2021 Annual Self-Monitoring Report
Don Edwards San Francisco Bay National Wildlife Refuge
Fremont, California

Prepared for:
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Introduction

The South Bay Salt Pond Restoration Project (Project) 2021 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 a new format that incorporates 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 2021 3) A summary of 2021 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). This Report will also be submitted to NOAA's National Marine Fisheries Service (NMFS) because we have included additional fisheries monitoring conducted as part of the Science Program's Applied Studies, which are intended to fill the most important gaps in our knowledge about South San Francisco Bay (South Bay) ecosystem.

It is anticipated that both water quality and fisheries information will help the Water Board 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) are:

- Most ponds maintained 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.

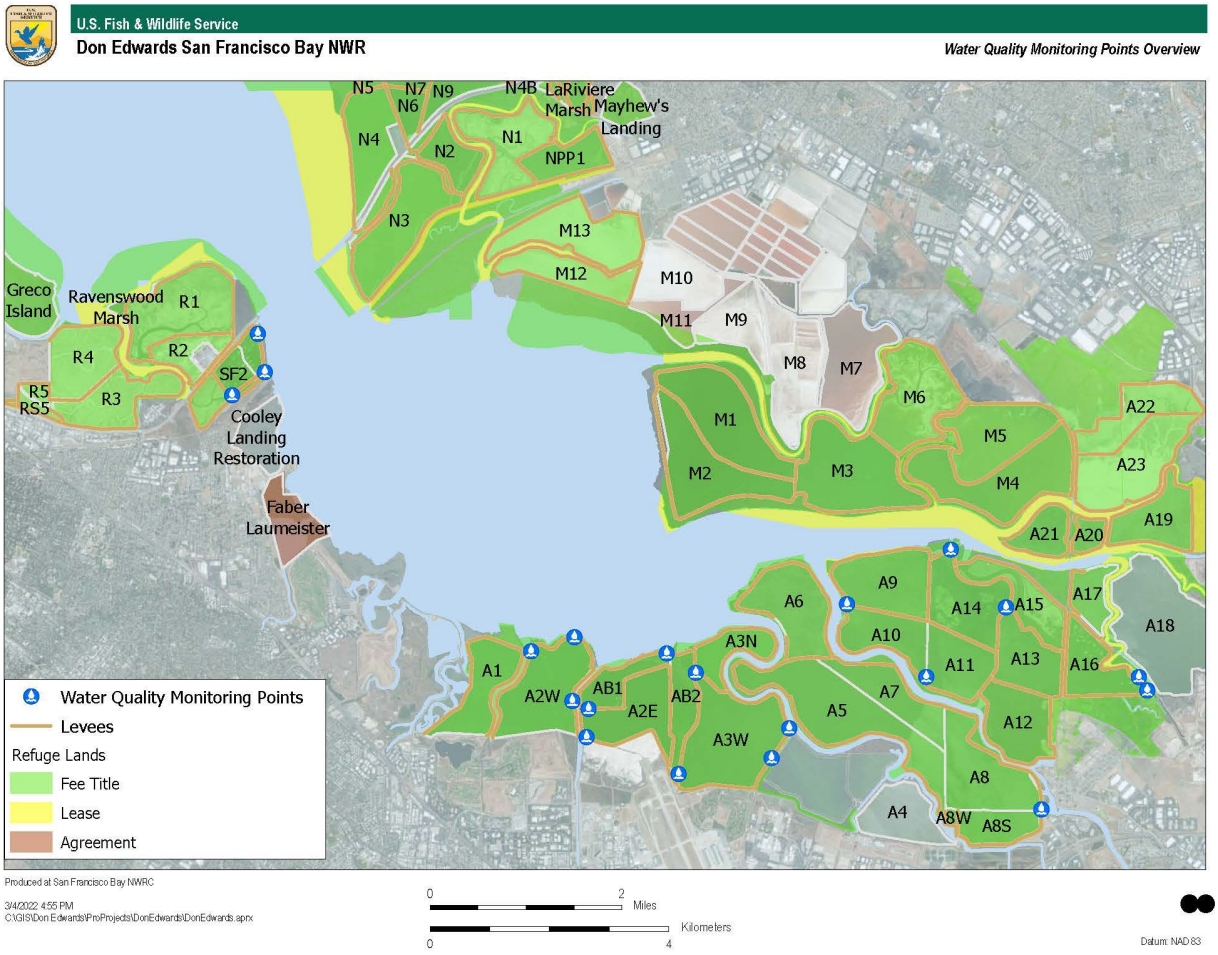
- Detect any adverse environmental conditions: HAB's, anoxic events leading to fish mortality, avian influenza.

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

Figure 1. Overview of Ponds



Results

Water quality measurement data and pond function information is presented below for each pond/pond system, and compared to RWQCB permit 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 Table 1. Pond R5/S5 levee, pond bottom and WCS construction continued in 2021, therefore no discharge occurred (Figure 1). All data collected during monthly water quality monitoring sampling, including discharge locations and pond CPs, can be found in Appendix 1.

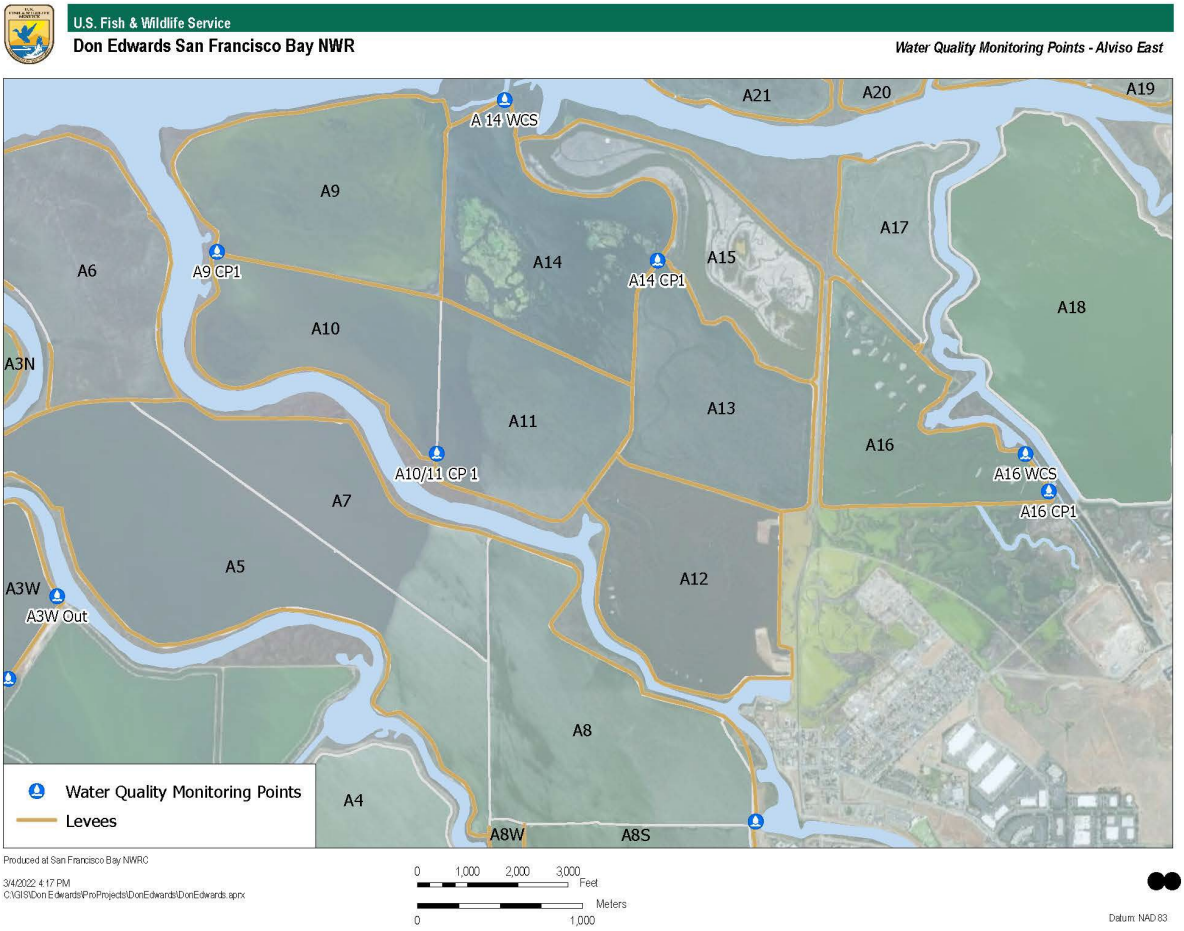
Table 1: Water quality measurements at Refuge discharge locations from June to September. Results are average values.

