in 2022. Over the course of the year only a few striped bass were found dead, cause undetermined.

In late July, a harmful algal blooms (HABs) caused by *Heterosigma akashiwo* was detected around Alameda/Oakland. By early August, the bloom had spread to the open bay regions of the South Bay and caused a large fish kill outboard of Refuge ponds. On August 25, 2022, USFWS documented 23 striped bass and 1 flatfish washed up at the Dumbarton fishing pier. Consequently over the next two weeks, upwards of 60 sturgeon, 60 striped bass, 2 guitarfish, and 1 flatfish were documented bayside/outboard of the following Refuge ponds: Alviso Unit Ponds (Santa Clara County): A2W, A1, AB2, AB1, Charleston Slough, Mountain View Slough, Ravenswood Unit Ponds (San Mateo County): R4, R1 and Ravenswood Slough and Newark Unit (Alameda County): Fishing Pier and Beach. The Bay-wide red tide event was one of the largest on record and resolved itself by the end of September. https://baynature.org/2022/09/21/on-the-enigmatic-flying-potato-neither-plant-nor-animal-that-caused-the-bays-biggest-harmful-algal-bloom-in-history/

Highly Pathogenic Avian Influenza

While conducting surveys to document fish mortality during the HAB event mentioned above, an unusual amount of dead birds were observed in Refuge ponds. At first the mortality was correlated with the HAB, but testing of several bird carcasses from the Refuge and adjacent properties resulted in a divergent cause of death, Highly Pathogenic Avian Influenza (HPAI). Over the course of four months, August thru November, over 50 dead birds were documented, though only a very small number were tested, due to the known presence of HPAI in the three counties that cover the Refuge, Alameda, Santa Clara, and San Mateo. Species included: colonial waterbirds, birds of prey, waterfowl, corvids and other waterbirds. On the Refuge, American white pelicans were the hardest hit, with 33 birds observed, the majority of which were bagged and removed from ponds. HPAI bird surveys will continue in 2023.

South Bay Salt Pond Restoration Project Progress in 2022

Phase 2 of the Project is a collaborative effort among federal, state, and local agencies working with scientists and the public to develop and implement habitat restoration, flood management, and wildlife oriented public access plans on Don Edwards National Wildlife Refuge. The former commercial salt ponds included in Phase 2 plans encompass about 2,385 acres on the Ravenswood and Alviso pond complexes (Figure 6) and will be restored to a mosaic of habitats, including tidal salt marsh, tidal mudflat, salt panne, subtidal flats and channels, sloughs, ponds, habitat transition zones (aka ecotone), and open water habitats (enhanced managed ponds), to support populations of wildlife, special-status species, migratory waterfowl, shorebirds, and anadromous and resident fish populations.

The amount of tidal marsh restoration approved under Order Nos. R2-2008-0078 and R2-2012-0014 was 10.5 percent of the 15,100-acre Project area. This increase remains well below the approved 50 percent endpoint analyzed for the Project. The amount of tidal marsh restoration approved under Order R2-2018-0020 will increase tidal marsh from 10.5 percent to 17 percent (2,605 acres) of the 15,100-acre project.

Ravenswood Unit: Ponds R3-S5

The Refuge began levee maintenance and habitat enhancement at the Ravenswood Ponds in July of 2018 (Figure 7). That work was largely import and placement of earthen fill in compliance with regulatory permits. Previous reports described the work performed as part of Phase 2 of the Project in 2019-2021. By the end of Phase 2 actions at Ravenswood, two habitat transition zones will be created within Pond R4, which will be breached to restore 294 acres to tidal marsh habitat. The 67 acres of pond habitat at Ponds R5/S5 have been improved for ducks and shorebirds with the removal of internal levees and the creation of a nesting and/or roosting island; operation to provide that habitat will begin in late 2023. Pond R3 (270 acres) has been enhanced with a new WCS to manage dry salt panne for threatened western snowy plovers. A new public access trail and interpretive panels will be added between Bayfront Expressway and the southern edge of Bedwell Bayfront Park.

In 2022, import continued under the Phase 2 RWQCB permit. Two entities, Pacific States Environmental and the EnviroMend Group imported soil under the guidelines of the approved Master Quality Assurance Project Plan for Don Edwards San Francisco Bay National Wildlife Refuge (Master QAPP) (Service and H. T. Harvey & Associates, updated 2021). Refer to HT Harvey Reports, Project No. 3685-01/4589-01 and EnviroMend Group's quarterly reports for more details. Material was imported to improve external levees, build up the All American Canal levee, and to build a second habitat transition zone within Pond R4. In 2023, the All-American Canal levee improvements and import and placement of material for 2nd habitat transition zone will be completed.

Construction of the four water control structures that began in 2021, was essentially completed, with only the external trash racks remaining to be installed early in 2023. Water management should begin in 2023 or early 2024. Channel excavation outboard of the future R4 breach location and channel excavation within Pond R4 pond bottom was completed. R4 will be breached in late 2023 or early 2024. Two outboard "donuts", remnant features from prior salt production use, were graded and seeded to restore to tidal marsh habitat. Save the Bay continued their work revegetating the western transition zone and will begin out-planting the second transition zone in late 2023. Revegetation of the transition zones will continue into 2024 and be completed under a separate grant. Development and construction of public access features, such as trails and interpretive panels will begin in 2023.

Alviso Unit: A8 Ponds (Ponds A8 & A8S)

In 2022, the Santa Clara Valley Water District (Valley Water) and the Refuge imported over 100,000 cubic yards of soil to the A8 Ponds for Phase 2 of the Project (Figure 8). The fill was imported under the Project's Phase 2 RWQCB Section 401 Water Quality Certification Order No. R2-2018-0020. As required by the Phase 2 RWQCB permit, Valley Water imported the soil under the guidelines of the approved Master Quality Assurance Project Plan for Don Edwards San Francisco Bay National Wildlife Refuge (Master QAPP) (USFWS and H. T. Harvey & Associates 2018). Refer to HT Harvey Report, Project No. 3685-01/4589-01 and EnviroMend Group's quarterly reports for details. In 2023, that imported soil will be used by the Project to construct two habitat transition zones at the southern edge and corners of the A8 Ponds.

Alviso Unit: Island Ponds (Ponds A19 & A20)
The Phase 2 construction action at Alviso Ponds A19 and A20 (the Island Ponds) was initiated and nearly completed in 2021, but work continued into mid-January of 2022 to complete the project (Figure 9). This construction consisted entirely of earthwork to modify existing levees around portions of these two former salt ponds to increase aquatic habitat connectivity and add complexity and completeness to the restoring marshes there. Two breaches were added to the northern levee of Pond A19, an existing breach on the southern side of A19 was widened, and portions of the levees along the northern and western levees of A19 and the eastern levee of A20 were lowered. All removed levee material was reused onsite by building ditch blocks in the borrow ditches to direct tidal flows into the interior of the ponds. No additional construction work is planned for these ponds in 2023 or thereafter.

Alviso Unit: Mountain View Pond A2W
Due to delays in negotiating easements and other necessary local government approvals with the adjacent City of Mountain View, 2022 was the first year of construction at this pond group under Phase 2 of the South Bay Salt Pond Restoration Project. In 2022, the EnviroMend Group and the Refuge imported over 50,000 cubic yards of soil to Pond A2Ws for Phase 2 of the Project (Figure 10). The fill was imported under the Project's Phase 2 RWQCB Section 401 Water Quality Certification Order No. R2-2018-0020. The imported soil will be used by the Project to construct a habitat transition zone at the southern edge of the pond and for levee repairs and habitat island construction (see Figure 10). As required by the Phase 2 RWQCB permit, the material was imported under the guidelines of the approved Master Quality Assurance Project Plan for Don Edwards San Francisco Bay National Wildlife Refuge (Master QAPP) (USFWS and H. T. Harvey & Associates 2021 updated version). Refer to EnviroMend Group's quarterly reports for details.

Refuge Operations and Maintenance Activities in 2022

The Refuge continues to improve and update the Ponds Ops Plan, renamed the Managed Pond and Managed Wetland Operations Plan in 2021. This living document helps document management objectives for each pond to meet regulatory requirements and to support nested targets identified under the Waterbird conservation target in the Refuge Complex's NRMP (USFWS 2019). A variety of activities were conducted in 2022 as part of USFWS Operations and Maintenance, which is covered under RWQCB Order R2-2018-0020 and U.S. Army Corps of Engineers Permit 2008-0001035.

Alviso Unit: Ponds A9-A15
The A14 WCS continued to degrade throughout 2022, and the Refuge no longer has any control over the movement of water through the structure (Figure 11). The Refuge issued a design/build contract to replace the WCS in September 2022, but due to supply chain issues and an unusually wet winter, work has yet to begin on that replacement.

O&M Deferred Maintenance will continue in 2023 with the replacement of the A14 WCS on-track to occur as soon as weather conditions allow.

