BRADMOOR ISLAND/ARNOLD SLOUGH TIDAL HABITAT RESTORATION ADAPTIVE MANAGEMENT AND MONITORING PLAN

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1. ACRONYMS AND ABBREVIATIONS

µS/cm	microsiemens per centimeter
BAAQMD	Bay Area Air Quality Management District
BCDC	San Francisco Bay Conservation and Development Commission
BDCP	Bay Delta Conservation Plan
BiOp	biological opinion
Blacklock	Blacklock restoration project

BMP	best management practice
Bradmoor	Bradmoor Island
CAAQS	California Ambient Air Quality Standards
CALFED	CALFED Bay-Delta Program
CalEEMod	California Emissions Estimator Model
CCR	California Code of Regulations
CDFW	California Department of Fish and Wildlife
CEQA	California Environmental Quality Act
CIWQS	California Integrated Water Quality System
cm	centimeter(s)
CNEL	community noise equivalent level
CO	carbon monoxide
CO_2	carbon dioxide
CRHR	California Register of Historical Resources
dB	decibel(s)
dBA	A-weighted decibel(s)
DFG	California Department of Fish and Game (now CDFW)
DO	dissolved oxygen
DPM	diesel particulate matter
DSC	Delta Stewardship Council
DWR	California Department of Water Resources
EB	exterior breach
EC	electrical conductivity
EIR	environmental impact report
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ER	Engineering Regulation
ERPP	Ecosystem Restoration Program Plan
ESA	Endangered Species Act

FHWA	Federal Highway Administration
ft/s	foot (feet) per second
GHG	greenhouse gas
Guidelines	Bay Area Air Quality Management District California Environmental Quality Act Air Quality Guidelines
IB	interior breach
ITE	Institute of Transportation Engineers
IVMP	Bradmoor Island and Arnold Slough Invasive Vegetation Management Plan
L_{eq}	equivalent continuous sound level
LiDAR	light detection and ranging
Marsh	Suisun Marsh
MHHW	mean higher high water
MLLW	mean lower low water
mS/cm	millisiemens per centimeter
MT CO_2e	metric tons of carbon dioxide equivalent
NAAQS	National Ambient Air Quality Standards
NAVD88	North American Vertical Datum of 1988
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NO_X	oxides of nitrogen
NPDES	National Pollutant Discharge Elimination System
NRHP	National Register of Historic Places
PG&E	Pacific Gas and Electric Company
PM	particulate matter
PM_{10}	particulate matter 10 micrometers in diameter or smaller
$PM_{2.5}$	particulate matter 2.5 micrometers in diameter or smaller

POD	Pelagic Organism Decline
Proposed Project	Bradmoor Island and Arnold Slough Restoration Project
Reclamation	U.S. Bureau of Reclamation
RMA	Resource Management Associates
RWQCB	Regional Water Quality Control Board
SFBAAB	San Francisco Bay Area Air Basin
SMP	*Suisun Marsh Habitat Management, Preservation, and Restoration Plan*, aka Suisun Marsh Plan
SMPA	Suisun Marsh Preservation Agreement
SRCD	Suisun Resource Conservation District
SWPPP	stormwater pollution prevention plan
SWRCB	State Water Resources Control Board
TAC	toxic air contaminant
UC	University of California
URBEMIS	Urban Land Use Emissions Model
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
WCS	water control structure

2. Project Purpose

The Bradmoor Island and Arnold Slough Restoration Project (Project) will restore 609 acres of tidal wetlands in Solano County, California. This project is intended to contribute toward the restoration acreage requirements of the U.S. Fish and Wildlife Service's (USFWS) December 15, 2008 *Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project and State Water Project* (USFWS 2008, File No. 81420-2008-F-1481-5) and carried forward in the 2019 *Reinitation of consultation on the Coordinated Operations of the Central Valley Project and State Water Project* (USFWS 2019, Service File No. 08FBTD00- 2019-F-0164), National Marine Fisheries Service's (NMFS) June 4, 2009 *Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project* (NMFS 2009, File No. 2008/09022),and carried forward in the 2019 *Biological Opinion on Long-term operations of the Central Valley Project and the State Water Project* (NMFS 2019, No. WCRO-2016-00069), the California Department of Fish and Wildlife's (CDFW) February 23, 2009 *California State Water Project Delta Facilities and Operations Incidental Take Permit* (ITP) (CDFW 2009, Permit No. 2081-2009-001-03) and carried forward in the 2020 CDFW *Incidental Take Permit for Long-Term operations of the State Water Project in the Sacramento-San Joaquin Delta* (CDFW 2020, Permit number 2081-2019-066-00) .

Upon construction, the project will partially fulfill the Department of Water Resources (DWR) requirement to restore 8,000 acres of intertidal and associated subtidal habitat for Delta Smelt and salmonids and 800 acres of intertidal and associated subtidal wetland habitat in a mesohaline part of the estuary for Longfin Smelt. In September 2011, a Memorandum of Agreement Regarding the Early Implementation of Habitat Projects for the Central Valley Project and State Water Projects Coordinated Operations and Bay Delta Conservation Plan was signed by the USFWS, NMFS, CDFW, DWR, Bureau of Reclamation (Reclamation), and State and Federal Contractors Water Agency (SFCWA) that sets forth a process of identifying and evaluating habitat projects. The Fishery Agency Strategy Team (FAST), comprised of a technical representative from each fishery agency (USFWS, NMFS, Reclamation, and CDFW), was created to review and assist in the planning of the habitat projects and provides guidance to DWR, Reclamation, and SFCWA on the expected benefits of the habitat projects in meeting restoration objectives. By restoring tidal exchange to Bradmoor Island and Arnold Slough, the project will create 609 acres of mesohaline tidal habitat for Delta Smelt and Longfin Smelt. This project will also increase wetland productivity that may feed the smelt food chain.

Because Bradmoor and Arnold are located in the Suisun Marsh, they also fall under the purview of the 2013 *Suisun Marsh Habitat Management, Preservation, and Restoration Plan*, referred to as the Suisun Marsh Plan (SMP). The SMP is intended to guide near-term and future actions related to restoring tidal wetlands and managed wetland activities. By restoring Bradmoor and Arnold, this project's 609 total restored acres contributes to the SMP's "Habitats and Ecological Processes" objective, which targets restoration of 5,000 to 7,000 acres of tidal wetlands (USFWS et al. 2013).

2.1 Fish Restoration Program

On October 18, 2010, DWR and CDFW signed an agreement regarding implementation of a Fish Restoration Program (FRP) to satisfy the 2008 USFWS Biological Opinion (BiOp), 2009 NMFS BiOp, and 2009 CDFW ITP (DWR and DFG 2010). The agreement signed between the agencies commits CDFW to work collaboratively with and assist DWR to establish the management and financial framework necessary to implement a fish restoration program that will satisfy DWR's obligations. Program structure, restoration principles, and action components are described in the Fish Restoration Program Agreement Implementation Strategy (CDWR and CDFW 2012).

The goals of FRP, as mutually agreed upon by DWR and CDFW, are to:

- identify and implement actions that will address the habitat restoration requirements of the Biological Opinions and ITP;
- facilitate interagency planning discussions to achieve the above goal;
- facilitate interagency project planning forums to achieve a process that will include public openness and the interests of stakeholders;
- utilize and incorporate sound science and current available information in developing restoration and enhancement designs; and
- maintain consistency with the Delta Stewardship Council's (DSC) Delta Plan and other large-scale planning efforts.

Objectives to achieve these goals are to:

- restore 8,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh, including 800 acres of mesohaline habitat to benefit Longfin Smelt, to enhance food production and availability for native Delta fishes;
- restore processes that will promote primary and secondary productivity and tidal transport of resources to enhance the pelagic food web in the Delta;
- increase the amount and quality of salmonid rearing and other habitat; and
- increase through-Delta survival of juvenile salmonids by potentially enhancing beneficial migratory pathways.

2.2 Project Goals and Objectives

Goal 1: Restoration will benefit listed fish species that have the potential to occur on Bradmoor Island and Arnold Slough properties, and in surrounding waterways.

Goal 2: Restoration will benefit special-status wildlife species that have the potential to occur on Bradmoor Island and Arnold Slough.

Goal 3: The restoration sites will be self-sustaining over time and incorporate design features that anticipate the potential effects of climate change where feasible.

Goal 4: The restoration project will be designed to facilitate monitoring of the habitats on Arnold Slough and in surrounding areas.

2.2.1 Project Objectives

- Increase available Delta Smelt and Longfin Smelt habitat, including enhancement of primary and secondary productivity.