DATE	SITE	Barometer (mmHg)	pH	ODO (% Sat)	ODO (mg/L)	Sal (psu)	Temp (°F)
6/17/2021	A8	755.1	8.6	190.1	13.4	20.5	83.6
7/13/2021	A8	759.1	8.5	121.9	8.9	24.3	76.0
8/18/2021	A8	757.8	8.2	64.7	4.8	24.3	73.4
9/17/2021	A8	760.4	8.2	47.7	3.6	25.6	71.6
6/17/2021	A14 WCS	755.1	8.4	100.4	6.8	31.8	78.4
7/13/2021	A14 WCS	759.0	7.9	71.3	5.3	26.7	71.9
8/18/2021	A14 WCS	758.1	7.6	66.0	4.8	29.2	72.6
9/17/2021	A14 WCS	760.8	7.6	70.2	5.1	32.1	70.8
6/17/2021	A16 WCS	755.0	9.1	194.3	13.1	21.7	85.4
7/13/2021	A16 WCS	758.8	8.5	109.0	8.1	14.3	79.0
8/18/2021	A16 WCS	758.2	8.2	78.4	6.0	17.4	74.9
9/17/2021	A16 WCS	760.9	8.3	75.0	5.7	18.9	73.9
6/17/2021	A2W WCS	757.1	8.5	114.2	8.0	32.5	75.4
7/13/2021	A2W WCS	760.4	8.5	104.8	7.5	33.9	72.1
8/17/2021	A2W WCS	757.5	7.9	76.5	5.6	27.9	72.4
8/30/2021	A2W WCS	756.4	8.4	101.9	7.2	33.8	73.7
6/17/2021	A3W WCS	756.2	8.3	119.8	8.1	25.5	82.9
8/17/2021	A3W WCS	756.9	8.2	63.5	4.6	26.2	75.2

Alviso Unit: A8 Pond Complex

The Pond A8 system consists of Ponds A5, A7, A8N, and A8S (Figure 2). This system 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 and future plans include breaching Pond A8 Complex to restore full-tidal exchange.

Figure 2. Alviso Pond Complexes A8 and A14 and sample locations.



The A8 Pond Complex is an eutrophic system with high amounts of primary production. This leads to a hyper oxygenated state during peak times for photosynthesis. Oxygen levels fluctuate throughout the day reaching their low points during the times respiration outpaces

photosynthesis. Water samples collected during low tide in June and July detected the highly oxygenated water discharging into Guadalupe Slough (Table 1). The August and September measurements were taken during high tide and documented the low oxygenated water of Guadalupe Slough flowing into A8. Oxygen states are generally lower in the bay and surrounding creeks and sloughs due to high levels of suspended sediments which limit primary production. Salinity levels in the Pond A8 Complex are well below the 40 ppt threshold set for pond discharges by the RWQCB.

Alviso Unit: A14 Pond Complex

The Pond A14 system consists of Ponds A9, A10, A11, A14, and Ponds A12, A13, and A15 (Figure 2). 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). Discharges from Pond A14 are well below permit requirements (Table 1) and water quality within Ponds A9, A10 and A11 were nominal (Appendix 1). The A9 WCS was replaced in 2021. The A14 WCS remains inoperable, allowing 2 way flow and is scheduled for repairs in 2022. In 2021, A12 and A13 batch ponds were managed for shallow water, while A15 was managed dry for snowy plovers.

Alviso Unit: Pond A16

Pond A16 provides 243 acres of managed shallow pond habitat with 16 nesting islands (along with 4 existing islands) (Figure 2). 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. Discharges from A16 WCS are within permit requirements (Table 3) and salinity levels are low compared to the rest of the ponds, due to its proximity to freshwater input from the Santa Clara Valley Water District water treatment plant discharge.

Alviso Unit: Ponds A1 and A2W

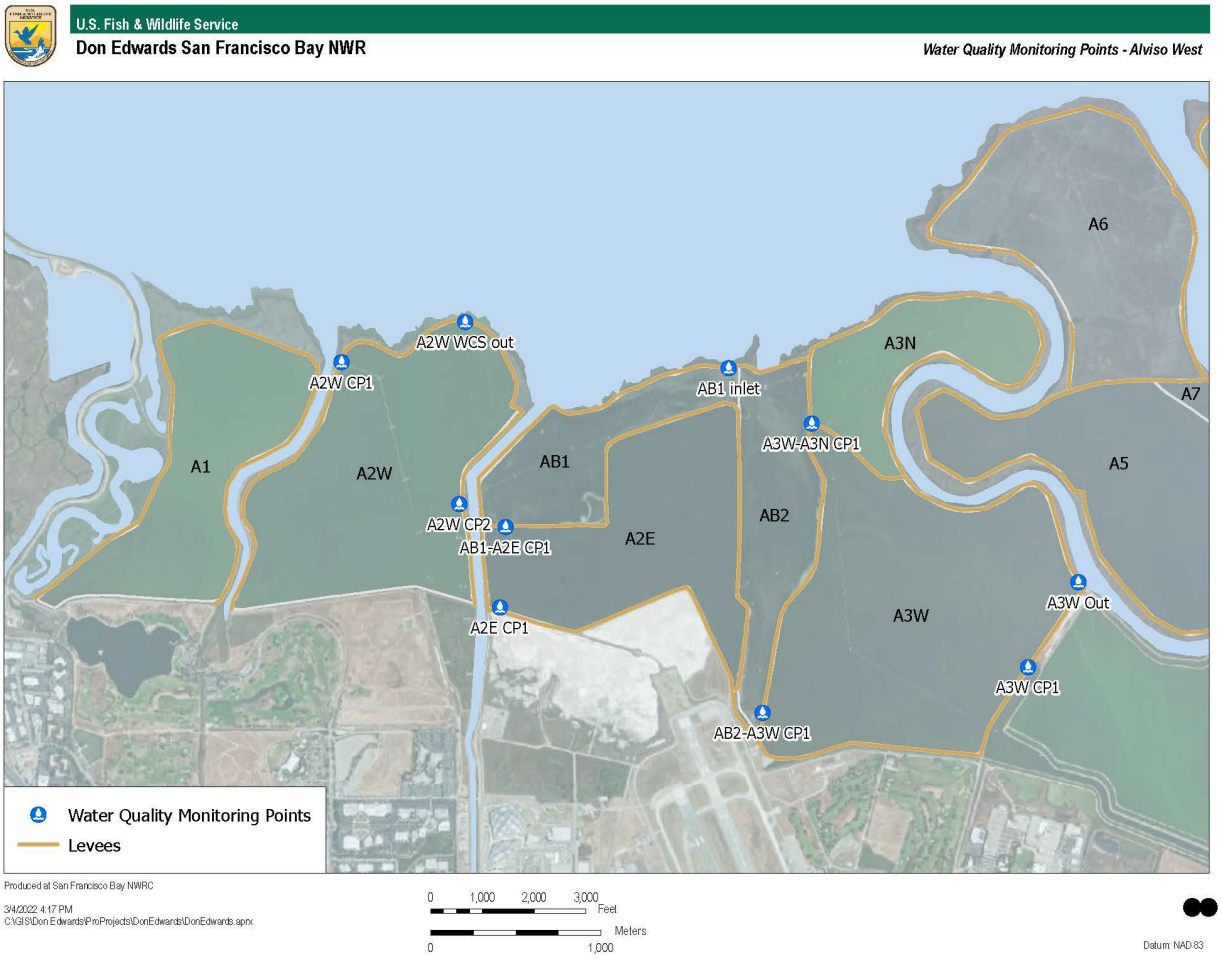
The main water quality objective for Ponds A1 (intake) and A2W (outlet) is to maintain full tidal circulation while maintaining discharge salinities to the Bay at less than 40 ppt (Figure 3). The two WCSs and siphon between Ponds A1 and A2W are fully functional. Discharge from A2W is well within permit requirements (Table 1). In addition to discharge measurements, several Collection Points were established in A2W. Of note is the results from June at Pond A2W CP2 (Appendix 1). Measurements taken at the surface and one meter depth highlighted the water stratification, with a layer of higher oxygenated water over a layer of water with lower levels of dissolved oxygen. This is normal for salt pond systems. Circulating a greater volume of water will reduce the effects of stratification. These ponds are part of Phase 2 of the Project, and are likely to be breached in the next 3 years to restore the ponds to tidal marsh.