Alviso Unit: Ponds AB1-A3W

Planned work to complete the O&M effort in the Moffett Pond Complex was limited in 2022 due to a transfer of funds to the A14 WCS replacement. The Refuge is working to secure additional funds which will eventually allow the Refuge to increase the A3N and A3W external levee heights to a minimum elevation of 13.1 feet NAVD88. The WCS between AB1 and A2E will be removed and the levee will be breached. The internal levee between AB1 and A2E and A2E and AB2 will be shaved down to provide roosting and nesting habitat. Wind break islands that also function as nesting islands, will be added to AB2 and A3N. Some additional substrate will be added to A3N to increase microtopography for roosting shorebirds. Hunting blinds in this pond complex will all be replaced.

Additional Documentation

The South Bay Salt Pond Restoration Project Phase 2 Fish Community Monitoring Plan at the Don Edwards San Francisco Bay National Wildlife Refuge was finalized in 2021 (Service and NMFS, 2021, see 2021 SMR for more details). In 2022, Ducks Unlimited awarded funds to Helix Environmental Planning to develop and conduct Fish Community and Water Quality Monitoring for the Ravenswood Restoration Project. HELIX will provide traditional fish community and water quality monitoring services, including pre- and post-construction continuous water quality monitoring and post-construction fish monitoring for the first two years of the Project. The two major objectives are: 1) Evaluate changes over time of the effects of habitat conditions to fish and invertebrates in Pond R5/S5 and Flood Slough as compared to reference conditions in Ravenswood Slough, and 2) Evaluate changes over time of water quality conditions in Pond R5/S5 and Flood Slough as compared to reference conditions in Ravenswood Slough.

Modified transect surveys will be performed to determine fish use of habitat types within the restored tidal marsh. Traditional fish monitoring includes a variety of netting methodologies specific to habitat types and in documents relative to previous sampling efforts. HELIX will also be responsible for 1) analyzing data collected by traditional means, and 2) comparing fish distribution at habitat types in this site to other similar restored wetlands in the South Bay as well as the entire San Francisco Estuary.

After supply chain issues delayed procurement of data sondes, water quality monitoring within Flood Slough and Ravenswood Slough began in the winter of 2022. The final study design and commencement of fish community monitoring will begin in 2023.

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Figures and Tables

Figure 1. Overview of Ponds

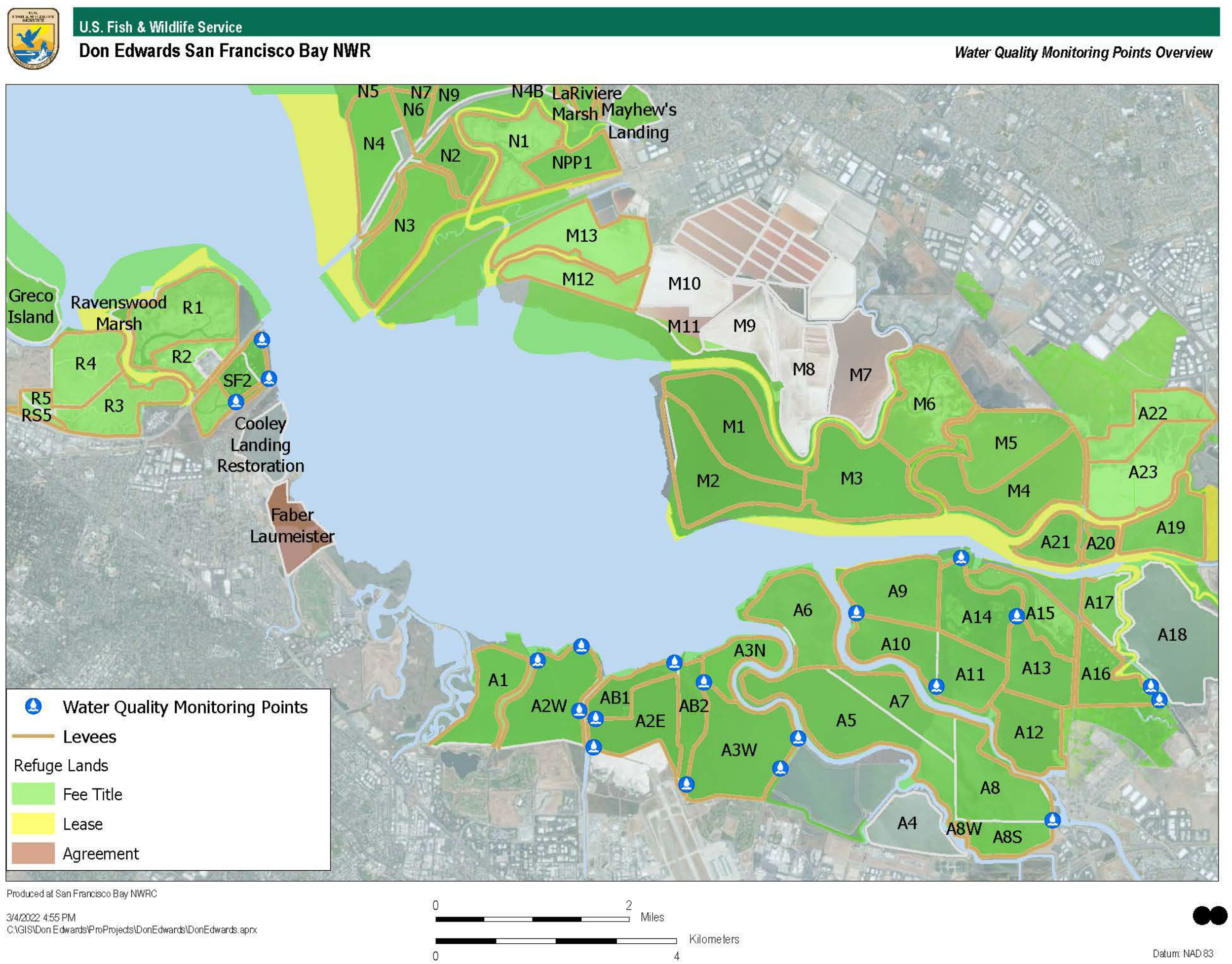

Figure 2. Water quality measurements at each discharge location in 2022.

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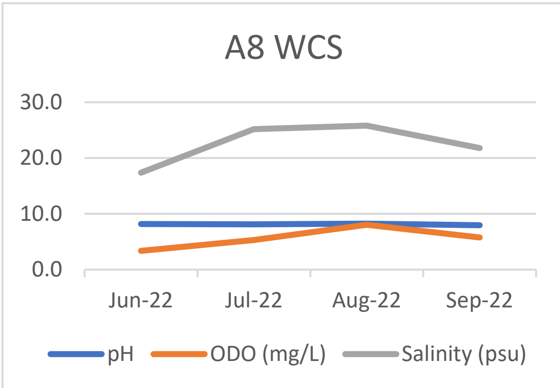

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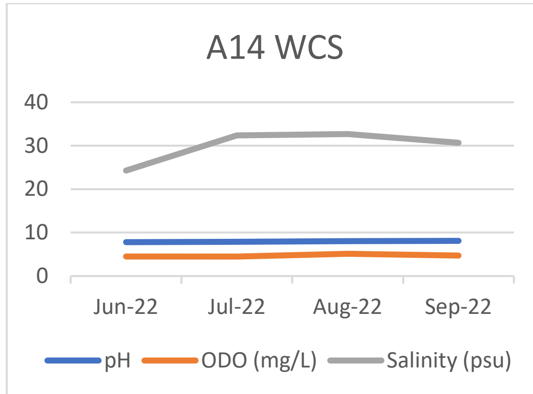

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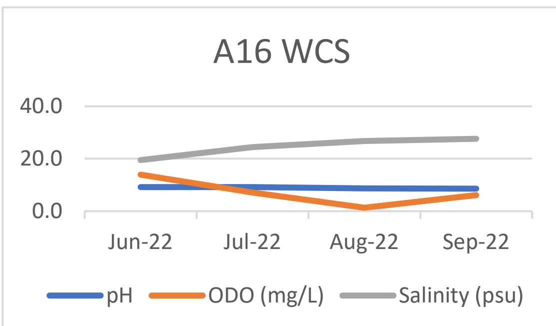

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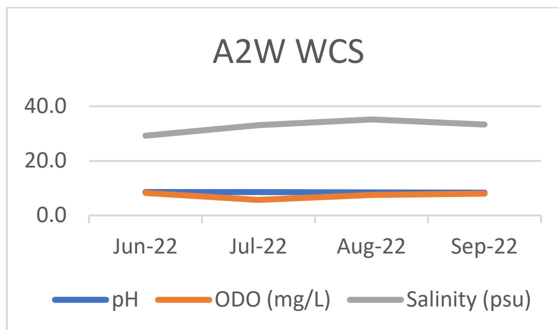

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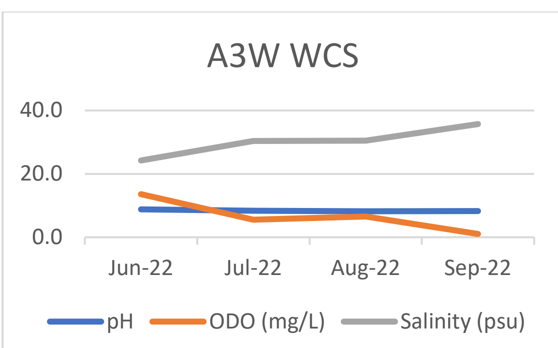

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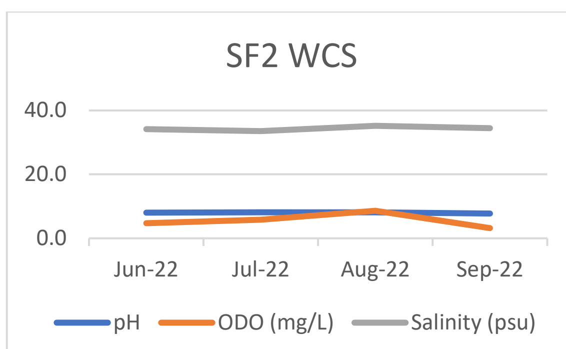


Figure 3. Alviso Pond Complexes A8 and A14 and sample locations.