- Enhance the quality of habitats to support more special-status and native wildlife.
- To the greatest extent practical, take advantage of the natural features of the site to promote habitat resiliency to changes in future Suisun Marsh conditions.
- Avoid promoting conditions, such as noxious weed infestations, that are in conflict with the above project objectives.

2.3 Project Description

2.3.1 Regional Setting

The restoration sites are located in the northeastern corner in the Marsh and Region 3 of the SMP. Bradmoor Island is bordered on the north and east by Denverton Slough, to the west by Nurse Slough, and to the south by Little Honker Bay. Arnold is located southeast of Bradmoor Island, and south of Little Honker Bay. It is bordered to the west by Blacklock and Arnold Slough. Blacklock is a tidal restoration site, completed in 2007, boarding Little Honker Bay. Blacklock, and the fringing marshes surrounding Little Honker Bay, can be used as comparison points for how restoration sites and existing marshes may develop over time.

Historically, the Suisun Marsh was a tidal marsh system, with the range of salinity, vegetation composition, and species utilization based on local geography and Sacramento and San Joaquin River inputs. In the late 1800s, most of the Marsh was diked for water management to support agriculture and duck hunting club activities. Suisun Marsh is frequently used as a spawning area for Longfin Smelt, with larvae and juveniles occurring throughout the spring (Merz et al. 2013). Adult Longfin Smelt are caught throughout the year, with abundance peaking in November or December of most years (Rosenfield and Baxter 2007). When outflow conditions are right, Suisun Marsh also provides fall low-salinity-zone habitat for rearing Delta Smelt (Moyle et al. 2016), and is considered part of the “arc” of native fish habitat that has been identified as critical for conservation of native fish diversity (Hobbs et al. 2017). Besides fishes, Suisun Marsh’s wetlands also provide important habitat for a variety of wildlife and plant species of conservation concern, including waterfowl, western pond turtles, the salt-marsh harvest mouse (SMHM), and many rare plant species (Moyle et al. 2014). Please see the Biological Assessment for more details on regional conditions and site use by special-status species.

2.3.2 Restoration Actions

The Proposed Project consists of restoring tidal hydrology to approximately 470 acres on Bradmoor and approximately 138 acres on Arnold by breaching levees in strategic locations, grading sections of the levees down, and filling ditches near breach locations to adjacent marsh plain elevation to create ditch blocks. Any previous infrastructure remaining on the Bradmoor and Arnold properties will also be removed and disposed of prior to restoration. Additionally, an old water control structure on Blacklock will also be removed. The total area of the Proposed Project is approximately 1,082 acres.

Bradmoor’s restoration will consist of removing water control structures, creating 5 exterior levee breaches, two interior levee breaches, and grading down an interior berm. At each exterior breach, fill will be placed in ditches adjacent to existing levees to marsh plain elevation to create a total of 13 ditch blocks. Remnants of a tidal slough will also be reconnected.

Arnold's restoration will consist of removing a water control structure, creating 3 exterior levee breaches, grading down sections of the exterior levee, and filling in ditches near the breaches to create 4 ditch blocks. Prior to breaching and grading the levees at Arnold, an old water control structure on Blacklock would be removed while the remnant levee is still accessible.