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

The Alviso Pond System A3W consists of Ponds AB1, AB2, A3W, A2E, and A3N (Figure 3). 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.

At the beginning of the season, the AB1 WCS was inoperable, allowing 2 way flow. It was replaced in the fall and winter of 2021 (see Refuge O&M update). Even though the AB1 WCS was broken, within pond water quality and pond discharges into Guadalupe Slough were all well within acceptable parameters (Table 1 and Appendix 1).

Figure 3. A2W & A3W pond complexes and sample locations.

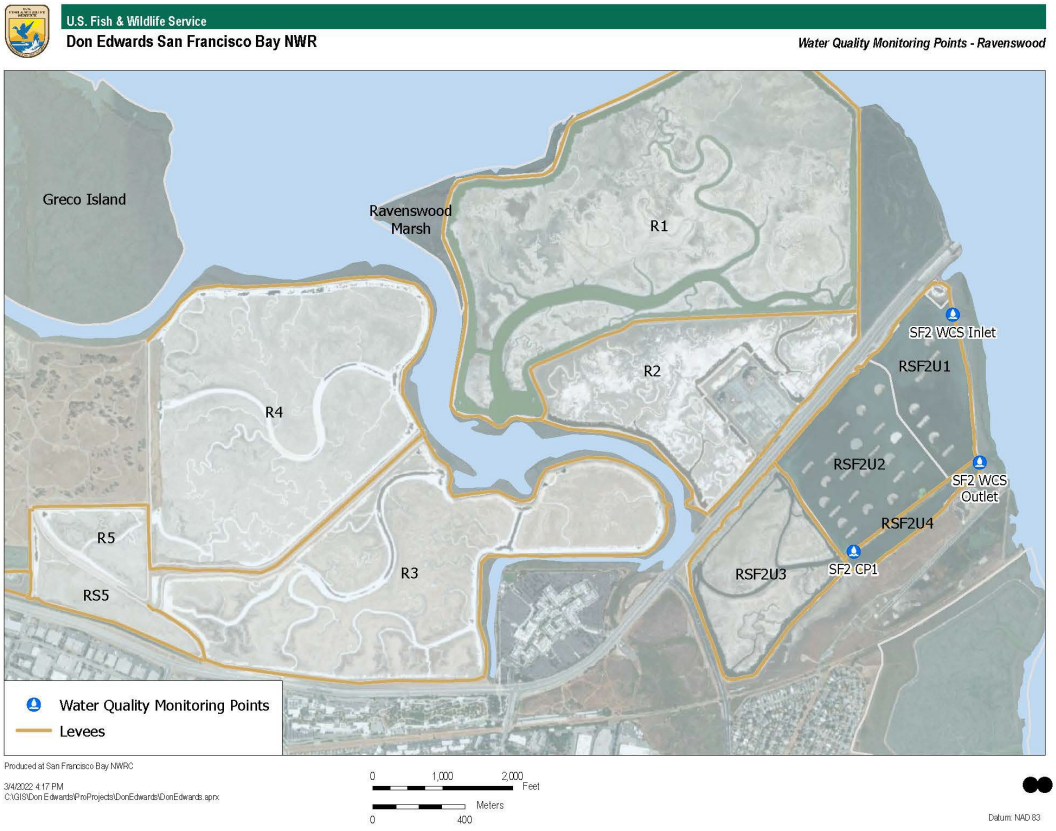


Ravenswood Unit: Pond SF2

The objectives of the Pond SF2 System is 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 4). 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.

Salinity levels from discharge are within permit requirements (Table 1). Like the many of the managed ponds, Pond SF2 is a eutrophic system. We see low oxygen levels in the morning before photosynthesis outpaces respiration. Oxygen levels start to climb throughout the day and will then decline again at night. Shorter resident times and more water through the system will keep oxygen extremes to a minimum. Water in the bay has high turbidity, leading to low primary production. When water enters the ponds, the silt starts to fall out of the water column allowing more sunlight to penetrate and increasing the number of photosynthetic organisms. Longer water resident times give more time for algae to accumulate.

Figure 4. Sampling Locations in Pond SF2, Ravenswood Unit.



In general, we see that water quality in the ponds is better with increased circulation and shorter residence times. The South Bay Salt Pond Restoration Project goals of increasing water flow through the ponds by adding notches to levees and improving water control structures is having a positive effect on water quality in the ponds. The USFWS management actions of allowing as much water as possible to circulate through the pond systems while protecting levees and critical infrastructure is working to provide quality habitat to South Bay fish and wildlife.

Problems Encountered in 2021

A few different issues influenced water monitoring in 2021. In July 2021, the switch to summer operation water levels temporarily flooded access to a few sites in pond complex A3W, preventing water quality monitoring in this pond. Starting in August, construction on A8 ecotone, replacement of two WCSs and levee repairs at Moffett Ponds, and levee improvements around the A9 loop, limited access to some sample sites. The rainy season started in October this year. Access to sites once the winter rain begins is not recommended due to poor levee conditions. In addition, WCS at the end of their life continue to fail. WCS are replaced as funding becomes available. In 2022, the R5/S5 pond and Pond R3 should come online and water quality sampling will begin.

Fish Kills

No large fish kills were detected in 2021. Over the course of the year only a few striped bass were found dead, cause undetermined.