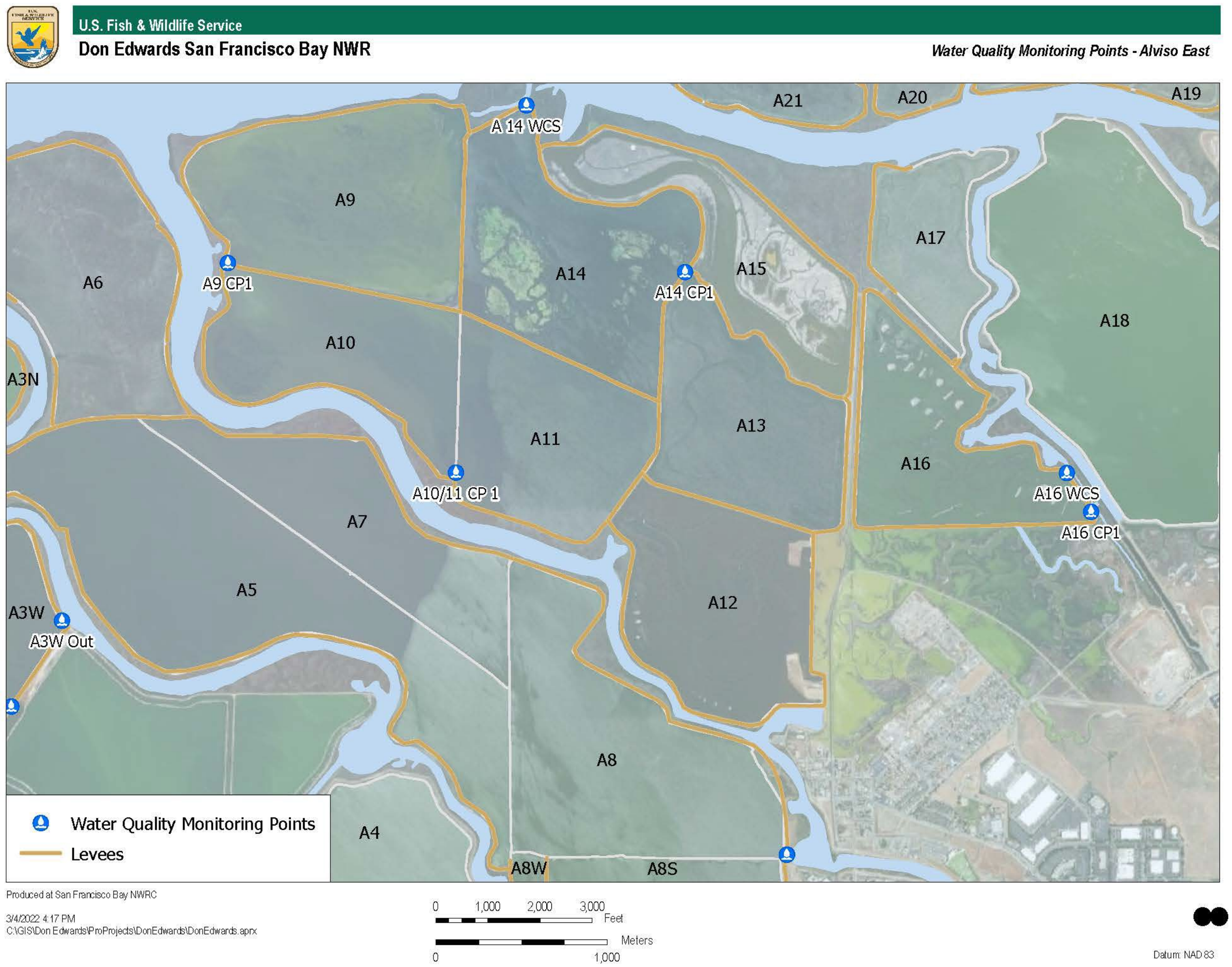


Figure 4. Mountain View (A1 and A2W) and Moffett Ponds (AB1-A3W) pond complexes and sample locations.

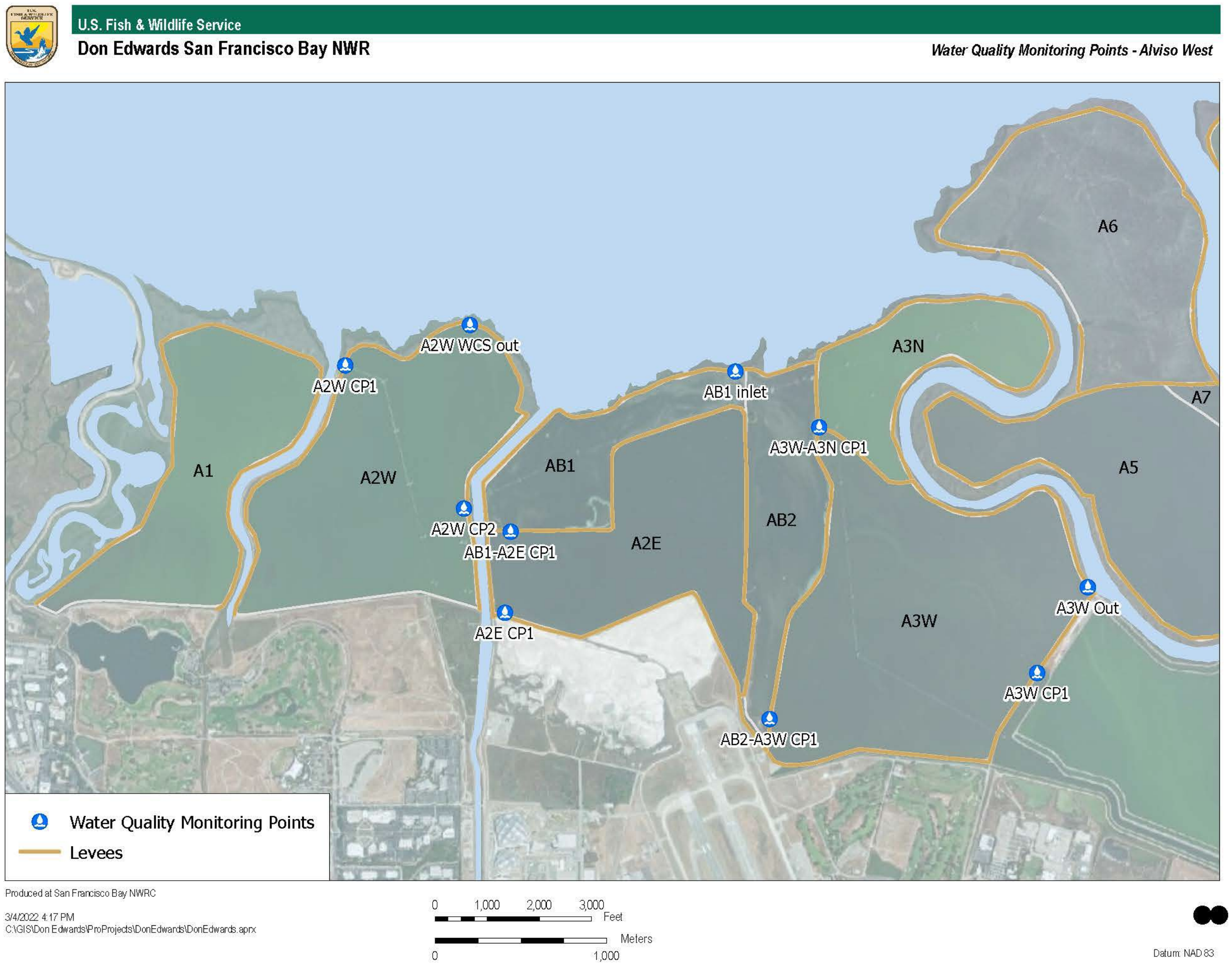


Figure 5. Sampling Locations in Pond SF2, Ravenswood Unit.