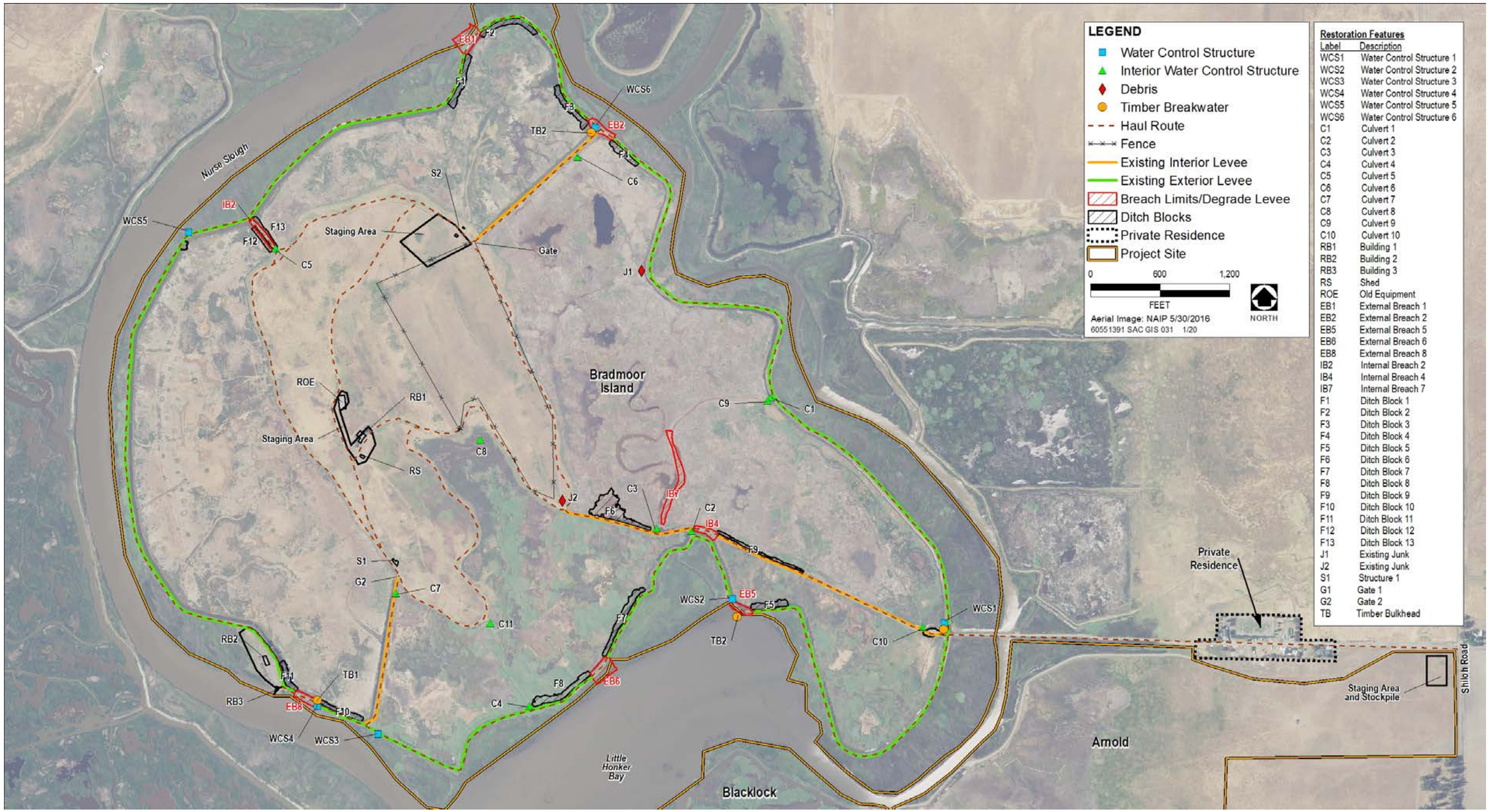

Figure 1. Map of the site with major restoration features at Bradmoor

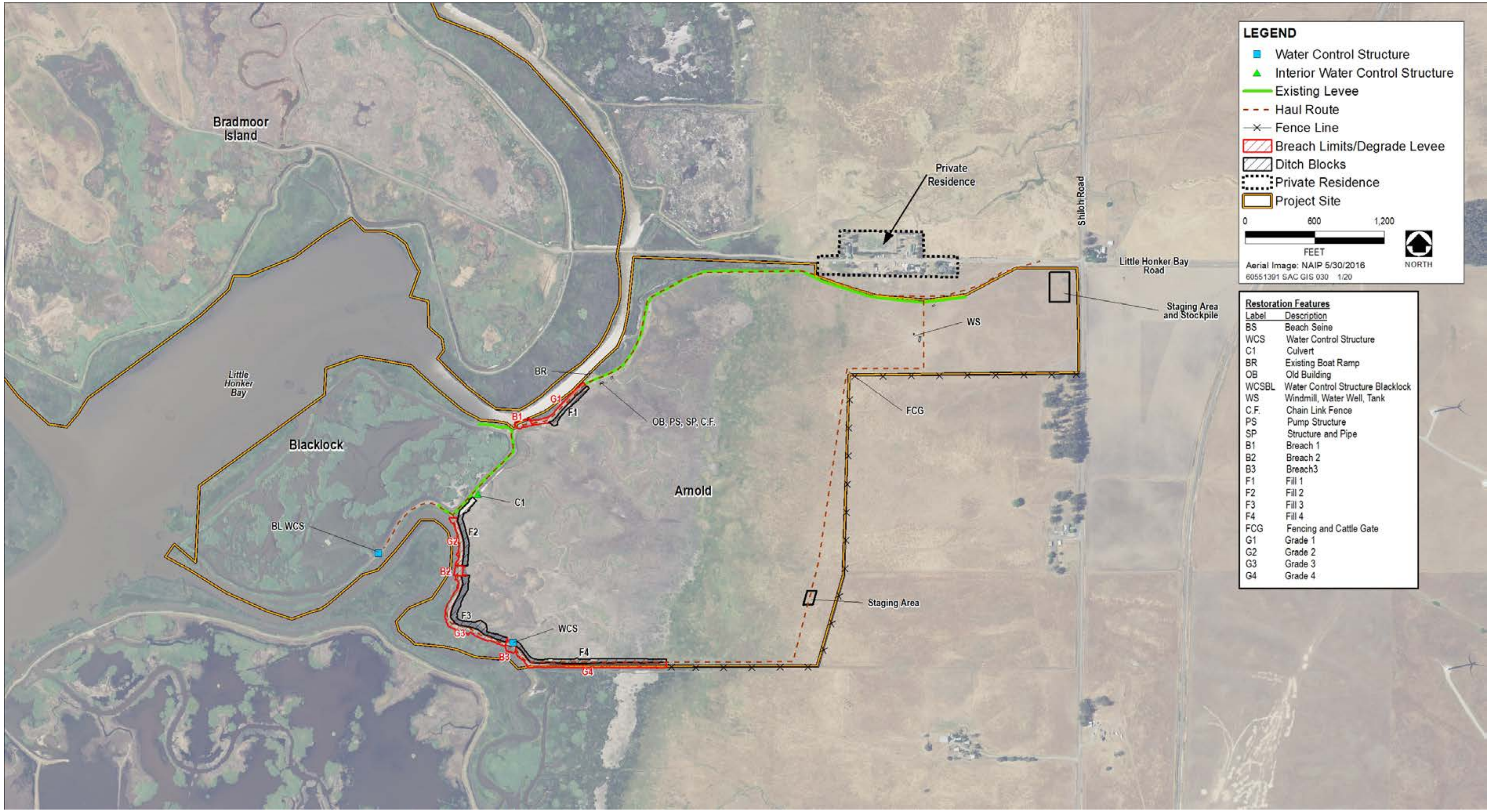

FIGURE 2. MAP OF THE SITE WITH MAJOR RESTORATION FEATURES AT ARNOLD

2.4 Restoration Potential

Upon Project completion, the interior of the Bradmoor and Arnold restoration sites would be reconnected with tidal waters from the surrounding waterways, creating new tidal wetland habitat from former managed wetland habitat. Managing interior vegetation on the site for during 2019-2021 will control the spread of invasive weeds, particularly *Phragmites australis*, as much as possible. Immediately after project construction, some of the newly tidal area may be barren due to construction impacts, but these areas are expected to vegetate within the first three years after construction. Restoration will result in a net increase of 609 acres of tidal wetlands.

3. Adaptive Management

3.1 Purpose

Adaptive management is a structured approach to environmental management and decision-making in the face of uncertainty. It involves taking risks, assuming that plans may not always turn out as intended, having a backup plan, and continuing to evaluate progress toward goals. It provides a pathway for undertaking actions when knowledge about a system is incomplete and then modifying the approach as knowledge is gained and uncertainty is reduced. Adaptive management makes learning more efficient and improves management practices.

Adaptive management fosters flexibility in management actions through an explicit process. It entails having clearly stated goals, identifying alternative management practices or objectives, framing hypotheses about ecological causes and effects, systematically monitoring outcomes, learning from the outcomes, sharing information with key players and decision-makers, and being flexible enough to adjust management practices and decisions (see Delta Independent Science Board 2016). Conceptual models often are used in adaptive management programs to integrate available knowledge and to provide synthesis and a means of developing and exploring promising management actions before they are attempted as field experiments or pilot projects.

Adaptive management may reduce uncertainty when management actions are thought of as experiments. By using a structured design that includes appropriate controls (or references), monitoring, and replication, observed outcomes can be disentangled from a welter of potentially confounding factors (Zedler 2005). As a result, one can have a good idea of why a management action did or did not work as expected.

3.2 Use of Best Available Science

Through project planning and implementation, DWR commits to utilizing the best available science to design, manage, and monitor the site. Adaptive management of the Project will be based on the utilization of input from monitoring data in conjunction with adaptive review of whether restoration goals and objectives are being achieved.

This plan is consistent with the *Tidal Wetland Monitoring Framework for the Upper San Francisco Estuary* (hereafter “Framework”; IEP TWM PWT 2017a), which was developed by the Interagency Ecological Program (IEP) Tidal Wetland Monitoring Project Work Team (TWM PWT). As such, this plan is structured around hypotheses that were derived from conceptual models of tidal wetland function with respect to smelt and salmon (Sherman et al. 2017). The theoretical underpinnings of the conceptual models derive from peer-reviewed literature and government reports describing studies throughout the estuary and relevant ecosystems elsewhere. The methods and sampling strategy described are designed to provide data that are comparable across restoration projects and with ongoing regional monitoring surveys. Comparable data from the channels adjacent to the project and a reference site will facilitate project monitoring as well as the eventual assessment of restoration *program* effectiveness. Project monitoring and adaptive management strategies are subject to adjustment as new information arises. Data comparability and transparency will be maintained throughout the evolution of the project and its monitoring period.

DWR has also collected extensive research at the project site itself. The design is based on modeling by DWR and Resource Management Associates using a combination of hydrodynamic and particle tracking models to evaluate ideal residence times, velocities, and potential for particle export. Modeling of salt transport, using electrical conductivity as a surrogate, was also performed to evaluate marsh-wide impacts of site restoration. (CEQA Addendum Appendix D.1, *Salinity Modeling Analysis of the Proposed Bradmoor Island / Arnold Slough Tidal Marsh Restoration).*

The Project has been the field site for multiple research projects on various Suisun Marsh wildlife species and processes, including research by DWR on waterbird abundance and habitat use (https://www.water.ca.gov/Programs/Environmental-Services/Applied-Research), a master's thesis on seed production for waterbird food (Roddy 2017), and ongoing SMHM monitoring and research conducted by CDFW (https://www.wildlife.ca.gov/Science-Institute/News/PostId/49/salt-marsh-harvest-mouse-survey).

The Project also learned much from the Blacklock Restoration site, including: ten years of monitoring data on SMHM, vegetation, and elevations (Department of Water Resources 2017), a special study of fish use on the site, 2013-2014 (Williamson et al. 2015), evaluation of methyl mercury flux (DWR 2013), and a master's thesis on flux of nutrients. (Strong 2015). Lessons learned from all these studies have contributed to the design of the new restoration projects.

3.3 Restoration Design and Uncertainties

Because Bradmoor Island and Arnold Slough include a variety of different types of wetlands, there are many opportunities to learn from the restoration design. Bradmoor Island was historically managed as three separate duck clubs, with varying levels of vegetation management pre-restoration, providing an opportunity to see whether more effective pre-restoration vegetation control can influence post-restoration invasion (as reviewed in Pawley et al. 2017). The year of pre-restoration hydrologic management to establish appropriate emergent plants on-site before breaching, and the planned experiment on revegetation techniques conducted by DWR on Bradmoor, will further elucidate the best methods for keeping invasive vegetation, particularly *Phragmites australis*, from overtaking future restoration sites.

Arnold Slough was also managed as a duck club, but contains an extensive remnant channel network. The planned levee degrades will allow greater connection between the marsh plain and surrounding slough than the discrete breaches planned at Bradmoor. Comparing productivity and transport between the two sites will allow FRP to learn the different benefits of increased connectivity versus *increased* residence time (as suggested in Hartman et al. 2017). A dendritic channel network, versus straighter ditches and open ponds, may also have varying levels of productivity and provide different habitat for native species (as suggested by Robinson et al. 2016; Williams et al. 2002).

The gentle upland transition zone at Arnold Slough will also be a valuable opportunity to research wetland response to sea level rise and the interaction between grazing and wetland transition zones. We expect sediment accretion to be able to keep pace with sea level rise (Schile et al. 2014), however, if repeated elevation transects shows sea level rising faster than sediment can accrete, the marsh may move into the upland transition zone instead. The uplands of Arnold Slough have been grazed by cattle for the past 200 years. Cattle grazing is often considered detrimental to rare wetland plants, including *Chloropyron molle* (Whitcraft et al. 2011), however, there is a population of *C. molle* at Arnold that has not suffered from the current level of grazing, and moderate grazing is often beneficial for controlling invasive plant species (DiTomaso et al. 2008; Zedler 2000). Post-restoration, grazing may be an important adaptive management tool to balance invasive species control and rare plant population maintenance.