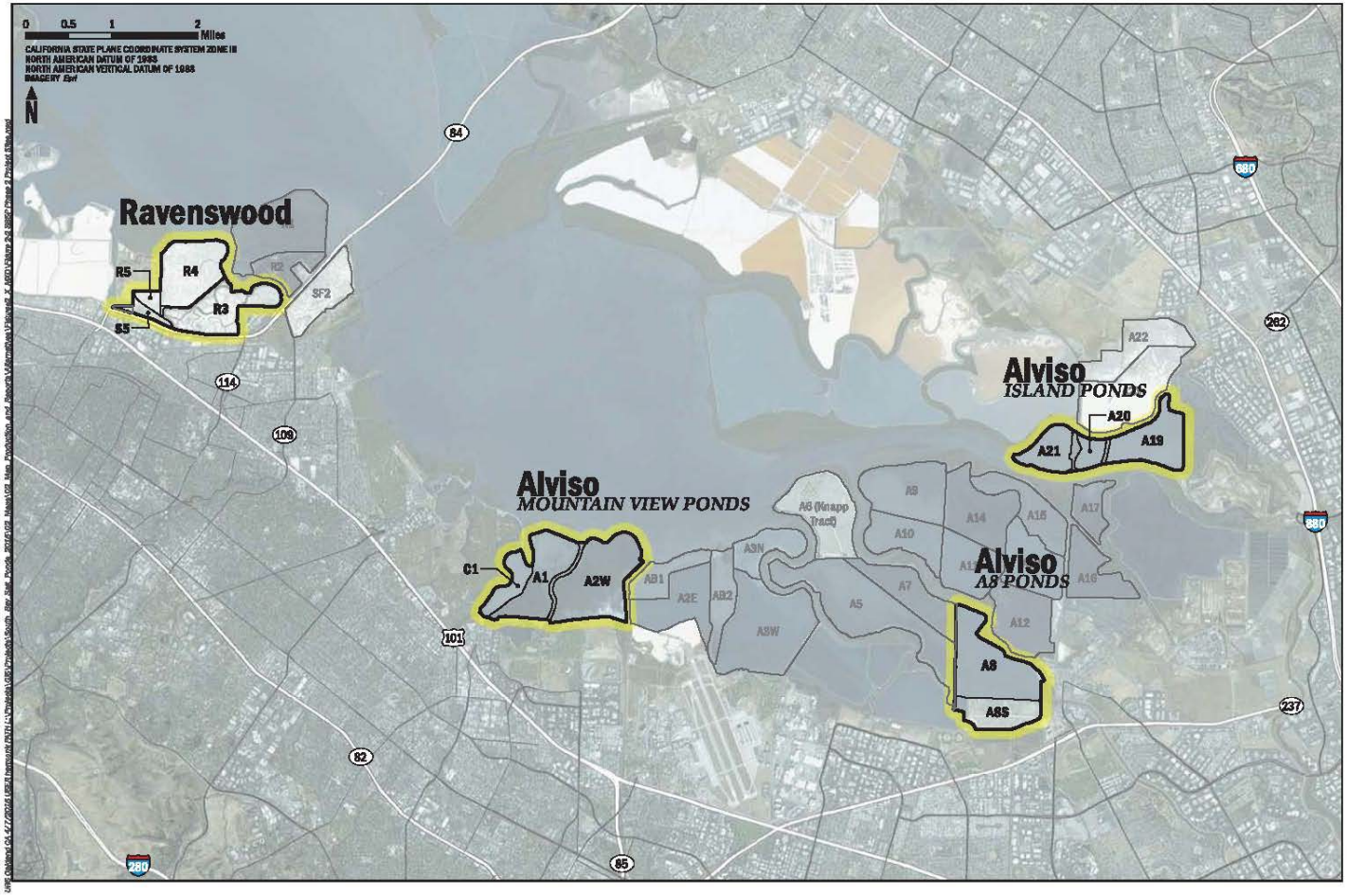
Harmful Algal Blooms

While not observed in recent years, harmful algal blooms (HABs) have been a perennial issue for water quality in Refuge ponds. HABs typically occur when high nutrient concentrations coincide with warm water and low circulation. South Bay salt ponds contain resident population of HAB organisms (Thébaultet al. 2008). In a recent survey, 98% of mussels sampled within the estuary in 2015 contained at least one of four HAB-associated toxins. Under the right conditions the bioaccumulation of these toxins in marine mussels can cause acute or chronic toxicosis in marine mammals and waterbirds (Gibble et al. 2017), potentially affecting the Refuge's ability to achieve management objectives.

South Bay Salt Pond Restoration Project Progress in 2021

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 systems (Figure 5) 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

Figure 5. 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

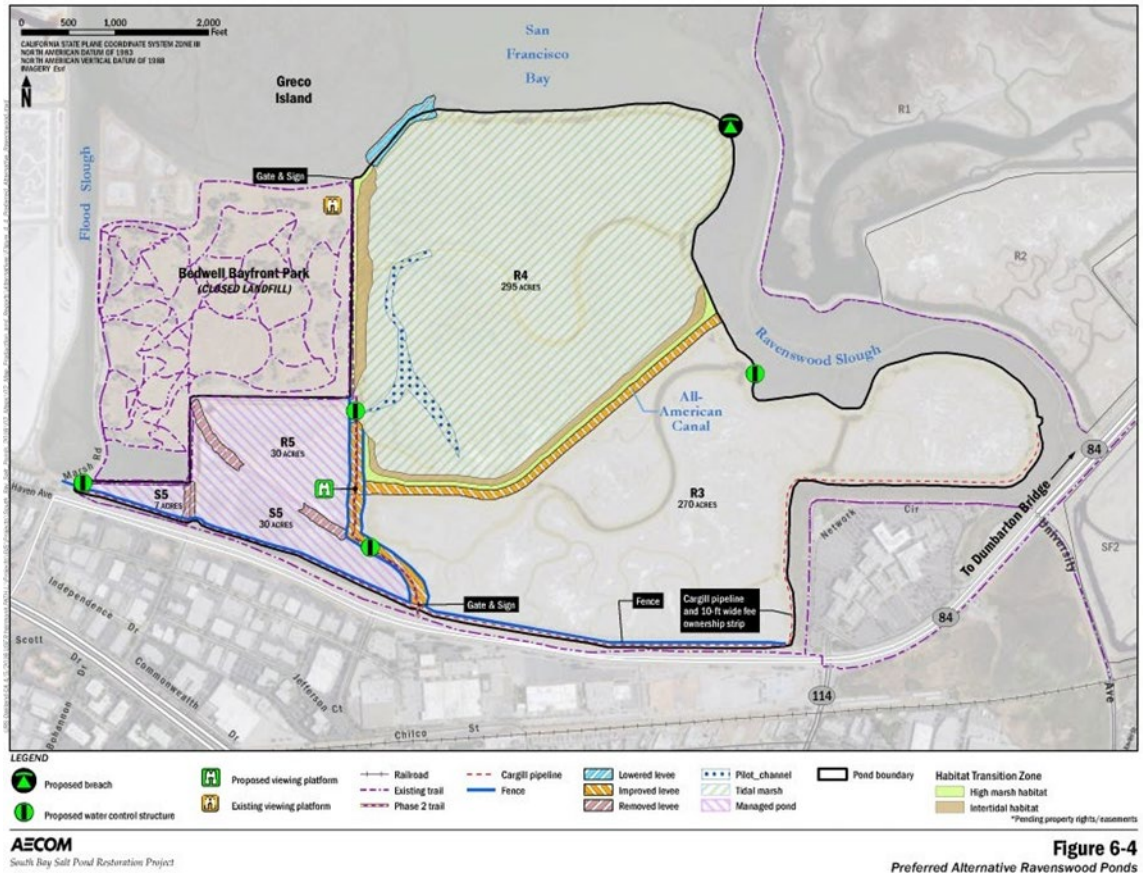
waterfowl, shorebirds, and anadromous and resident fish populations.