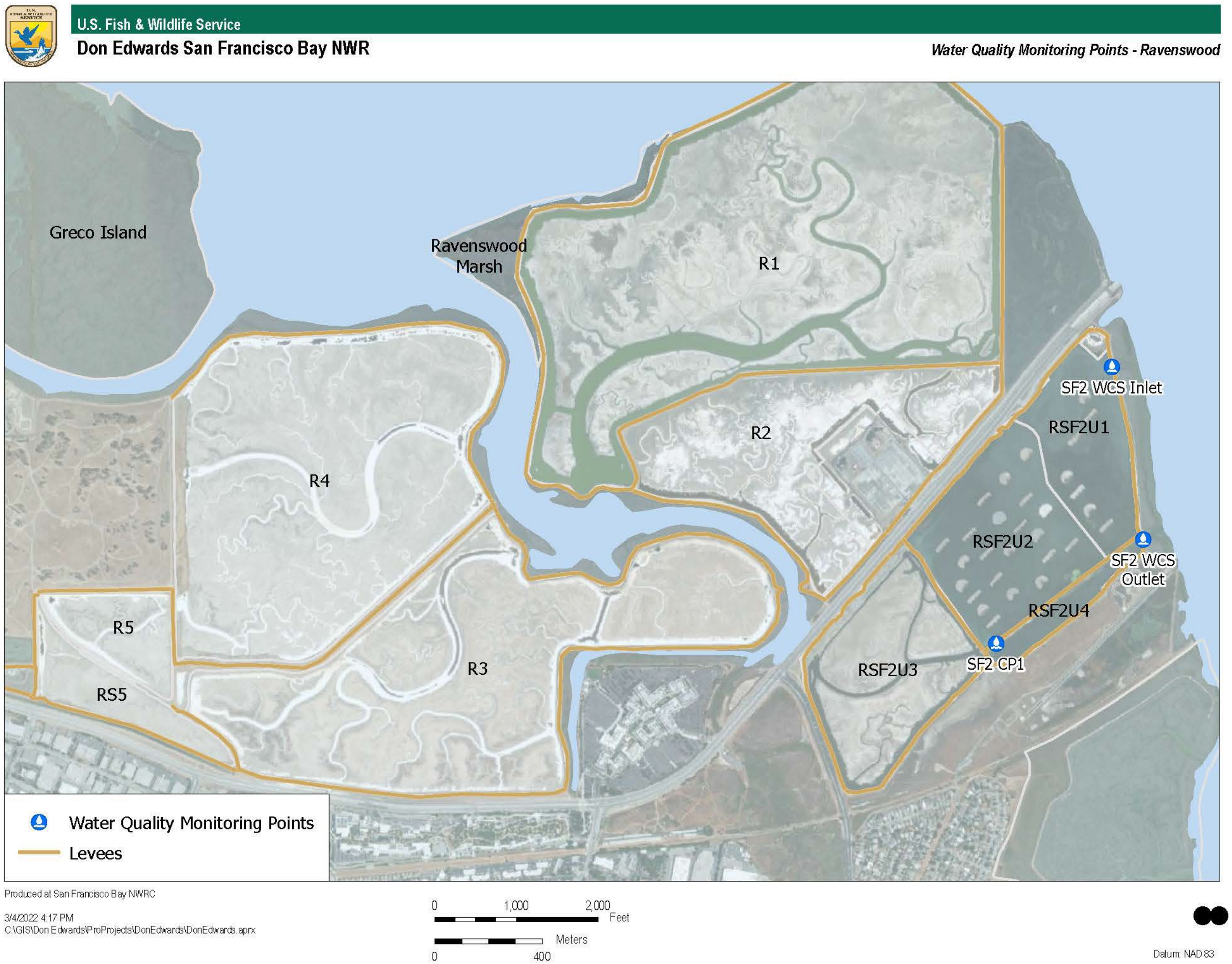
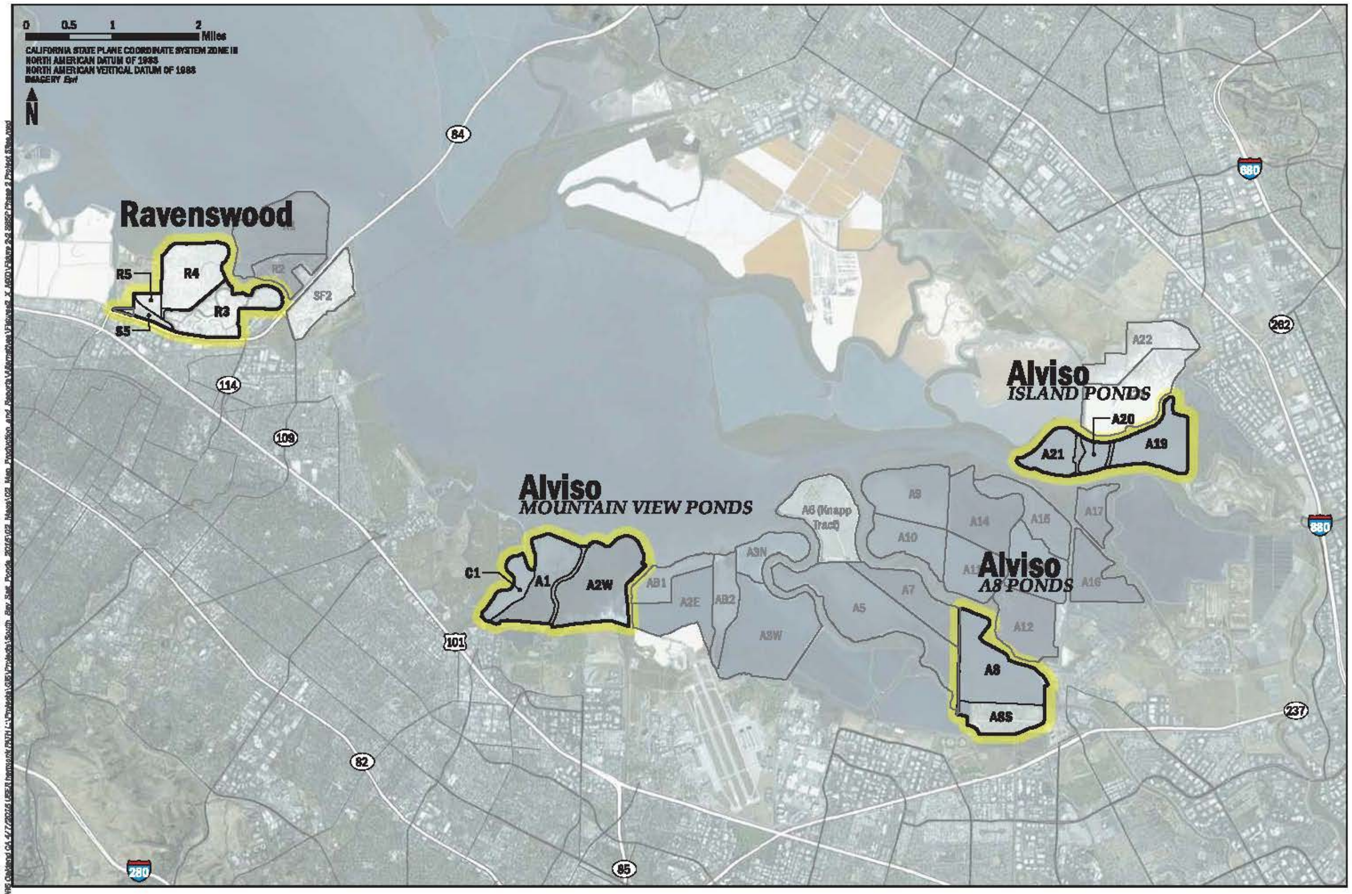


Figure 6. Phase 2 of the South Bay Salt Pond Restoration Project



AECOM
South Bay Salt Pond Restoration Project

Figure 2-2
SBSP Phase 2 Project Sites

Figure 7. Map of Ravenswood Pond Complex and proposed restoration actions.