4. Monitoring

The Suisun Marsh ecosystem is extremely dynamic on multiple temporal and spatial scales. In the absence of rigorous monitoring, fluctuations in natural populations of native and non-native flora and fauna, as well as variations in the physical environment related to climate and anthropogenic influences, are likely to complicate the assessment of tidal wetland restoration actions. This document outlines a scientifically defensible approach to ascribing changes in habitat and food web characteristics in the vicinity of Bradmoor Island and Arnold Slough to restoration actions. Monitoring is an integral component of adaptive management as well. The plan incorporates elements of the Framework (IEP TWM PWT 2017a) and comprises three major components:

- Compliance monitoring – determining whether restoration actions have been completed as planned, including compliance with construction-related permitting requirements.
- Routine effectiveness monitoring – evaluating hypotheses related to the premise that tidal wetland restoration will benefit listed fish species in accordance with project objectives.
- Potential special studies – Effectiveness monitoring that is too intensive in terms of time, expertise, and resources for regular implementation, but that would provide detailed information on the mechanisms responsible for wetland physical and ecological processes.

4.1 Compliance Monitoring

The Project's goal is to partially fulfill the 8,000-acre tidal restoration obligations of the FRPA in satisfaction of the BiOps (USFWS 2008, NMFS 2009) and ITP, as credited by the FAST through the Prospectus. The Project will verify implementation by post-construction monitoring of constructed outputs (acres restored, as-built topography and elevations, and hydrology).

In addition, regulatory permits obtained for constructing the Project have associated conservation and mitigation measures that require specific monitoring actions to satisfy compliance. These monitoring elements focus on permitting requirements and mitigation measures under the SMP, Clean Water Act sections 401, 402, and 404, ESA Section 7, and Suisun Marsh development permit (BCDC).

4.1.1 Physical Processes Performance Standards

The following performance standards for hydrologic connections will be verified through a combination of photo-point pictures, water stage, and flow monitoring (metrics “tidal regime” and “general habitat conditions” in Table 2).

- Years 1, 3, and 5: All breaches and levee degrades are open and channels show evidence of evolving over time.
- Years 1, 3, and 5: Water level inside the restoration sites fluctuates in response to the daily tidal regime equal to that in Nurse Slough.
- Years 5, and 10: There is a net rise in elevation of the marsh surface over time, capable of keeping pace with sea level rise. No scour unless it is caused by channel formation.

4.1.2 Food Web Productivity Performance Standards

CDFW will use a combination of sampling methods to collect primary and secondary production data within and adjacent to the restoration site (see Effectiveness Monitoring section for methods; all metrics under the “Food Web” monitoring group in Table 2).

- Years 2 - 7: Some combination of primary and secondary production is exported from the restoration site or made available during certain times in the tidal cycle in at least 3 of the 6 years. If Delta Smelt take restrictions prohibit monitoring of secondary production in two or more years, this performance standard will be based solely on primary production.

4.1.3 Fish Performance Standards

Delta Smelt and Longfin Smelt performance standards were not developed for this project in order to reduce take of these imperiled species. Delta Smelt are known to occur year-round in the waters surrounding Bradmoor Island and Arnold Slough and at the time of writing, their relative abundance was at a historic low (data available http://www.dfg.ca.gov/delta/data/). Because most fish sampling gear that catch any native fish can also catch Delta Smelt, performance standards were not developed for other native fishes.

4.1.4 Other Native Species Performance Standards

CDFW and DWR will conduct surveys for rare plants and other native species of concern that may benefit from the project as highlighted in the SMP (see Effectiveness Monitoring *section* for methods; all metrics under the “Other Monitoring” monitoring group in Table 2).

- Years 1, 3, and 5: *Chloropyron molle hispidum* is present on Arnold.
- Years 1, 3, and 5: There is no reduction in detection of rails and other secretive marsh birds.
- Year 5, 10: There is no reduction in habitat for SMHM.

4.1.5 Invasive Aquatic Vegetation Performance Standards

The following performance standards will be used to document establishment of invasive plants in the restoration site by using a combination, as appropriate, of photo-point pictures, aerial pictures, GIS mapping, and/or transect surveys across the tidal wetland (metrics “general habitat conditions,” “vegetation composition and cover,” and “invasive plants” in Table 2).

- Years 3 and 5: Invasive weed percent coverage in the restoration site is similar to or lower than what is observed in other wetlands in Suisun Marsh, targeting not more than 20% of the site area.

4.1.6 Compliance Checkpoint Schedule

DWR and CDFW will monitor the restoration site for a minimum of ten years. The monitoring schedule is outlined in Table 1. The monitoring schedule is approximate and could be adjusted every year to account for changing environmental conditions (e.g., floods, drought), listed species take authorization, and current status of performance standards.

If remedial activities are required to meet the performance standards, annual monitoring of any remediated habitat will occur for two out of the next five growing seasons or until the performance standards have been met.

TABLE 1. Bradmoor Island/Arnold Slough performance standards monitoring schedule.

Performance Standards	Years Post-Breach	Season
Hydrologic Connections	1,3, 5	Spring, Fall
Invasive Aquatic Vegetation	3, 5	Summer
Food Web Productivity	1, 2, 3, 4, 5*	Up to Spring, Summer, Fall

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*Sampling years 6-10 are discretionary

4.2 Effectiveness Monitoring

Effectiveness monitoring will track progress towards objectives by measuring indicators of ecological status and function ("metrics") and comparing the measurements to expected or hypothesized outcomes. Sampling techniques ("methods") will include terrestrial surveys of vegetation, hydrologic and water quality monitoring via instrumentation, sampling of aquatic food web components, and sampling of fish presence, where permitted. Measurements of physical and biological components will be used to evaluate the evolution of habitat on the site including tidal channel and marsh morphology, vegetation response (including non-native invasive plants) to the reconnected tidal influence, habitat component contributions to the food web, and identification of occupied fish habitat.

The effects of restoration on local and regional biological resources will be evaluated relative to pre-construction conditions ("baseline"), concurrent monitoring of an existing wetland (Blacklock and fringing marshes around Little Honker Bay), and conditions in the channels adjacent to the project (Little Honker Bay and Nurse Slough). To test for differences between areas within Bradmoor and Arnold, sampling will target multiple habitat types, as shown in Figure 2.

Hypotheses applicable to project objectives were selected from the Framework and modified to reflect site-specific considerations. Framework hypothesis identification codes are noted in parentheses.

Objective: Increase available Delta Smelt and Longfin Smelt habitat, including enhancement of primary and secondary productivity.

- P1: The area of substrate and structure suitable for rearing, refuge, and/or adult residence of smelt on-site will increase after restoration.

- P2: Water quality will be suitable for smelt during the time they are likely to be present.
- P3: Connections between the restoration sites and surrounding sloughs will be characterized by structure, water quality, and flow that allow fish increased opportunity to access high quality habitat.
- F4: Pelagic invertebrate (zooplankton) community composition and size structure will change seasonally and affect the aquatic food web.
- F5: Restoration of Bradmoor and Arnold will increase the contribution of epiphytic, epibenthic, and drift invertebrates to the food web relative to pre-project conditions and data from Montezuma Slough.
- F9 &10: Restoration will result in a net increase of primary and secondary production exported from the site, or at a minimum increase access to productivity by making it available at certain times in the tidal cycle.
- P4: Smelt will be present in restored habitat for some portion of their life history, with a frequency similar to, or higher than Blacklock and Little Honker Bay, and reflecting current population trends.

Objective: To the greatest extent practical, take advantage of the natural features of the site to promote habitat resiliency to changes in future Suisun Marsh conditions

- P6: Bradmoor Island and Arnold Slough will increase in elevation through sediment deposition and organic matter accumulation.

Objective: Avoid promoting conditions, such as noxious weed infestations, that are in conflict with the above project objectives.

- P7: Bradmoor and Arnold Island tidal will be passively colonized by aquatic vegetation species that are proximate and connected to the restoration site.
- P8: Planting, plant propagation method and propagule size, along with timing of restoration action and initial colonizer species, will influence vegetation community composition.
- P14: Establishment and growth of aquatic vegetation will influence fish community structure and abundance on site.