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 6). As part of Phase 2 of the Project, in 2019 and 2020, Phase 2 activities at the Ravenswood Ponds included the import of fill for the All-American Canal and habitat transition zone/ecotone at Pond R4, as well as the removal of the R5/S5 interior levee and completion of the waterbird island in R5/S5. As required by the Phase 2 RWQCB permit, Pacific States 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) (Service and H. T. Harvey & Associates 2018). Refer to HT Harvey Reports, Project No. 3685-01.

Figure 6. Map of Ravenswood Pond Complex and proposed restoration actions.



In 2021, no material was available for import, but construction began on the installation of four water control structures and associated earthwork, rip rap placement, and construction of appurtenant maintenance access structures. Also, one of the two habitat transition zones was out-planted with nursery-grown native plants and a native seed mix.

By the end of Phase 2 actions, 294 acres of new tidal marsh will be added at Ravenswood when the levee at pond R4 is breached to the bay and 67 acres of improved pond habitat constructed by removing internal levees in ponds R5 & S5 for ducks and shorebirds. Pond R3 (270 acres) will be managed as dry salt flat for threatened western snowy plovers to nest. A new public access trail and viewing platform will be added between Bayfront Expressway and the southern edge of Bedwell Bayfront Park.

In 2022, Phase 2 activities will include completing the installation of four water control structures, importing the rest of the material needed to finish levee improvements and the 2nd habitat transition zone, building the public access trail and viewing platform, and finishing the project by excavating channels and breaching Pond R4 to connect it to the San Francisco Bay.

Alviso Unit: A8 Ponds (Ponds A8 & A8S)

In 2021, the Santa Clara Valley Water District (Valley Water) and the Refuge imported over 60,000 cubic yards of soil to the A8 Ponds for Phase 2 of the Project (Figure 7). 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 two habitat transition zones at the southern edge and corners of the A8 Ponds. 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. 4306-03 for details.

Alviso Unit: Island Ponds (Ponds A19 & A20)

Between October and December of 2021, the Phase 2 construction action at Alviso Ponds A19 and A20 (the Island Ponds) was initiated and nearly completed (work continued into mid-January to complete the project) (Figure 8). 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.

Figure 7. Map of Phase 2 operations at Ponds A8 & A8S

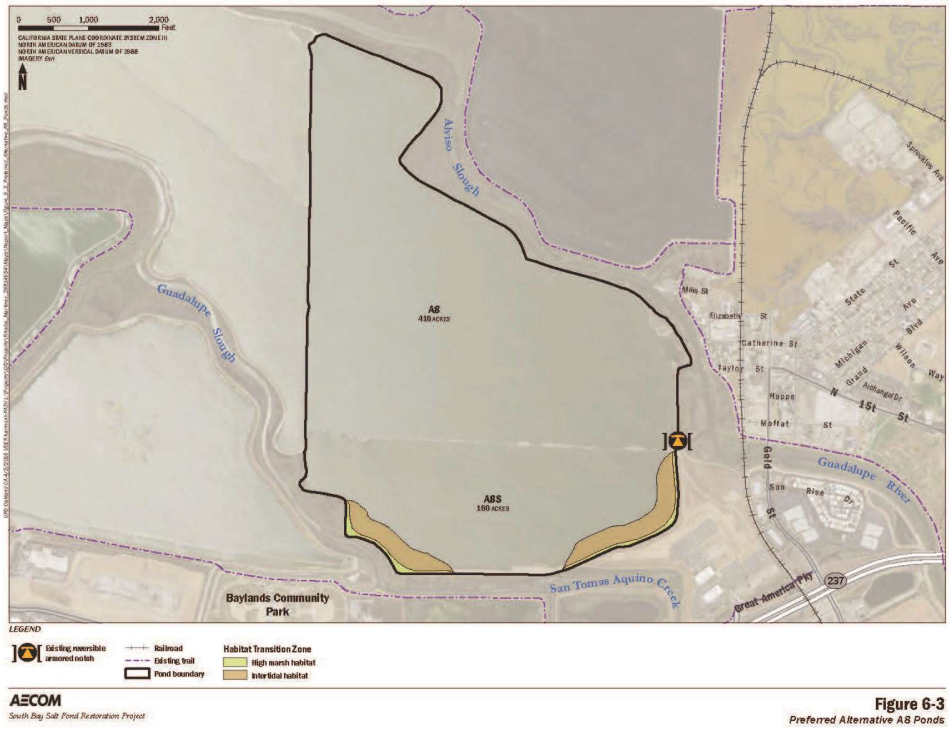
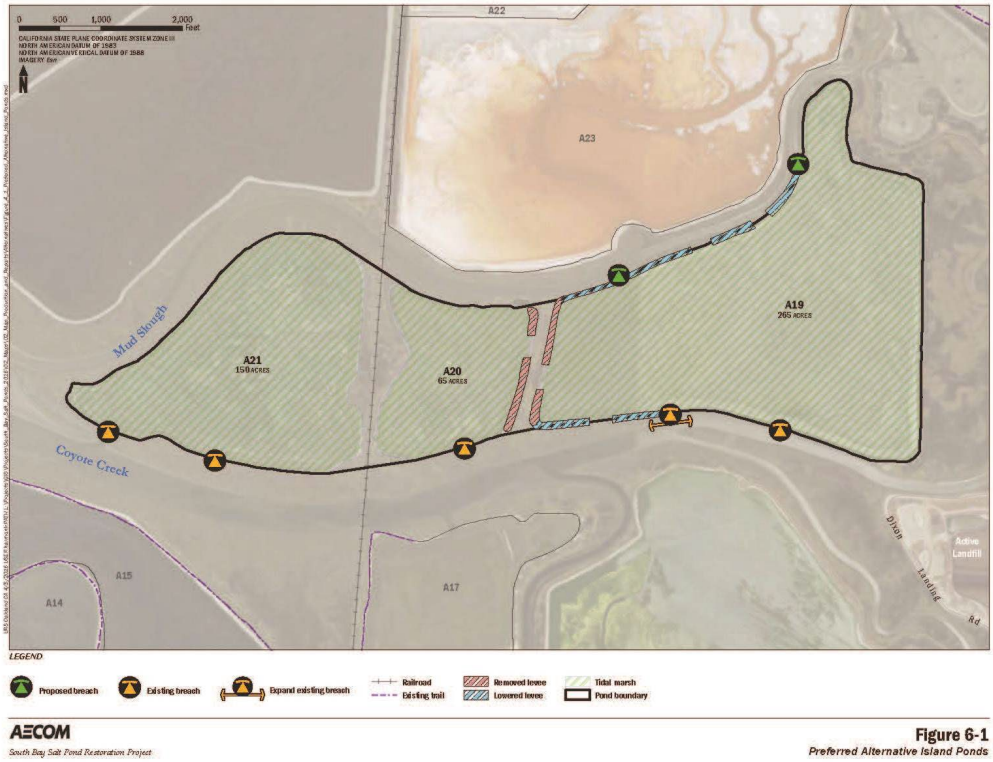


Figure 8. Map of Phase 2 activities at Island Ponds



The permitted Phase 2 project at this site was reduced in scale because of the greater-than-expected numbers of salt marsh harvest mouse nests that were discovered as the approved vegetation clearing was taking place. To avoid unnecessary impacts to this special-status species and still achieve the goals of the project, selected areas without suitable marsh vegetation habitat were identified, and the levee modifications were limited to those locations instead of the full extent of modifications originally planned. No additional construction work is planned for these ponds in 2022.