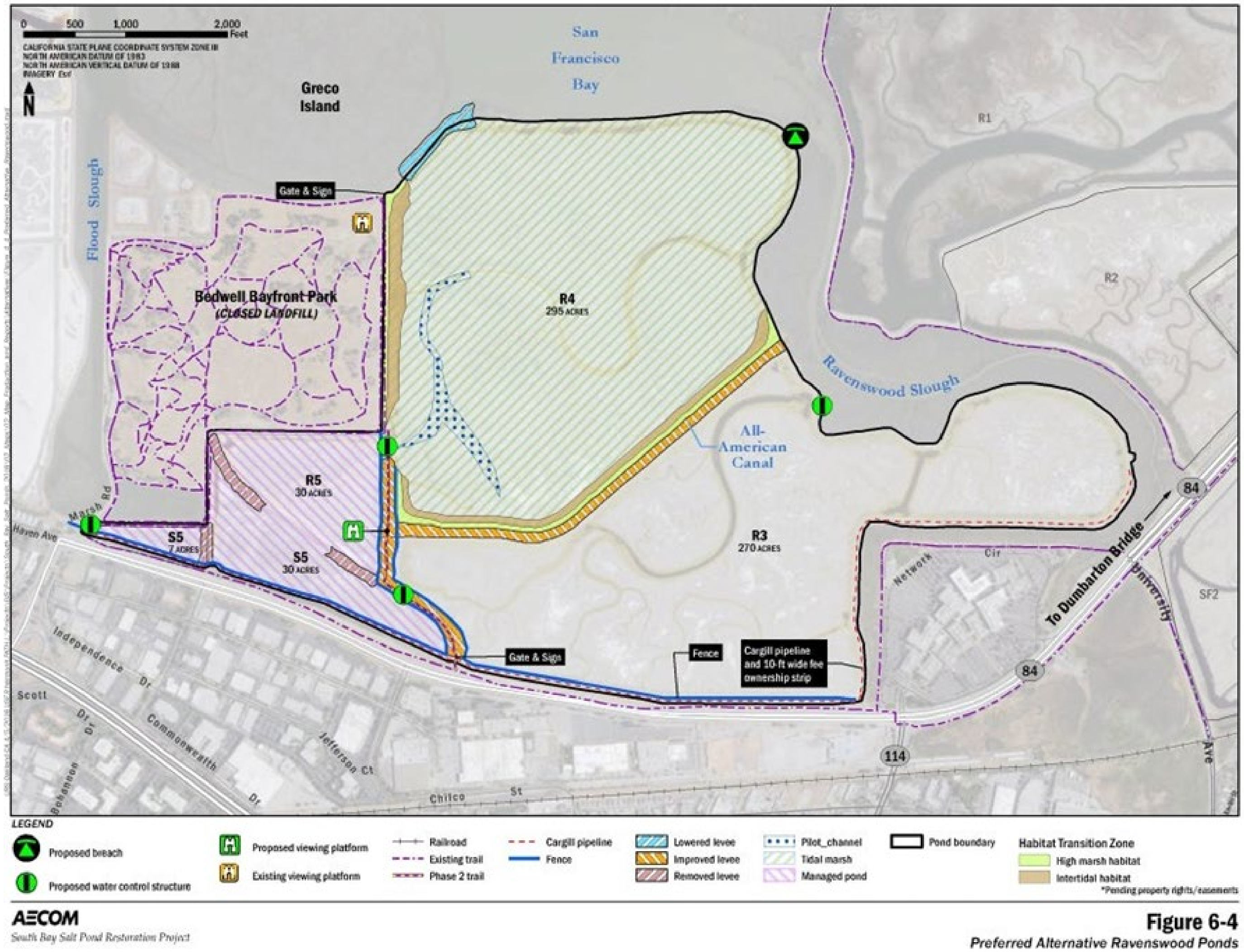


Figure 8. Map of Phase 2 actions at Ponds A8 & A8S

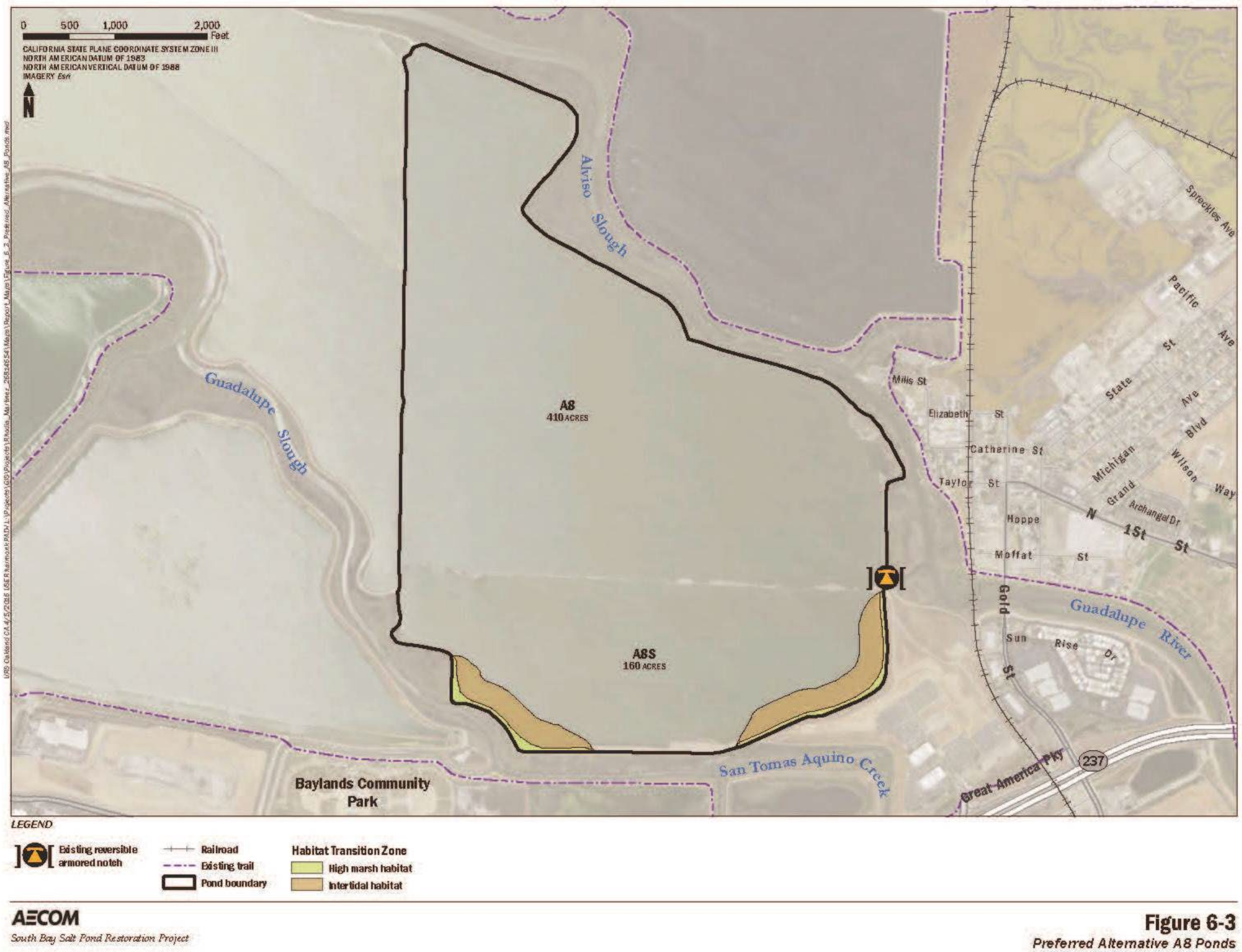


Figure 9. Map of Phase 2 actions at Island Ponds

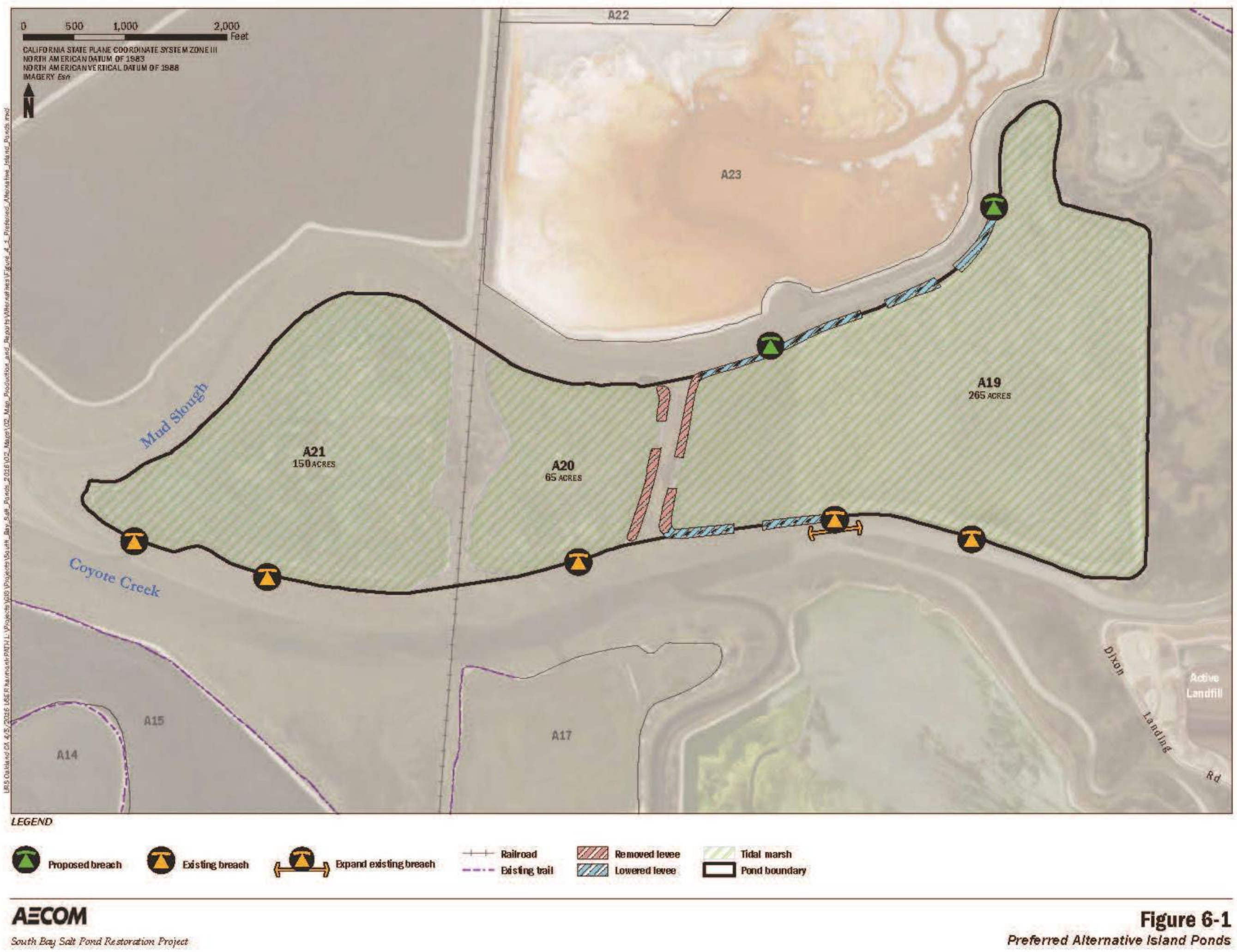


Figure 10. Map of Phase 2 actions at Mountain View Ponds

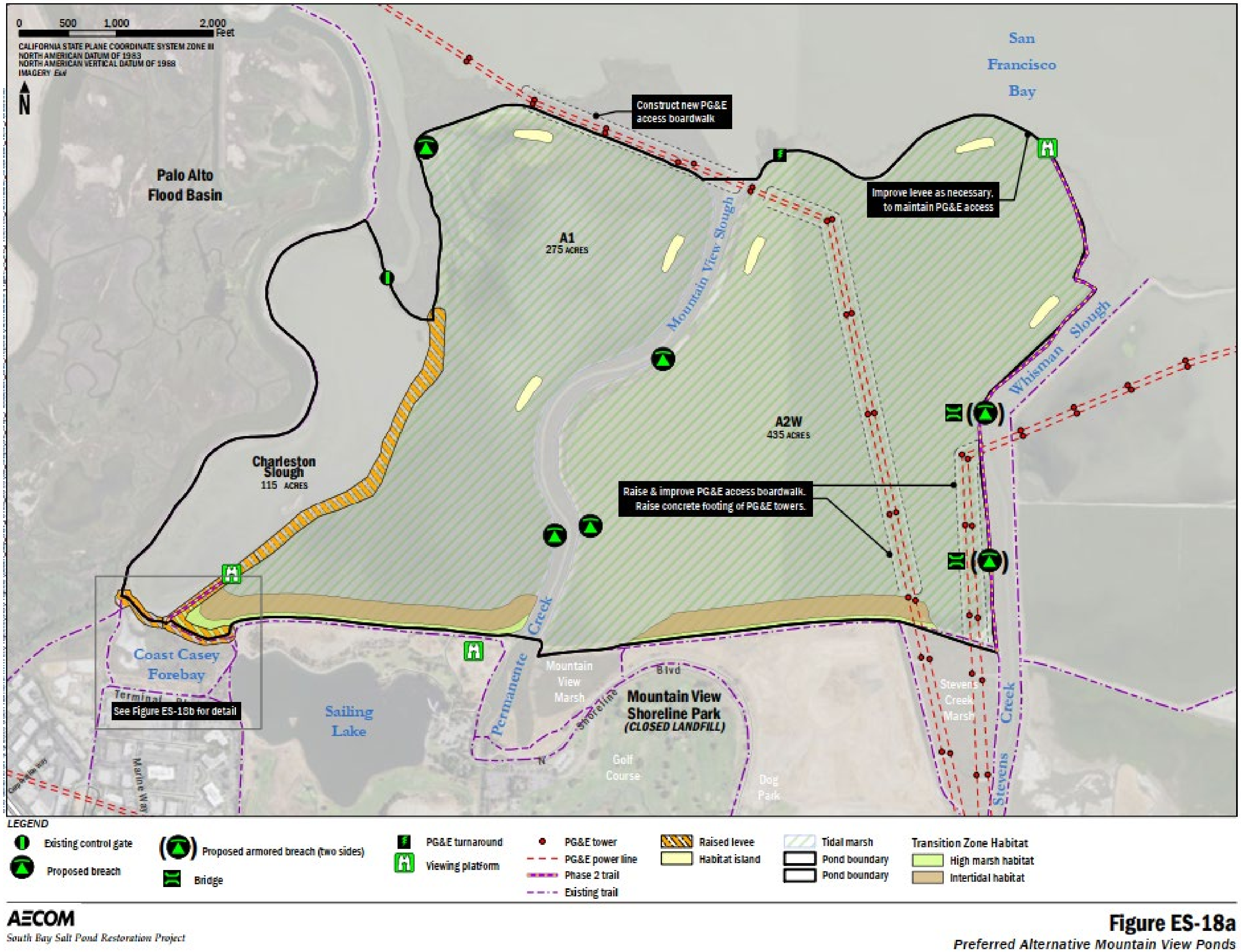


Figure 11. Failing A14 WCS

Table 1: Water quality measurements at Refuge discharge locations from June to September, 2022. Results are average values.

DATE	SITE	Barometer (mmHg)	pH	ODO (% Sat)	ODO (mg/L)	Sal (psu)	Temp (°C)
6/10/2022	A8 WCS	760.6	8.2	43.5	3.4	17.4	23.0
7/14/2022	A8 WCS	761.0	8.1	72.0	5.3	25.2	23.6
8/19/2022	A8 WCS	757.8	8.2	113.5	8.0	25.8	25.4
9/27/2022	A8 WCS	761.6	8.0	74.7	5.8	21.8	22.0
6/10/2022	A14 WCS	760.2	7.8	61.3	4.5	24.3	23.5
7/14/2022	A14 WCS	761.3	7.9	62.3	4.5	32.4	22.4
8/19/2022	A14 WCS	758.5	8.0	74.3	5.1	32.7	24.6
9/27/2022	A14 WCS	762.2	8.1	64.7	4.8	30.7	21.8