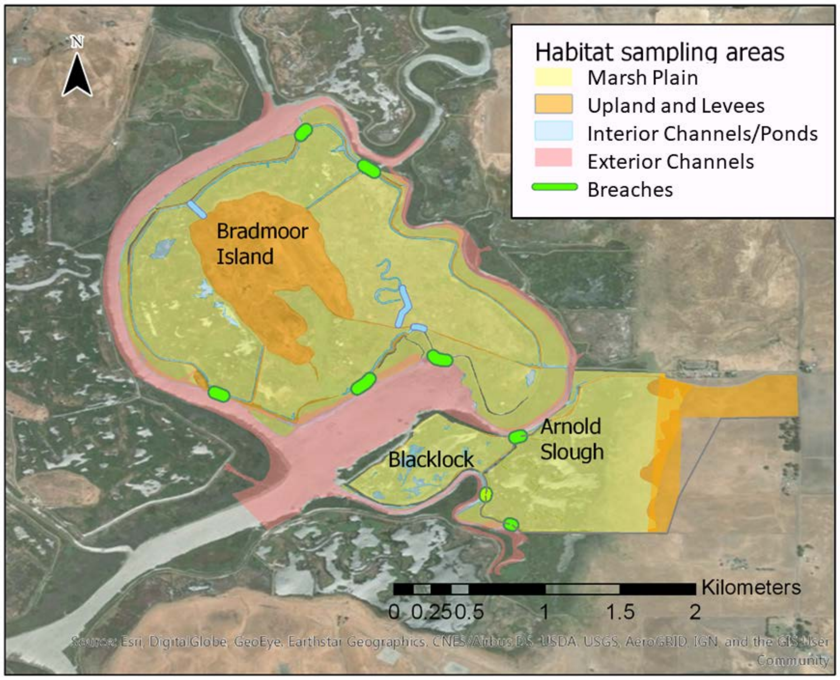

FIGURE 3. Proposed sampling zones within project area, reference site, and adjacent channels. Samples collected on marsh plain include: vegetation, invasive plants, salt-marsh harvest mouse, and black rail. Samples collected on the interior channels and ponds and exterior channels: Benthic and epiphytic invertebrates, chlorophyll, nutrients, water quality, and zooplankton. Samples collected at breaches: Chlorophyll, nutrients, tidal regime, water quality, zooplankton.

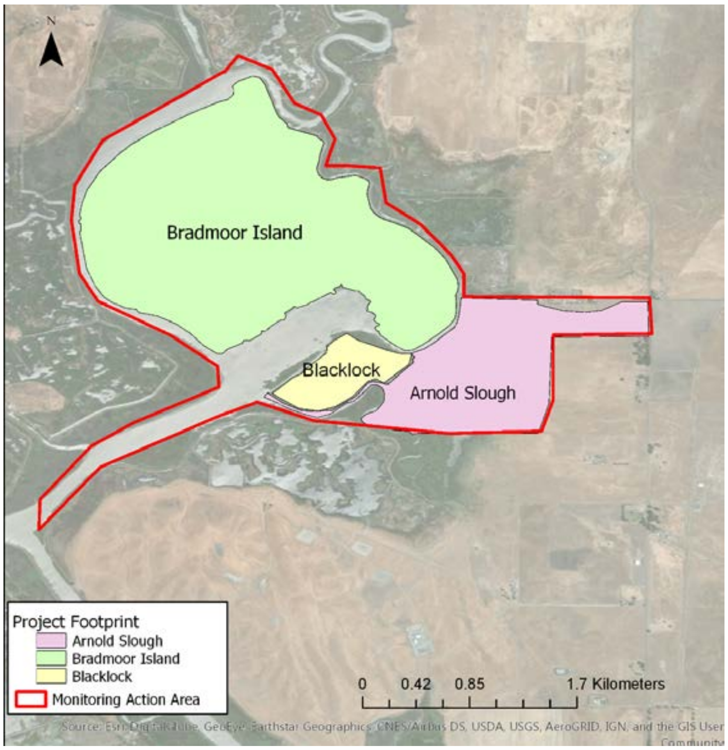

FIGURE 4. Monitoring Action Area. Monitoring activities will take place within the project footprint as well as surrounding sloughs and the Blacklock Tidal Wetland Restoration site.

4.2.1 Routine Monitoring

The following sections describe the metrics and methods that may be used in routine monitoring of the Bradmoor Island and Arnold Slough Tidal Habitat Restoration Project, subject to the constraints of sampling sites, gear availability, staff availability, and budget. Multiple metrics will be necessary to evaluate each Project hypothesis, and a given metric may be pertinent to multiple hypotheses.

TABLE 2. Bradmoor Island and Arnold Slough Tidal Marsh Restoration Metrics and Monitoring Methods

Monitor Group	Metric	Method	Time of Year, Frequency	Sampling Intervals	Sites and Samples
Hydrologic Connections, Physical Processes, and Hydrology	Topography and bathymetry (e.g., channel morphology, pond depths)	Ground-based global positioning system (GPS) survey, or light detection and ranging (LiDAR) if available, aerial photos	Annual during summer	Prebreach and post breach. Sample once every 5 years after breach.	Project area, up to 10 cross-sections including breaches, major channels, marsh plain
Hydrologic Connections, Physical Processes, and Hydrology	Tidal Regime	Gauges or water level loggers	automatic measurements (may focus on spring-fall or tidal extremes)	Post breach. Sample during 1, 3, and 5), Discretionary sampling after year 5.	2-5 sites (breaches, main channel, marsh plain)
Water Quality	Water quality (temperature, electrical conductivity, turbidity, pH, dissolved oxygen)	data sonde	Automatic measurements (may focus on spring-fall period)	Post breach and once a year after breach for 5 years. Discretionary sampling after year 5.	1-5 site (temporary sondes at various locations)
Water Quality	Water Quality	Discrete seasonal samples	Up to 9 monthly events; typical: 3 events (spring, summer, fall)	Prebreach and post breach. Sample once a year after breach for 5 years. Discretionary sampling after year 5.	At sonde locations and concurrently with invertebrate sampling.
Water Quality	Nutrients (NH4-PO_4)	Grab samples, standard methods	Up to 9 monthly events; typical: 3 events (spring, summer, fall)	Prebreach and post breach. Sample once a year after breach for 5 years. Discretionary sampling after year 5.	Up to 21 sites (9 sites within Bradmoor, 6 sites in Arnold, 3 sites in Little Honker Bay (LHB), 3 sites in Blacklock.)
Water Quality	Particulate organic matter (POM), dissolved organic matter (DOM)	Grab samples, standard methods or FDOM on sonde	Up to 9 monthly events; typical: 3 events (spring, summer, fall)	Prebreach and post breach. Sample once a year after breach for 5 years. Discretionary sampling after year 5.	Up to 21 sites (9 sites within Bradmoor, 6 sites in Arnold, 3 sites in LHB, 3 sites in Blacklock.)
Food web productivity	Chlorophyll a	Optical sensor (if available); Grab samples	Up to 9 monthly events; typical: 3 events (spring, summer, fall)	Prebreach and post breach. Sample once a year after breach for 5 years. Reduced frequency sampling after 5 years.	Up to 21 sites (9 sites within Bradmoor, 6 sites in Arnold, 3 sites in LHB, 3 sites in Blacklock.)
Food web productivity	Phytoplankton	Plankton grab samples lab sorting	Up to 9 monthly events; typical: 3 events (spring, summer, fall)	Prebreach and post breach. Sample once a year after breach for 5 years. Reduced frequency sampling after 5 years.	Up to 21 sites (9 sites within Bradmoor, 6 sites in Arnold, 3 sites in LHB, 3 sites in Blacklock.)
Food web productivity	Zooplankton	Mesozooplankton and mysid net trawls, lab sorting	Up to 9 monthly events; typical: 3 events (spring, summer, fall)	Prebreach and post breach. Sample once a year after breach for 5	Up to 21 sites (9 sites within Bradmoor, 6 sites in Arnold, 3 sites in LHB, 3 sites in Blacklock.)