Refuge Operations and Maintenance Activities in 2021

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 2021 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

Starting in 2020 and completed in 2021, fill was imported along the levee along the eastern side of Ponds A13 and A15 and brought up to a minimum elevation of 11 feet NAVD88 (Figure 9). Crushed gravel aggregate was added to the top of the levee for accessibility. 4,417 feet of Flexamat was added to the interior pond side of A13 and A15 to prevent wind erosion (Figure 10). This levee was identified as a priority location for repair in our Pond Infrastructure Master Plan (in progress). In addition, the A9 WCS replacement was completed in 2021.

O&M Deferred Maintenance will continue in 2022 with the replacement of the A14 WCS.

Alviso Unit: Ponds AB1-A3W

In fall of 2021, construction began in the Moffett Ponds, as part of a USFWS Operations and Maintenance activity (Figure 11). This work included removal of one 36" gate at AB1 and the removal and replacement of the 48" gate at AB1. Work on removing and replacement of the 36" gate between AB2 and A3W was started in 2021 and completed in 2022. In addition to these WCS, the levee height was increased to a minimum elevation of 13.1 feet NAVD88 along the 22,460 linear feet of the AB1 and AB2 external levees with 5,291 CY of imported fill and 2,208 tons of riprap.

O&M Deferred Maintenance will continue in 2023 with increasing 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.

Figure 9. Refuge O&M in the Alviso Unit: A9-A15

Figure 10. Picture of Flexamat installation on pond-side of Pond A15.

Figure 11. Refuge O&M in the Alviso Unit: AB1-A3W

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

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 September 2021 (Service and NMFS, 2021). As part of Phase 2 of the Project the Refuge, in coordination with NMFS, has prepared this fish and habitat monitoring plan to document the effects of Project activities on federally listed and managed fish, per the May 24, 2018, NMFS biological opinion (WCR-2017-6803). At the time of preparation of the South Bay Salt Pond Restoration Project Phase 2 Monitoring Plan and Water Quality Self-monitoring Program for Refuge Lands (Strong and Underwood, 2018), only general language for fish monitoring was included. Since then, Project, Refuge and NMFS staff have developed this detailed fish monitoring plan to be included as an appendix to the Phase 2 Monitoring Plan. This plan includes the following components:

- Improve understanding of Project actions on fish and invertebrate communities in breached ponds, managed ponds, adjacent sloughs, and San Francisco Bay (Bay) waters.
- Evaluate fish and invertebrate species diversity, presence/absence, and seasonal patterns in breached ponds, managed ponds, and adjacent sloughs in Ravenswood and

Mountain View areas affected by Phase 2 activities of the Project.

- Conduct quarterly monitoring for a minimum of three years.
- Monitor water quality and habitat characteristics in breached ponds, managed ponds, adjacent sloughs, and Bay waters.

Water quality monitoring and fish sampling will begin at the Ravenswood Unit in 2022. In addition, fish community monitoring by UC Davis will continue in the South Bay.

Steelhead Entrainment Studies

On December 16, 2020, FISHBIO submitted their Pond A8 Notch and Guadalupe River PIT Antenna Operation Final Report to the SCC. This study is a continuation of the studies started in 2014 by Jim Hobbs, UC Davis, to assess the risk of entrainment and fate of entrained juvenile/smolt steelhead at the muted tidal connection of Pond A5, A7, A8, and A8S with the Guadalupe River/Alviso Slough. A total of 305 O. mykiss were tagged with Passive Integrated Transponders (PIT tags) in association with these surveys. Total number of O. mykiss implanted with PIT tags in the Guadalupe Watershed (Table 2 from FISHBIO 2020, and updated in 2021 by Valley Water*).

Total number of O. mykiss implanted with PIT tags in the Guadalupe Watershed (Table 2 from FISHBIO 2020, and updated in 2021 by Valley Water).*

Tagging Period	Total Tagged	Tagging Organization
Winter 2013- 2014	70	UC Davis
Fall 2014	28	UC Davis
Fall 2018	125	Valley Water
Fall 2019	~~70~~ (82*)	Valley Water

Antennas were deployed to detect PIT tagged steelhead in four of the past seven years (2014, 2015, 2019 and 2020; Hobbs 2015, FISBIO 2020) at Pond A8 notch, Pond A5 Water Control Structure (WCS), Pond A7 WCS and Guadalupe River. Additional antennas were deployed by Valley Water from 2018 to 2020 in the Upper Guadalupe Watershed and their results are presented in separate reports (https://www.valleywater.org/project-updates/creek-river-projects/fahce-fish-and-aquatic-habitat-collaborative-effort). In 2014, PIT antennas were installed at the Pond A5 and Pond A7 water control structures, but due to failing infrastructure, they were not continued in following years. During these surveys, six steelhead were detected in the Guadalupe River in 2014; five of those fish presumably navigated past the Pond A8 armored notch and just one was detected at the Pond A8 antenna. That single individual at the Pond A8 notch was detected by Jim Hobbs in 2014 who reported, "Given the tide level prediction, the height of notch construction and our observations of water levels and flow from the pond, the data suggest the fish was likely exiting the pond when detected as the pond would have been spilling into the starter channel at the time of detection" (Hobbs 2014).

Additional tagged fish detected at the A8 notch include one PIT tag of an unknown species was recorded at 3:30 AM on December 4, 2019 at the Pond A8 notch (FISHBIO 2020), and one

tagged adult striped bass (originally tagged to access predation risk for steelhead) was detected both exiting and entering Pond A8 (Hobbs 2015). At the Guadalupe River antenna, just one steelhead (tagged in 2018) was detected in April 2019 (900_226000319368). Years between the UC Davis survey and the FISHBIO surveys included drought years when CDFW collecting permits were not awarded and additional planning time for Phase 2 permits.

In addition to the near-zero detection of steelhead at the Pond A8 notch, both studies experienced very challenging survey conditions, including faulty antennas, loss of antennas, vandalism of solar panel and cables, decreased PIT tag detection efficiency due to high flows, and reader malfunctions. Unfortunately these technical challenges have impeded this research effort and work to date has yielded little to no information about juvenile steelhead movements around the notch structure and other Refuge water control structures. The South Bay Salt Ponds Restoration Project has begun the planning process to breach the Pond A8 Complex and restore full-tidal exchange.

There are challenges associated with monitoring salmonids and connectivity associated with water control structures. A continued investigation is important to better understand the risks to salmonids presented by the Pond A8 Complex (NMFS 2016). The recommendation to continue PIT tagging steelhead in partnership with Valley Water for cost savings and applying lessons learned to improve probability of yielding reliable results has been included in the 2021 Fish Monitoring Plan and will be considered as funding becomes available.

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Appendix 1: Monthly water quality monitoring at multiple locations throughout the ponds was conducted using the YSI multimeter from June thru September 2021.