6/10/2022	A16 WCS	759.8	9.2	194.0	13.9	19.5	26.7
7/14/2022	A16 WCS	761.0	9.2	98.2	7.1	24.4	24.4
8/19/2022	A16 WCS	759.2	8.7	18.3	1.3	26.7	23.9
9/27/2022	A16 WCS	761.8	8.6	83.5	6.1	27.6	22.9
6/9/2022	A2W WCS	759.8	8.5	113.6	8.3	29.2	22.9
7/13/2022	A2W WCS	761.3	8.6	80.2	5.7	33.0	22.8
8/18/2022	A2W WCS	761.0	8.5	106.8	7.5	35.2	23.0
9/27/2022	A2W WCS	761.3	8.3	109.8	7.9	33.3	21.8
6/9/2022	A3W WCS	759.2	8.8	189.0	13.6	24.2	25.1
7/13/2022	A3W WCS	761.0	8.4	79.1	5.6	30.4	24.2
8/18/2022	A3W WCS	760.2	8.2	95.3	6.6	30.5	25.3
9/23/2022	A3W WCS	760.4	8.3	14.1	1.0	35.7	19.7
6/9/2022	SF2 WCS	760.0	8.0	65.0	4.8	34.1	20.7
7/13/2022	SF2 WCS	761.6	8.1	79.6	5.8	33.5	21.0
8/18/2022	SF2 WCS	760.1	8.1	131.0	8.6	35.2	26.7
9/23/2022	SF2 WCS	762.1	7.8	42.2	3.2	34.4	19.0

Appendix 1: Monthly water quality monitoring at multiple locations throughout the ponds was conducted using the YSI multimeter from June thru September 2022.