				years. Reduced frequency sampling after 5 years.	
Food web productivity	Benthic macroinvertebrates	Benthic grab samples or sediment cores, lab sorting	Up to 2 events (spring and fall)	Prebreach and post breach. Sample year 1, 3, 4, and 5 after breached. Reduced frequency sampling after 5 years.	Up to 21 sites (9 sites within Bradmoor, 6 sites in Arnold, 3 sites in LHB, 3 sites in Blacklock.)
Food web productivity	Surface invertebrates	Neuston tow	Up to 2 events (spring and fall)	Prebreach and post breach. Sample year 1, 3, 4, and 5 after breached. Reduced frequency sampling after 5 years.	Up to 21 sites (9 sites within Bradmoor, 6 sites in Arnold, 3 sites in LHB, 3 sites in Blacklock.)
Food web productivity	Epibenthic/epiphytic macroinvertebrates	Sweep nets	Up to 2 events (spring and fall)	Prebreach and post breach. Sample year 1, 3, 4, and 5 after breached. Reduced frequency sampling after 5 years.	Up to 21 sites (9 sites within Bradmoor, 6 sites in Arnold, 3 sites in LHB, 3 sites in Blacklock.)
Wetlands and Vegetation	General habitat conditions	Photo points (qualitative record)	Annual during growing season (summer)	Sample pre-breach and once a year for five years. After five years sample once every 5 years.	Up to 10 points across site
Wetlands and Vegetation	EPA recommended level II assessment (optional)	California Rapid Assessment Method (CRAM: http://www.cramwetlands.org/)	Once during growing season (summer)	Sample pre-breach. Sample year 1 and year 5. After year 5 discretionary sampling	Vegetated marsh plain
Wetlands and Vegetation	Vegetation composition and cover	Surveys consistent with marsh-wide protocols. rake transect for submerged aquatic	Once during growing season (summer)	Sample pre-breach. Sample year 1, 3, and year 5. After year 5 discretionary sampling.	Plots across sites for terrestrial vegetation, channels for submerged aquatic vegetation.
Wetlands and Vegetation	Invasive plants	Visual survey (aerial imagery and ground surveys)	Annual during early growing season	Sample pre-breach and post-breach. Sample year 1, 3, and 5. After year 5 sample every 5 years.	Survey entire site. Annual checks to continue during qualitative site surveys.
Other monitoring	*Chloropyron molle*	Presence/ absence, extent and density if possible.	Annual during growing season	Sample pre-breach and post breach. Sample once a year for 5 years. Sample every year after 5 years	Arnold Slough transition zones
Other monitoring	Salt Marsh Harvest Mouse	CDFW trapping protocols	Every 3-5 years	Sample pre-breach. Sample year 2 and year 5. Sample every 5 years after year 5.	Established grids on Arnold and Bradmoor
Other monitoring	Secretive marsh birds	Currently accepted marsh protocol	3 times during survey season, every other year	Sample pre-breach and post-breach. Sample year 2 and year 4. Sample every 5 years after year 5.	Several points around Arnold and Bradmoor

Monitor Group	Metric	Method	Time of Year, Frequency	Pre-Breach	Post-Breach	Years after breach[1] 1	2	3	4	5	Yr 5-10	Sites and samples
Hydrologic Connections, Physical Processes and Hydrology												
-	Topography and bathymetry (e.g., channel morphology, pond depths)	Ground-based GPS survey, or LiDAR if available, aerial photos	Annual during summer	X	X					X	Once Every 5 years	Project area, up to 10 cross-sections including breaches, major channels, marsh plain
	Tidal Regime	Gauges or water level loggers	All year, automatic measurements (may focus on spring-fall or tidal extremes)		X	X		X		X	D	2-5 sites (breaches, main channel, marsh plain)
Water Quality												
-	Water quality (temperature, EC, turbidity, pH, DO)	data sonde on Bradmoor bridge	Automatic measurements (may focus on spring-fall period)	X	X	X	X	X	X	X	D	Up to 1-5 sites (temporary sondes at various locations), permanent water quality station at Bradmoor bridge
	-	Discrete seasonal samples	Up to 9 monthly events; typical: 3 events (spring, summer, fall)	X	X	X	X	X	X	X	D	At sonde locations and concurrently with invertebrate sampling.
	Nutrients (NH_4-PO_4)	Grab samples, standard methods	Up to 9 monthly events; typical: 3 events (spring, summer, fall)	X	X	X	X	X	X	X	D	Up to 21 sites (9 sites within Bradmoor, 6 sites in Arnold, 3 sites in LHB, 3 sites in Blacklock.)
	Particulate organic matter (POM), dissolved organic matter (DOM)	Grab samples, standard methods or FDOM on sonde.	Up to 9 monthly events; typical: 3 events (spring, summer, fall)	X	X	X	X	X	X	X	D	Up to 21 sites (9 sites within Bradmoor, 6 sites in Arnold, 3 sites in LHB, 3 sites in Blacklock.)
Food Web Productivity												
-	Chlorophyll a	Optical sensor (if available); Grab samples	Up to 9 monthly events; typical: 3 events (spring, summer, fall)	X	X	X	X	X	X	X	Reduced frequency	Up to 21 sites (9 sites within Bradmoor, 6 sites in Arnold, 3 sites in LHB, 3 sites in Blacklock.)
	Phytoplankton	Plankton grab samples lab sorting	Up to 9 monthly events; typical: 3 events (spring, summer, fall)	X	X	X	X	X	X	X		
	Zooplankton	Mesozooplanton and mysid net trawls, lab sorting	Up to 9 monthly events; typical: 3 events (spring, summer, fall)	X	X	X	X	X	X	X		

Monitor Group	Metric	Method	Time of Year, Frequency	Sampling Intervals: Pre-Breach	Post-Breach	Years after breach[1] 1	2	3	4	5	Yr 5-10	Sites and samples
	Benthic macroinvertebrates	Benthic grab samples or sediment cores, lab sorting	Up to 2 events (spring and fall)	X	X	X	X	X	X	X	Reduced frequency	Up to 21 sites (9 sites within Bradmoor, 6 sites in Arnold, 3 sites in LHB, 3 sites in Blacklock.)
	Surface invertebrates	Neuston tow	Up to 2 events (spring and fall)	X	X	X	X	X	X	X		Up to 21 sites (9 sites within Bradmoor, 6 sites in Arnold, 3 sites in LHB, 3 sites in Blacklock.)
	Epibenthic/epiphytic macroinvertebrates	Sweep nets	Up to 2 events (spring and fall)	X	X	X	X	X	X	X		Up to 21 sites (9 sites within Bradmoor, 6 sites in Arnold, 3 sites in LHB, 3 sites in Blacklock.)
Wetlands and Vegetation												
-	General habitat conditions	Photo points (qualitative record)	Annual during growing season (summer)	X		X	X	X	X	X	Every 5 years	Up to 10 points across site
	EPA recommended level II assessment (optional)	California Rapid Assessment Method (CRAM: http://www.cram wetlands.org/)	Once during growing season (summer)	X		X				X	D	Vegetated marsh plain
	Vegetation composition and cover	Surveys consistent with marsh-wide protocols. rake transect for submerged aquatic	Once during growing season (summer)	X		X		X		X	D	Plots across sites for terrestrial vegetation, channels for submerged aquatic vegetation.
-	Invasive plants	Visual survey (aerial imagery and ground surveys)	Annual during early growing season	X	X	x		X		X	Every 5 years	Survey entire site. Annual checks to continue during qualitative site surveys.
Other Monitoring												
-	*Chloropyron molle hispidum*	Presence/ absence, extent and density if possible.	Annual during growing season	X	X	X	X	X	X	X	Every year	Arnold Slough transition zones
	Salt Marsh Harvest Mouse	CDFW trapping protocols	Every 3-5 years	X			X			X	Every 5 years	Established grids on Arnold and Bradmoor
-	Secretive marsh birds	Currently accepted marsh protocol	3x during survey season, every other year	X	X		X		X		Every 5 years	Several points around Arnold and Bradmoor

Notes:
1. Years after breach: X = Sampling proposed in this year, D = Discretionary sampling, contingent on available resources, partners, and project needs.

Effectiveness monitoring activities are subject to adaptation. Considerable uncertainty about the response of the ecosystem to tidal wetland restoration is identified in the suite of Tidal Wetland Conceptual Models (chapters in Sherman et al. 2017). Sampling methods, frequency, and/or location may be adjusted, in consultation with regulatory agencies, such that statistical rigor is optimized and system response uncertainty is reduced.

Where possible, existing data will be leveraged from long-term fish and zooplankton monitoring conducted by various IEP and academic programs (Table 3, Figure 5).

TABLE 3. Summary of long-term monitoring programs in the Delta and Suisun Marsh that FRP may use for regional status and trends. Adapted from the Bay-Delta Conservation Plan public draft**.**

Monitoring Program	Agency	Primary Purpose and Timeframe
Environmental Monitoring Program	DWR, CDFW	Monitors water quality, phytoplankton, benthos, microzooplankton, and macrozooplankton.
Spring Kodiak Trawl Survey (SKT)	CDFW	Monitors spawning adult delta smelt distribution, relative abundance, and reproductive status, January–May, 2002–present.
Delta Smelt 20 mm Survey (20 mm)	CDFW	Monitors postlarval-juvenile delta smelt distribution and relative abundance, March–June, 1995–present.
Summer Townet Survey (STN)	CDFW	Monitors striped bass and delta smelt abundance indices, June–August, 1959–present.
Fall Midwater Trawl Survey (FMWT)	CDFW	Monitors striped bass and delta smelt abundance indices, September–December, 1967–present.
Smelt Larval Study	CDFW	Monitors smelt larval distribution and relative abundance, January–March, 2009–present.
San Francisco Bay Study Survey	CDFW	Monitors abundance indices for a variety of species in South San Francisco and Suisun Bays, year-round, 1980–present.
Suisun Marsh Fish Community Survey	UC Davis	Monitors abundance of all fish species in Suisun Marsh, year-round, 1979–present.
Chipps, Mossdale, and Sacramento Trawl Survey	USFWS	Monitors fish abundance and distribution in mid-channel at surface at Chips Island, Mossdale (RM 54), and Sacramento (RM 55), and survival through the Delta, targets Chinook salmon, year-round, 1976–present.
Delta Juvenile Fish Monitoring Program Beach Seine	USFWS	Monitors fish abundance and distribution throughout the Delta, upstream Sacramento River, northern San Francisco and San Pablo Bays, targets Chinook salmon, year-round, 1976–present.
Chinook salmon escapement estimates	CDFW, DWR	Collects all life history variants of Chinook salmon escapement.