Pond A8

DATE	TIME	SITE	Barometer (mmHg)	pH	ODO (% Sat)	ODO (mg/L)	Sal (psu)	Temp (°F)
6/17/2021	3:10:12 PM	A8 WCS	755	8.65	183.9	13.25	20.52	83.6
6/17/2021	3:11:03 PM	A8 WCS	755.1	8.63	196.2	13.55	20.48	83.6
7/13/2021	2:51:49 PM	A8 WCS	759.1	8.53	120.9	8.79	24.31	76
7/13/2021	2:52:30 PM	A8 WCS	759.1	8.5	122.9	8.93	24.33	76
8/18/2021	1:37:15 PM	A8 WCS	757.8	8.22	69.5	5.19	24.3	73.3
8/18/2021	1:38:01 PM	A8 WCS	757.7	8.2	59.9	4.46	24.37	73.5
9/17/2021	2:06:40 PM	A8 WCS	760.4	8.19	54.1	4.08	25.61	71.6
9/17/2021	2:07:24 PM	A8 WCS	760.4	8.17	41.2	3.1	25.64	71.6

Ponds A9, A10, A11, and A14

DATE	TIME	SITE	Barometer (mmHg)	pH	ODO (% Sat)	ODO (mg/L)	Sal (psu)	Temp (°F)
6/17/2021	3:37:27 PM	A10 A11 CP1	755.2	8.28	126.1	8.57	31.23	78.9
6/17/2021	3:38:06 PM	A10 A11 CP1	755.2	8.28	133.2	8.88	34.63	78.9
6/17/2021	3:48:11 PM	A9 CP1	755.3	8.93	205.4	11.92	40.68	90.8
6/17/2021	3:49:14 PM	A9 CP1	755.3	8.94	216.3	12.55	40.78	90.8
6/17/2021	4:01:19 PM	A14 WCS	755	8.37	100.4	6.83	31.92	78.3
6/17/2021	4:02:08 PM	A14 WCS	755.2	8.37	100.4	6.83	31.74	78.4
6/17/2021	4:12:47 PM	A14 CP1	755.2	8.2	102.7	6.72	31.44	82.8
6/17/2021	4:13:43 PM	A14 CP1	755.2	8.21	101.9	6.68	31.49	82.6
7/13/2021	3:22:38 PM	A10 A11 CP1	759.2	8.26	130	8.71	36.48	77.2
7/13/2021	3:23:24 PM	A10 A11 CP1	759.1	8.26	147.1	9.83	36.52	77.5
7/13/2021	3:33:59 PM	A9 CP1	759.2	8.28	133.1	8.65	34.22	81.9
7/13/2021	3:34:50 PM	A9 CP1	759.2	8.27	139.4	9.05	34.25	82
7/13/2021	3:48:31 PM	A14 WCS	759	7.9	78.2	5.84	26.64	71.9
7/13/2021	3:49:27 PM	A14 WCS	759	7.86	64.3	4.8	26.66	71.9
7/13/2021	4:02:30 PM	A14 CP1	759.2	8.28	110.2	7.63	33.45	75.6
7/13/2021	4:03:05 PM	A14 CP1	759.2	8.26	107.9	7.47	33.47	75.6
8/18/2021	12:35:11 PM	A14 CP1	758	7.95	111.8	7.94	34.21	72.6

8/18/2021	12:36:20 PM	A14 CP1	758.2	7.97	115.3	8.18	34.29	72.6
8/18/2021	12:49:57 PM	A14 WCS	758	7.55	68.8	5.03	29.18	72.6
8/18/2021	12:50:47 PM	A14 WCS	758.1	7.57	63.1	4.61	29.16	72.6
8/18/2021	1:04:02 PM	A9 CP1	758.1	8.21	188.8	13.2	33.7	74.4
8/18/2021	1:05:02 PM	A9 CP1	758.2	8.25	219.6	15.31	34.01	74.6
8/18/2021	1:14:00 PM	A10-A11 CP1	758.2	8.02	84	5.98	31.69	73.7
8/18/2021	1:15:02 PM	A10-A11 CP1	758.2	8.01	73.7	5.25	31.39	73.8
9/17/2021	12:56:04 PM	A14 CP1	760.9	8.23	148.2	10.23	36.22	74.3
9/17/2021	12:57:01 PM	A14 CP1	761	8.22	173.1	11.9	36.44	74.5
9/17/2021	1:10:42 PM	A14 WCS	760.8	7.6	74.1	5.42	32.13	70.8
9/17/2021	1:11:46 PM	A14 WCS	760.8	7.58	66.2	4.85	32.11	70.7
9/17/2021	1:26:55 PM	A9 CP1	760.9	8.32	179.6	12.21	36.32	75.8
9/17/2021	1:27:53 PM	A9 CP1	761	8.36	233.1	15.81	36.35	76
9/17/2021	1:39:55 PM	A10-A11 CP1	761	8.01	104.8	7.24	39.12	72.5
9/17/2021	1:40:50 PM	A10-A11 CP1	761	8.01	105.7	7.29	39.11	72.6

Pond A16

DATE	TIME	SITE	Barometer (mmHg)	pH	ODO (% Sat)	ODO (mg/L)	Sal (psu)	Temp (°F)
6/17/2021	4:28:46 PM	A16 WCS	755	9.14	177.4	11.98	21.63	85.3
6/17/2021	4:29:22 PM	A16 WCS	754.9	9.15	211.1	14.23	21.67	85.5
7/13/2021	4:23:10 PM	A16 WCS	758.8	8.47	107.1	8.03	14.32	78.6
7/13/2021	4:24:03 PM	A16 WCS	758.8	8.46	110.8	8.25	14.28	79.4
8/18/2021	12:11:31 PM	A16 WCS	758.1	8.2	82.5	6.3	17.32	74.9
8/18/2021	12:12:30 PM	A16 WCS	758.2	8.22	74.3	5.68	17.45	74.8
9/17/2021	12:13:41 PM	A16 CP1	761	8.58	147.6	10.36	29.86	76.3
9/17/2021	12:14:11 PM	A16 CP1	761	8.58	157.5	11.06	29.87	76.3
9/17/2021	12:20:48 PM	A16 WCS	760.9	8.26	77.5	5.94	18.85	73.9
9/17/2021	12:21:37 PM	A16 WCS	760.8	8.26	72.4	5.54	18.86	73.9

Pond A2W

DATE	TIME	SITE	Barometer (mmHg)	pH	ODO (% Sat)	ODO (mg/L)	Sal (psu)	Temp (°F)
6/17/2021	11:34:25 AM	A2W CP1	756.9	8.55	105.9	7.37	33	75.3
6/17/2021	11:35:28 AM	A2W CP1	756.9	8.55	107.1	7.43	33.06	75.7
6/17/2021	11:47:25 AM	A2W WCS OUT	757.1	8.55	115.1	8.09	32.51	74.6
6/17/2021	11:48:30 AM	A2W WCS OUT	757.1	8.52	113.2	7.84	32.48	76.1
6/17/2021	12:02:33 PM	A2W CP2 (surface)	756.9	8.4	82.1	5.68	32.26	76.5
6/17/2021	12:04:32 PM	A2W CP2 (1 m)	757	8.32	37.4	2.66	32.57	73.4

6/17/2021	12:06:30 PM	A2W CP2 (1 m)	756.9	8.32	35.2	2.5	32.59	73.5
6/17/2021	12:07:32 PM	A2W CP2 (surface)	757	8.4	83.3	5.75	32.22	76.6
7/13/2021	11:29:45 AM	A2W CP1	760	8.54	110.5	7.91	34.05	71.8
7/13/2021	11:30:38 AM	A2W CP1	760	8.55	112.7	8.07	34.11	71.8
7/13/2021	11:42:49 AM	A2W OUT	760.4	8.49	103.7	7.41	33.89	72
7/13/2021	11:43:28 AM	A2W OUT	760.3	8.49	105.8	7.56	33.94	72.2
7/13/2021	11:56:07 AM	A2W CP2	760.4	8.35	61.8	4.43	33.56	72.1
7/13/2021	11:57:05 AM	A2W CP2	760.3	8.35	56.6	4.05	33.57	72.1
8/17/2021	10:49:34 AM	A2W CP1	757.1	8.35	99.3	7.11	32.1	72.9
8/17/2021	10:50:26 AM	A2W CP1	757.2	8.36	90.9	6.5	32.19	73
8/17/2021	11:03:53 AM	A2W OUT	757.5	7.91	79.6	5.87	27.94	72.4
8/17/2021	11:04:50 AM	A2W OUT	757.5	7.86	73.4	5.42	27.82	72.4
8/17/2021	11:17:45 AM	A2W CP2	757.2	8.27	84.4	5.96	32.04	74.5
8/17/2021	11:18:45 AM	A2W CP2	757.3	8.26	70.8	4.99	32.17	74.7
8/30/2021	10:58:48 AM	A2W CP1	756.2	8.38	96.6	6.74	34.48	74.1
8/30/2021	10:59:38 AM	A2W CP1	756.2	8.38	95.8	6.69	34.45	74.1
8/30/2021	11:18:49 AM	A2W OUT	756.4	8.36	102	7.18	33.76	73.7
8/30/2021	11:19:31 AM	A2W OUT	756.3	8.35	101.7	7.16	33.75	73.7