Pond A8							
Date	Site	Barometer (mmHg)	pH	ODO (% sat)	ODO (mg/L)	Sal (psu)	Temp °C
6/10/2022	A8 WCS	760.5	8.13	46.4	3.6	17.38	23.1
6/10/2022	A8 WCS	760.6	8.19	40.5	3.14	17.38	23.0
7/14/2022	A8 WCS	760.9	8.07	73.2	5.38	25.17	23.6
7/14/2022	A8 WCS	761	8.16	70.8	5.19	25.17	23.6
8/19/2022	A8 WCS	757.8	8.24	113	8.01	25.81	25.4
8/19/2022	A8 WCS	757.7	8.25	113.9	8.07	25.82	25.4
9/27/2022	A8 WCS	761.6	7.96	74.9	5.77	21.79	22.0
9/27/2022	A8 WCS	761.6	7.96	74.5	5.73	21.83	22.0

Ponds A9, A10, A11 and A14							
Date	Site	Barometer (mmHg)	pH	ODO (% sat)	ODO (mg/L)	Sal (psu)	Temp °C
6/10/2022	A10-A11 CP1	760.1	8.26	185.6	12.34	30.03	27.8
6/10/2022	A10-A11 CP1	760.3	8.31	191.9	12.78	30.22	27.6
6/10/2022	A14 CP1	760.1	8.15	112	7.34	28.48	29.2
6/10/2022	A14 CP1	760	8.17	111.5	7.31	28.48	29.2
6/10/2022	A14 OUTLET	760.2	7.79	62.6	4.63	24.52	23.4
6/10/2022	A14 OUTLET	760.1	7.72	59.9	4.41	24.04	23.7
6/10/2022	A9 CP1	759.9	8.32	260	16.73	29.42	30.0
6/10/2022	A9 CP1	759.9	8.32	284.9	18.3	29.43	30.1
6/10/2022	A9 INLET	760.2	7.71	94.8	6.69	26.46	25.5
6/10/2022	A9 INLET	760.1	7.73	92.4	6.51	26.39	25.5
7/14/2022	A10-A11 CP1	761.1	8.14	91.7	6.55	35.38	21.8
7/14/2022	A10-A11 CP1	761.1	8.08	57	4.01	35.38	22.7
7/14/2022	A14 CP1	761.2	8.14	44.7	3.21	33.29	22.1
7/14/2022	A14 CP1	761.3	8.13	60.9	4.38	33.16	22.1
7/14/2022	A14 OUTLET	761.3	7.9	63.5	4.57	32.35	22.4

7/14/2022	A14 OUTLET	761.2	7.89	61.1	4.4	32.37	22.4
7/14/2022	A9 CP1	761.2	7.82	53.2	3.97	30.65	20.9
7/14/2022	A9 CP1	761.2	7.93	48.8	3.61	31.95	20.9
7/14/2022	A9 INLET	761.2	7.61	38.5	2.85	31.99	20.9
8/19/2022	A10-A11 CP1	758.2	7.93	85.7	5.87	35.97	24.0
8/19/2022	A10-A11 CP1	758	7.94	81.5	5.57	36.06	24.1
8/19/2022	A14 CP1	758.4	6.5	87.9	5.98	35.6	24.6
8/19/2022	A14 CP1	758.3	7.11	93.4	6.34	35.61	24.6
8/19/2022	A14 OUTLET	758.5	7.98	74	5.12	32.3	24.6
8/19/2022	A14 OUTLET	758.5	7.98	74.5	5.13	33.07	24.6
8/19/2022	A9 CP1	758.3	8.46	220.2	14.88	35.56	24.9
8/19/2022	A9 CP1	758.3	8.47	219.4	14.82	35.55	25.0
8/19/2022	A9 INLET	758.3	8.02	74.3	5.28	35.32	22.1
8/19/2022	A9 INLET	758.2	8.01	75.5	5.37	35.32	22.1
9/27/2022	A10-A11 CP1	762.5	7.8	57.3	4.16	34.52	21.2
9/27/2022	A10-A11 CP1	762.5	7.78	48.1	3.48	34.58	21.3
9/27/2022	A14 CP1	762	8.12	124.1	8.82	34.17	22.5
9/27/2022	A14 CP1	761.9	8.12	126.1	8.97	34.18	22.5
9/27/2022	A14 OUTLET	762.1	8.08	66.1	4.85	30.86	21.8
9/27/2022	A14 OUTLET	762.2	8.05	63.2	4.65	30.48	21.8
9/27/2022	A9 CP1	762.5	8.13	102.3	7.38	37.26	20.6
9/27/2022	A9 CP1	762.5	8.16	98.3	7.09	37.36	20.6
9/27/2022	A9 INLET	762.2	7.8	58.2	4.39	27.09	21.4
9/27/2022	A9 INLET	762.3	7.8	56.6	4.27	27.1	21.4

Pond A16							
Date	**Site**	**Barometer (mmHg)**	**pH**	**ODO (% sat)**	**ODO (mg/L)**	**Sal (psu)**	**Temp °C**
6/10/2022	A16 CP1	759.6	9.09	258.4	18.54	17.26	27.5
6/10/2022	A16 CP1	759.5	9.15	283.6	20.23	17.1	27.9
6/10/2022	A16 OUTLET	759.8	9.15	186.2	13.38	19.51	26.7
6/10/2022	A16 OUTLET	759.7	9.18	201.8	14.46	19.47	26.8
7/14/2022	A16 CP1	761	9.26	95.3	7	24.67	23.7
7/14/2022	A16 CP1	761.1	9.17	68	5.01	24.61	23.6
7/14/2022	A16 OUTLET	761	9.19	98.3	7.15	24.46	24.4
7/14/2022	A16 OUTLET	761	9.19	98.1	7.13	24.43	24.4
8/19/2022	A16 CP1	759.1	8.49	55.3	4.05	26.38	23.4
8/19/2022	A16 CP1	759.1	8.42	50.5	3.69	26.47	23.4

8/19/2022	A16 OUTLET	759.2	8.73	27.8	2.01	26.6	23.9
8/19/2022	A16 OUTLET	759.1	8.74	8.8	0.64	26.81	23.8
9/27/2022	A16 CP1	761.7	8.64	142.7	10.26	27.26	24.1
9/27/2022	A16 CP1	761.6	8.65	143.4	10.25	27.73	24.3
9/27/2022	A16 OUTLET	761.8	8.59	89.9	6.6	27.52	22.9
9/27/2022	A16 OUTLET	761.8	8.59	77	5.65	27.69	22.9

Pond A2W							
Date	**Site**	**Barometer (mmHg)**	**pH**	**ODO (% sat)**	**ODO (mg/L)**	**Sal (psu)**	**Temp °C**
6/9/2022	A2W CP1	759.8	8.67	127.1	8.98	29.15	24.5
6/9/2022	A2W CP1	759.8	8.67	129.6	9.18	29.21	24.3
6/9/2022	A2W CP2	759.9	8.68	114.2	8.57	29.24	21.1
6/9/2022	A2W CP2	759.8	8.67	112.2	8.42	29.23	21.1
6/9/2022	A2W OUTLET	759.8	8.53	112.2	8.16	29.24	22.8
6/9/2022	A2W OUTLET	759.8	8.55	114.9	8.34	29.21	22.9
7/13/2022	A2W CP1	761.1	8.59	91.3	6.78	24.1	23.3
7/13/2022	A2W CP1	761	8.58	93.7	6.6	32.94	23.3
7/13/2022	A2W CP2	761.2	8.46	54.8	3.88	32.98	23.1
7/13/2022	A2W CP2	761.1	8.45	52.5	3.72	32.99	23.1
7/13/2022	A2W OUTLET	761.2	8.56	76.7	5.46	33.04	22.7
7/13/2022	A2W OUTLET	761.3	8.57	83.7	5.95	33.05	22.8
8/18/2022	A2W CP1	761.1	8.47	92.7	6.43	35.54	23.4
8/18/2022	A2W CP1	761	8.52	90	6.24	35.59	23.4
8/18/2022	A2W CP2	760.8	8.16	29.9	2.13	34.43	22.4
8/18/2022	A2W CP2	760.8	8.16	29.6	2.11	34.47	22.4
8/18/2022	A2W OUTLET	760.9	8.49	102.8	7.22	35.22	22.9
8/18/2022	A2W OUTLET	761	8.49	110.8	7.74	35.13	23.1
9/27/2022	A2W CP1	761.3	8.52	123.7	8.77	35.03	22.3
9/27/2022	A2W CP1	761.3	8.52	125.1	8.87	35.05	22.3
9/27/2022	A2W CP1	761.1	8.36	117.2	8.4	33.91	22.1
9/27/2022	A2W CP1	761.2	8.36	117.5	8.41	33.93	22.2
9/27/2022	A2W OUTLET	761.3	8.35	110.1	7.96	33.4	21.8
9/27/2022	A2W OUTLET	761.3	8.34	109.5	7.93	33.28	21.8