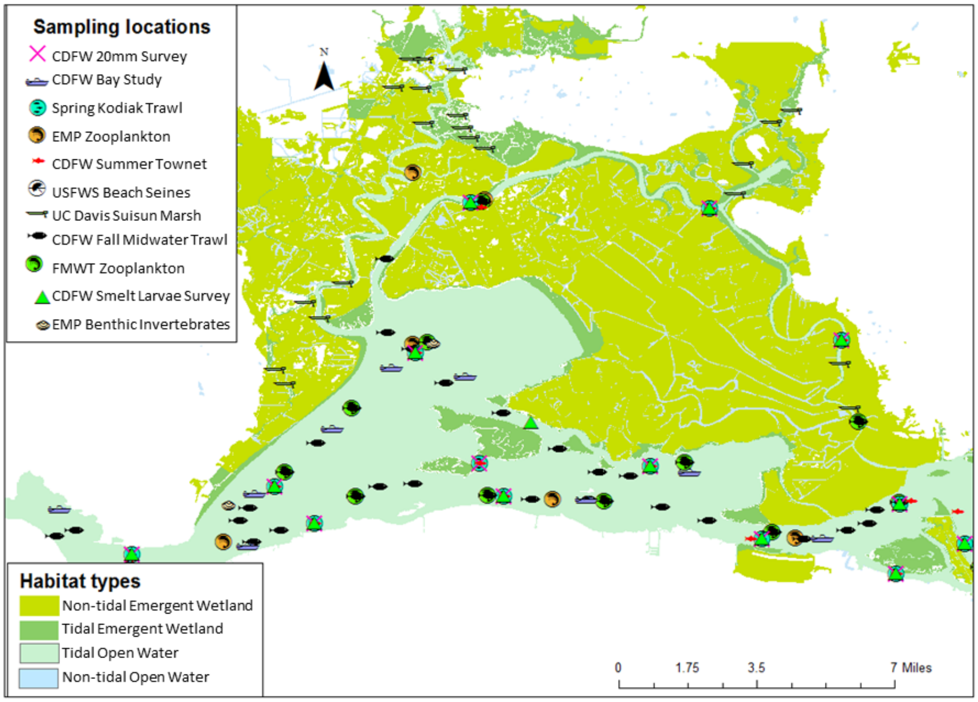

FIGURE 5. Existing long-term IEP monitoring stations in the region surrounding the restoration site.

Hydrologic Connections and Physical Processes

FRP wetland restoration projects are being constructed to develop physical habitats suited to native fishes and their food webs. With the return of tidal action via levee breaching and lowering, channel excavation, and removal of water control structures, natural processes such as sedimentation, erosion, and vegetation establishment will continually change the wetland complex. These changes may affect wetland productivity (e.g., via changing water residence times; Sommer et al. 2004) and suitability of fish habitat (e.g. turbidity; Hasenbein et al. 2013). Thus it is important to track changes as a site evolves, not only to assess performance of the project, but also to inform adaptive management and design of future restoration projects. The following metrics are particularly important in addressing the hypotheses associated with the first project objective (Increase available Delta Smelt and Longfin Smelt habitat, including enhancement of primary and secondary productivity), and the third project objective (To the greatest extent practical, take advantage of the natural features of the site to promote habitat resiliency to changes in future Suisun Marsh conditions).

Water Quality

Water quality parameters are as important as the physical structure of the habitat in determining where fish will thrive. Important water quality parameters can change very quickly, requiring precise and targeted monitoring. A combination of temporarily deployed sondes, water quality transects, and point measurements taken concurrently with other sampling will be used to characterize water quality parameters, including temperature, electrical conductivity, pH, turbidity, and dissolved oxygen.

California Rapid Assessment Method (CRAM) (www.cramwetlands.org)

CRAM is a standard wetland monitoring and assessment tool that is used throughout the state as a validated "level 2" evaluation in the EPA three-tier wetland monitoring framework. This rapid assessment combines considerations of site ecocline position with measures of hydrology, physical structure, and biotic structure and facilitates placing the development, or lack thereof, of a restoring wetland into a landscape context. CRAM results may also be used as factors in statistical models to characterize aquatic community composition. Multiple assessment areas (each ~ 1 hectare) will be assessed every 2 to 5 years post-restoration to track restoration trajectory. Comparison with pre-restoration CRAM scores is not appropriate, as wetland type will change from depressional to estuarine with restoration.

Topography and bathymetry

Topography and bathymetry of the site will control hydrology within the site, as well as area of available habitat and rates of sediment action. The evolution of bathymetry after restoration is particularly important in understanding fish opportunity to access the site. The baseline topography and bathymetry were described in the project planning process, and will be re-assessed periodically. If feasible, LIDAR and SONAR surveys will be conducted. Otherwise more traditional elevational survey transects may be used (as described in Roegner et al. 2008).

Internal hydrology and connections

After construction, tidal range within the site will be compared to outside the site to verify restoration of full tidal action. Inundation extent, duration, timing, and frequency are the metrics most directly related to provisioning of wetland habitat for fish (Robinson et al. 2014). The inundation regime is expected to change over time as the bathymetry, hydrology, and sedimentation rate changes during the process of wetland evolution. Water levels will be measured concurrently with water quality at the sites of semi-permanent sondes. Photo points will also aid in documenting tidal range.

Channel length, Width, and Complexity

If feasible, Lidar and/or aerial photography will be used to map locations of tidal channels with line features in a GIS. The total length of these lines will then be measured and tracked over time to see if length and width of tidal channels evolve. Maps of channels, combined with vegetation maps, can be analyzed to determine habitat heterogeneity, length of edge, channel complexity, area of different habitat types, ratio of marsh to open water area, and Shannon-Weiner index of habitat diversity as recommended by SFEI' s Delta Landscapes Project (Robinson et al. 2014)

Food Web Sampling

Tidal wetlands are hypothesized to produce and export phytoplankton and zooplankton resources for the pelagic food web, but it is unclear whether they will provide these benefits in all circumstances (Herbold et al. 2014; Lehman et al. 2010). For example, presence of invasive bivalve grazers (*Potamocorbula amurensis* and *Corbicula fluminea*) may cause tidal restoration areas to become net sinks for zooplankton (Lucas and Thompson 2012). Therefore, benthic and planktonic invertebrates, nutrients, primary productivity, and food web processes will be monitored to determine when and whether tidal wetlands increase resources for fishes. The following metrics most directly relate to the hypotheses under the first project objective: Increase available Delta smelt and longfin smelt habitat, including enhancement of primary and secondary productivity.

Nutrients and Organic Carbon

Nutrient concentration and form will influence the abundance and community composition of primary producers. Dissolved and particulate organic carbon (DOC and POC) are indicators of the detrital loop. Grab samples from the exterior breaches at Bradmoor, Arnold, and Blacklock and multiple replicates inside and outside the site will be collected up to 3 times per year for analysis of all relevant nutrients and carbon species. The methods of DWR's discrete water quality monitoring program will be used (drawn from EPA 600/4-79/020, Methods for Chemical Analysis of Water and Wastes, (Campisano et al. 2017), and Standard Methods for the Examination of Water and Wastewater (APHA 2017)).

Phytoplankton

Phytoplankton productivity in the SFE has experienced declines in quantity and quality over the past 30 years, possibly due to a combination of changing nutrient concentrations and grazing by introduced clams (*Corbicula fluminea* and *Potamocorbula amurensis*) (Baxter et al. 2010 POD report). Zooplankton that contribute most to fish food resources (large calanoid copepods, mysids) depend on phytoplankton production (Mueller-Solger et al. 2006). However, not all plankton are equally important to the diet of consumers such as the macro and mesozooplankton on which smelt rely. Large, nutritionally valuable diatoms are significantly more important to some zooplankton than microflagellates (Mueller-Solger et al. 2006). Cyanobacteria such as *Microcystis* may cause harmful algal blooms that may reduce dissolved oxygen and release toxins that can kill invertebrates (Lehman et al. 2013) and harm fishes (Baxter et al. 2010). Therefore, phytoplankton will be collected and preserved up to three times per year,. Community composition will be identified using the Utermöhl microscopic method by a contracting lab (Utermöhl 1958).