Ponds AB1, A2E and A3W

DATE	TIME	SITE	Barometer (mmHg)	pH	ODO (% Sat)	ODO (mg/L)	Sal (psu)	Temp (°F)
6/17/2021	12:37:10 PM	AB1-A2E CP1	756.8	8.63	141.6	9.36	31.08	81.9
6/17/2021	12:38:02 PM	AB1-A2E CP1	756.8	8.62	145.1	9.59	31.06	82
6/17/2021	12:57:30 PM	AB1 INLET	756.4	7.74	76.7	4.83	28.33	89
6/17/2021	12:58:30 PM	AB1 INLET	756.4	7.73	74.6	4.7	28.3	89.1
6/17/2021	1:10:09 PM	A3W-A3N CP1	756.5	8.92	133.8	8.48	37.65	82.6
6/17/2021	1:11:01 PM	A3W-A3N CP1	756.6	8.92	136.4	8.66	37.6	82.4
6/17/2021	1:31:05 PM	A3W OUT	756.2	8.34	118.7	8.03	25.5	82.8
6/17/2021	1:32:03 PM	A3W OUT	756.2	8.33	120.9	8.17	25.51	83
6/17/2021	1:42:15 PM	A3W CP1	756.2	8.51	101.2	6.71	30.24	82.2
6/17/2021	1:43:03 PM	A3W CP1	756.2	8.5	96.4	6.39	30.31	82.2
6/17/2021	1:59:31 PM	AB2-A3W CP1	756.1	8.57	133.5	8.66	31	84.1
6/17/2021	2:00:24 PM	AB2-A3W CP1	756.1	8.56	155.6	10.06	30.99	84.5
6/17/2021	2:19:57 PM	A2E CP1	756.1	8.88	216.8	13.58	32.29	87.2
6/17/2021	2:20:46 PM	A2E CP1	755.9	8.87	217.2	13.6	32.34	87.2
6/17/2021	2:21:30 PM	A2E CP1	755.8	8.92	228.4	14.75	27.15	87.6
6/17/2021	2:22:19 PM	A2E CP1	755.9	8.9	222.4	13.88	32.39	87.5
6/17/2021	2:22:44 PM	A2E CP1	755.9	8.91	219.9	13.71	32.41	87.6
6/17/2021	2:23:23 PM	A2E CP1	755.9	8.92	221.2	13.79	32.43	87.6

7/13/2021	12:27:44 PM	AB1-A2E CP1	760.3	8.74	85.7	6.24	32.94	70.7
7/13/2021	12:28:28 PM	AB1-A2E CP1	760.3	8.75	78.7	5.73	32.84	70.8
7/13/2021	1:03:39 PM	AB1 INLET	760	7.81	93.2	6.66	29.04	74.9
7/13/2021	1:04:27 PM	AB1 INLET	760.1	7.79	89.5	6.39	29.1	75
8/17/2021	11:51:37 AM	AB1-A2E CP1	757.2	8.32	141	10.02	30.68	74.6
8/17/2021	11:52:49 AM	AB1-A2E CP1	757.1	8.33	158.5	11.24	30.78	74.7
8/17/2021	12:12:12 PM	AB1 INLET	757.1	7.68	62	4.59	26.44	72.8
8/17/2021	12:13:14 PM	AB1 INLET	757.1	7.67	58.9	4.36	26.44	72.8
8/17/2021	12:36:11 PM	A3W OUT	756.8	8.21	68.1	4.94	26.34	75.1
8/17/2021	12:37:16 PM	A3W OUT	756.9	8.18	58.9	4.27	26.1	75.2
8/17/2021	12:42:51 PM	A3W CP1	756.8	8.62	117.2	8.18	30.01	76.9
8/17/2021	12:43:45 PM	A3W CP1	756.9	8.66	108.4	7.57	30.31	76.5

Pond SF2

DATE	TIME	SITE	Barometer (mmHg)	pH	ODO (% Sat)	ODO (mg/L)	Sal (psu)	Temp (°F)
6/17/2021	10:24:20 AM	SF2 INLET	757.7	7.99	86.7	6.04	33.49	75
6/17/2021	10:25:02 AM	SF2 INLET	757.7	8.02	88.8	6.18	33.48	75.1
6/17/2021	10:34:39 AM	SF2 OUT	757.6	8.8	162	11.06	36.43	75.3
6/17/2021	10:35:19 AM	SF2 OUT	757.7	8.8	163.8	11.19	36.43	75.2
6/17/2021	10:45:46 AM	SF2 CP1	757.5	8.34	93.9	6.6	35.85	72.6
6/17/2021	10:46:18 AM	SF2 CP1	757.5	8.33	93.3	6.56	35.84	72.7
7/13/2021	10:04:09 AM	SF2 INLET	760.4	7.62	79.5	6.02	33.31	66.8
7/13/2021	10:05:02 AM	SF2 INLET	760.4	7.67	71.2	5.38	33.35	66.8
7/13/2021	10:22:44 AM	SF2 OUT	760.5	8.23	75.5	5.56	35.21	68.2
7/13/2021	10:23:27 AM	SF2 OUT	760.5	8.23	68.3	5.04	35.23	68.3
7/13/2021	10:33:15 AM	SF2 CP1	760.3	8.13	80.4	5.99	35.28	67.1
7/13/2021	10:34:06 AM	SF2 CP1	760.4	8.13	61.6	4.58	35.24	67.4
8/17/2021	9:18:11 AM	SF2 INLET	757.4	7.3	35.6	2.71	31.85	67.2
8/17/2021	9:19:17 AM	SF2 INLET	757.4	7.33	35	2.65	31.85	67.5
8/17/2021	9:45:35 AM	SF2 OUT	757.5	7.79	74.6	5.46	32.85	70.2
8/17/2021	9:46:30 AM	SF2 OUT	757.5	7.77	64.6	4.73	32.83	70.3
8/17/2021	9:57:10 AM	SF2 CP1	757.6	7.75	69.5	5.02	33.64	71.1
8/17/2021	9:58:13 AM	SF2 CP1	757.6	7.73	49.2	3.55	33.62	71.2
8/30/2021	9:32:39 AM	SF2 INLET	756.8	7.34	46.5	3.47	33.96	67.9
8/30/2021	9:34:25 AM	SF2 INLET	756.8	7.48	25.8	1.92	33.96	67.9
8/30/2021	9:41:16 AM	SF2 OUT	756.8	7.47	63.3	4.6	34.86	69.8
8/30/2021	9:42:18 AM	SF2 OUT	756.8	7.46	32.4	2.35	34.81	69.9
8/30/2021	9:58:52 AM	SF2 CP1	756.8	7.61	52.7	3.79	35.32	70.5
8/30/2021	9:59:48 AM	SF2 CP1	756.8	7.61	43.1	3.1	35.32	70.6