Pond AB1, A2E, and A3W							
Date	**Site**	**Barometer (mmHg)**	**pH**	**ODO (% sat)**	**ODO (mg/L)**	**Sal (psu)**	**Temp °C**
6/9/2022	A2E CP1	759.5	8.71	166.9	11.09	34.94	26.2
6/9/2022	A2E CP1	759.8	8.71	165.1	10.97	34.94	26.1
6/9/2022	A3W CP1	759.2	8.62	129.5	9.73	25.39	22.2
6/9/2022	A3W CP1	759.4	8.62	127.4	9.59	25.34	22.1
6/9/2022	A3W OUTLET	759.2	8.81	188	13.52	24.16	25.1
6/9/2022	A3W OUTLET	759.2	8.79	189.9	13.65	24.29	25.1
6/9/2022	A3W-A3N CP1	759.3	8.55	125.6	9.14	26.59	23.7
6/9/2022	A3W-A3N CP1	759.5	8.54	131.1	9.5	26.69	23.9
6/9/2022	AB1 INLET	759.2	7.67	24	1.84	26.46	20.6
6/9/2022	AB1 INLET	759.2	7.69	34.6	2.63	26.43	21.1
6/9/2022	AB1-A2E CP1	759.8	8.6	134.4	9.28	33.95	24.3
6/9/2022	AB1-A2E CP1	759.6	8.61	138.1	9.55	34.02	24.1
6/9/2022	AB2-A3W (AB2)	759.3	8.61	197.2	13.79	29.4	25.0
6/9/2022	AB2-A3W (AB2)	759.4	8.61	194.5	13.59	29.39	25.0
6/9/2022	AB2-A3W CP1 (A3W)	759.3	8.56	145.4	10.49	27.02	24.0
6/9/2022	AB2-A3W CP1 (A3W)	759.3	8.56	145.2	10.46	27.04	24.0
7/13/2022	A2E CP1	761.3	8.33	88.9	6.04	38.92	23.4
7/13/2022	A2E CP1	761.3	8.54	86.6	5.86	39.13	23.7
7/13/2022	A3W CP1	761.1	8.52	119.3	8.03	34.58	25.5
7/13/2022	A3W CP1	761	8.52	112.9	7.59	34.64	25.6
7/13/2022	A3W OUTLET	761	8.36	80.6	5.68	30.35	24.2
7/13/2022	A3W OUTLET	761	8.36	77.6	5.47	30.36	24.2
7/13/2022	A3W-A3N CP1 (A3W)	761.4	8.85	233.3	15.08	40.36	25.9
7/13/2022	A3W-A3N CP1 (A3W)	761.3	9.05	293.8	17.47	55.04	26.0
7/13/2022	AB1 INLET	761.3	7.53	15.9	1.18	29.8	21.5
7/13/2022	AB1 INLET	761.3	7.53	13.6	1.01	29.83	21.5
7/13/2022	AB1-A2E CP1	761.4	8.59	106.4	7.52	34.52	22.7
7/13/2022	AB1-A2E CP1	761.3	8.58	113	7.82	36.21	23.3
7/13/2022	AB2 WCS CP1 (A3W)	761.3	8.29	83	5.74	33.55	24.3
7/13/2022	AB2 WCS CP1 (A3W)	761.3	8.3	84	5.8	33.65	24.3
7/13/2022	AB2 WCS CP1 (AB2)	761.3	8.26	75.6	5.25	33.27	24.1
7/13/2022	AB2 WCS CP1 (AB2)	761.3	8.26	75.3	5.23	33.29	24.1
8/18/2022	A2E CP1	760.7	8.4	77.4	5.14	44.04	23.2
8/18/2022	A2E CP1	760.7	8.4	75.6	5	44.07	23.3

8/18/2022	A3W CP1	760.3	8.39	45.6	3.27	32.43	22.5
8/18/2022	A3W CP1	760.3	8.39	45.5	3.27	32.43	22.5
8/18/2022	A3W OUTLET	760.1	8.19	95.3	6.59	30.51	25.3
8/18/2022	A3W OUTLET	760.2	8.2	95.3	6.58	30.51	25.4
8/18/2022	A3W-A3N CP1	760.6	8.51	105.4	7.26	36.04	23.7
8/18/2022	A3W-A3N CP1	760.6	8.54	115.2	7.92	36.49	23.6
8/18/2022	AB1 INLET	760.4	7.69	23.5	1.75	31.34	20.9
8/18/2022	AB1 INLET	760.5	7.69	20.8	1.55	31.38	20.8
8/18/2022	AB1-A2E CP1	760.7	8.44	61.5	4.09	44.89	22.8
8/18/2022	AB1-A2E CP1	760.6	8.44	58.4	3.87	45.08	22.9
8/18/2022	AB2 WCS CP1 (A3W)	760.4	8.61	91.7	6.35	34.88	23.7
8/18/2022	AB2 WCS CP1 (A3W)	760.4	8.61	91.3	6.32	34.89	23.7
8/18/2022	AB2 WCS CP1 (AB2)	760.4	8.59	90.5	6.28	34.94	23.6
8/18/2022	AB2 WCS CP1 (AB2)	760.4	8.6	90.1	6.25	34.94	23.6
9/23/2022	A2E CP1	761.6	8.47	128.6	8.77	42.93	21.9
9/23/2022	A2E CP1	761.6	8.5	155.4	10.58	43.27	22.0
9/23/2022	A3W CP1	760.6	8.43	102.7	7.31	35.74	21.9
9/23/2022	A3W CP1	760.4	8.4	81.4	5.85	35.7	21.4
9/23/2022	A3W OUTLET	760.4	8.29	19.3	1.42	35.75	19.8
9/23/2022	A3W OUTLET	760.4	8.29	14.3	1.06	35.71	19.7
9/23/2022	A3W OUTLET	760.4	8.28	13.8	1.02	35.71	19.7
9/23/2022	A3W-A3N CP1	761.1	8.64	157.8	11.42	31.58	22.3
9/23/2022	A3W-A3N CP1	761.1	8.67	160.4	11.53	32.61	22.4
9/23/2022	AB1 INLET	761	7.79	71.2	5.35	27.96	21.4
9/23/2022	AB1 INLET	761	7.78	70.2	5.27	27.97	21.4
9/23/2022	AB1-A2E CP1	761.6	8.5	94.1	6.39	44.17	21.8
9/23/2022	AB1-A2E CP1	761.6	8.5	94.4	6.4	44.28	21.9
9/23/2022	AB2 WCS CP1 (A3W)	761	8.46	104	7.33	36.28	22.2
9/23/2022	AB2 WCS CP1 (A3W)	761	8.45	103	7.26	36.26	22.3
9/23/2022	AB2 WCS CP1 (AB2)	760.8	8.36	93.1	6.66	34.14	22.1
9/23/2022	AB2 WCS CP1 (AB2)	761	8.36	93.6	6.69	34.12	22.2

Pond SF2							
Date	**Site**	**Barometer (mmHg)**	**pH**	**ODO (% sat)**	**ODO (mg/L)**	**Sal (psu)**	**Temp °C**
6/9/2022	SF2 CP1	760	8.1	101.7	7.26	34.28	22.2
6/9/2022	SF2 CP1	760	8.1	103.4	7.39	34.39	22.1
6/9/2022	SF2 WCS INLET	760.1	7.5	48.1	3.6	31.97	20.4
6/9/2022	SF2 WCS INLET	760.1	7.61	48.3	3.6	31.78	20.6
6/9/2022	SF2 WCS OUTLET	760	7.98	58	4.31	34.25	20.0
6/9/2022	SF2 WCS OUTLET	760	8	72	5.22	34.04	21.4

7/13/2022	SF2 CP1	761.6	8.25	74.5	5.26	35.75	22.4
7/13/2022	SF2 CP1	761.6	8.25	73.6	5.2	35.72	22.3
7/13/2022	SF2 WCS INLET	761.5	7.47	45.7	3.37	32.77	20.9
7/13/2022	SF2 WCS INLET	761.5	7.54	46	3.39	32.78	20.9
7/13/2022	SF2 WCS OUTLET	761.6	8.13	80.2	5.88	33.51	21.0
7/13/2022	SF2 WCS OUTLET	761.6	8.15	78.9	5.77	33.58	21.1
8/18/2022	SF2 CP1	759.8	8	129.4	8.7	34.92	25.5
8/18/2022	SF2 CP1	759.7	8	130.3	8.71	35.11	25.7
8/18/2022	SF2 WCS INLET	759.9	7.55	77.1	5.26	35.02	24.6
8/18/2022	SF2 WCS INLET	760	7.56	68.7	4.63	34.76	25.4
8/18/2022	SF2 WCS OUTLET	760.1	8.08	129.6	8.56	35.04	26.5
8/18/2022	SF2 WCS OUTLET	760.1	8.08	132.3	8.67	35.36	26.8
9/23/2022	SF2 CP1	761.9	7.99	75.9	5.55	34.28	20.9
9/23/2022	SF2 CP1	761.9	7.99	75.9	5.55	34.28	20.9
9/23/2022	SF2 WCS INLET	761.9	7.52	33.9	2.61	33.91	18.2
9/23/2022	SF2 WCS INLET	761.9	7.49	18	1.39	33.86	18.1
9/23/2022	SF2 WCS OUTLET	762	7.75	44.4	3.36	34.45	19.0
9/23/2022	SF2 WCS OUTLET	762.1	7.75	39.9	3.02	34.41	19.0