During ecologically relevant time periods, sondes will be deployed to collect continuous chlorophyll435*a* fluorescence. In addition, at each zooplankton trawling station, field crews will use hand-held sondes to measure chlorophyll fluorescence or take grab samples for laboratory analysis. At a subset of sampling stations, samples will be taken to calibrate fluorescence readings in the lab. Field crews will fill a 1 L bottle water, withdraw a 500 mL sub-sample and aspirate it through a 47 mm diameter glass fiber filter of 0.3 µm pore size. The filters will then be frozen on dry ice and analyzed for chlorophyll *a* and pheophytin by DWR's Bryte laboratory (as per EMP's methods, Brown 2009).

Vegetation

The major classes of terrestrial and aquatic vegetation will be mapped across the site before construction, and periodically after construction. True-color aerial photography will be collected and digitized using CDFW's Vegetation Classification and Mapping Program methods (as in Hickson and Keeler-Wolf 2007), and ground-truthed with field surveys.

Submerged aquatic vegetation (SAV), which is poorly characterized by aerial imagery, will be characterized using sonar or rake transects. When possible, a Lowrance sonar will record a track over beds of aquatic vegetation, and tracks will be processed with BioBase's EcoSound software to convert the sonar tracks to biovolume of SAV (CMAP Inc., https://www.cibiobase.com/). This software converts sonar data to estimates of water column filled with submerged aquatic vegetation. To supplement sonar, or if sonar is infeasible, SAV will be characterized by random samples using a thatch rake.

Methods will be consistent with standard procedures developed by the IEP Aquatic Vegetation Project Work Team.

Zooplankton

Planktivorous fishes, such as Delta Smelt and Longfin Smelt, rely on zooplankton for a large percentage of their diet (Feyrer et al. 2003). However, they preferentially consume large meso- and macro-zooplankton such as calanoid copepods and mysid shrimp. Introduction of several non-native zooplankton to the region such as *Limnoithona tetraspina* (a small cyclopoid copepod with low nutritional value that now dominates the low salinity zone of the estuary) may be competing with larger zooplankters (Gould and Kimmerer 2010). Other introduced species, including the Asian calanoid copepod *Pseudodiaptomus forbesi,* now constitute the most important food source for adult smelt (Slater and Baxter, 2014). Because declines in zooplankton were implicated in the Pelagic Organism Decline (POD) (Baxter et al. 2010), it is important to quantify both the quantity and quality of zooplankton both in the wetland and exported to the surrounding sloughs. The following gears are used to sample pelagic invertebrates; catch per unit effort (CPUE) will be calculated as organisms per volume of water filtered, as measured by a flow meter (Similar to CDFW IEP zooplankton methods; Hennessy 2009).

Mesozooplankton, such as copepods and Cladocera, will be sampled with a 150 µm mesh net with 15 cm mouth diameter and a 5.9 cm diameter cod end. The net will be towed obliquely or near the surface for five minutes. The net will be rinsed from the outside, and organisms preserved in ethanol or formalin for later identification in the lab.

Mysid nets have been used extensively to characterize water column macrozooplankton that are large components of fish diets (Feyrer et al. 2003; Slater and Baxter 2014). Mysid nets may be mounted to a sled and sampled by trawling across the bottom of the substrate (benthic trawl), pulled obliquely through the water column, or sampled at the surface of the water, each for five minutes. FRP uses sleds with mysid nets that have a 40 cm by 40 cm mouth and 500 µm mesh that tapers to a 1,000 mL , 8.9 cm diameter cod end. When pulling a surface trawl, FRP uses a 50 cm diameter conical net that is 2 m long and tapers to a 1000 mL, 11.5 cm diameter cod end. After retrieval, the net is rinsed from the outside to wash the sample to the cod end. All organisms in the cod end are preserved in ethanol or formalin for later identification in the lab. The mesozooplankton and mysid nets may be attached to the same frame and deployed simultaneously to sample multiple size classes of plankton.

Benthic Invertebrates

Benthic infauna may provide a large proportion of the diet of juvenile fish in shallow water. For example, one study found chironomids (which can spend their larval stage in benthic sediments) make up over 50% of the food biomass for Chinook Salmon in a recently restored tidal wetland (Simenstad et al. 2000), and are an important component of the diet of many other pelagic and littoral fishes in the Delta (Grimaldo et al. 2009). However, invasive bivalves which also reside in the benthos may deplete phytoplankton and cut off subsidy of wetland productivity to the surrounding environment (Baxter et al. 2010 POD report). Decreases in mysid shrimp have been linked to increases in invasive bivalves, and subsequent cascading effects have caused dietary shifts and contributed to population declines of several native fish (Feyrer et al. 2003).

Benthic grab samples will be collected with methods similar to Wetlands Regional Monitoring Program Plan (Lowe 2002) and DWR Environmental Monitoring Program sampling (Wells 2015). In brief, a 0.05

m^2 surface area of the benthos will be sampled to a depth of 20 cm at each sampling location. A Ponar grab will be used where a vessel can access the larger channels. The grab is equipped with hinged stainless steel mesh lids with rubber flaps to allow flow through of water during descent and retrieval to minimize disturbance of surface sediments and to trap organisms on the sediment surface. In small channels or vegetated areas, a 10 cm PVC corer will be used to obtain the same surface area and volume of sediment.

At the field wash station, crews will gently wash the sample through the nested 1 mm and 500 µm sieves. They will then transfer the cleaned material to labeled sample jars and fixed in 70 % ethanol.

Epifaunal Invertebrates

Macroinvertebrates associated with vegetation and the bottom of the water column, such as amphipods and insect larvae, are important to salmonid diets (Maier and Simenstad 2009; Sommer et al. 2001), and are a component of Delta Smelt diets when smelt occur in areas of high macrophyte production (Whitley and Bollens 2014). In heavily vegetated areas, trawling and benthic grab samples may be unable to accurately sample the invertebrate community. Therefore, additional samples will be taken to quantify the invertebrate community associated with vegetation.

Sweep nets are used to collect invertebrates that associate closely with a substrate in shallow water; they include a handle attached to a metal ring that supports a tapered net. Sweep nets are typically pulled by hand through the water just above mud, sand, cobble, or riprap. They can be used to scrape invertebrates off vegetation in emergent vegetation and are used as a method of harvesting submerged aquatic vegetation. Sweep nets can also be used to collect organisms associated with floating aquatic vegetation by placing the net beneath the vegetation and lifting the net from below while severing the connection to surrounding plant material with shears. These nets are d-frame nets, with a 30 cm by 25 cm mouth and 500 µm mesh, tapering to a blind tightly-woven cod-end. The net is inverted and rinsed down to retrieve the sample, which is preserved in 70% ethanol.

Terrestrial and Drift Invertebrates

Emerging insects and Collembola found at the surface of the water are an important feature in salmonid diets, and are commonly sampled using neuston tows and drift nets (Howe et al. 2014; Sommer et al. 2001). The neuston net is a 45 cm x 30 cm rectangular net, 1 m long with 500 µm mesh towed half-way out of the water to sample invertebrates on the surface of the water. The neuston net will be towed at the surface of the water from the side of the boat via a davit or boat-hook. Tows are three to five minutes, depending on fouling. In narrow channels, the net may be pulled along the edge of emergent vegetation by hand (as in Howe et al. 2014). Effort is calculated by surface area sampled. After retrieval, all content collected in a cod end will be preserved in 70% ethanol for later ID .

Fish Sampling

Though draining and channelization of previously complex Marsh habitat pre-dates precipitous declines in native species abundances, large-scale loss of suitable habitat may have reduced population resilience to other stressors (Moyle et al. 2010). Restoration of a heterogeneous wetland complex on Bradmoor Island and Arnold Slough may provide spawning, rearing, and/or adult habitat for Delta Smelt and Longfin Smelt. The closest IEP survey locations regularly catch larval, juvenile and adult Longfin Smelt, and occasionally catch juvenile and adult Delta Smelt (Table 4).

TABLE 4. Total annual catch of Delta Smelt at IEP survey stations proximate to Bradmoor Island and Arnold Slough and reference wetlands from 2012-2016. Data downloaded from ftp://ftp.dfg.ca.gov/Delta%20Smelt/ on June 29, 2018.

		Delta Smelt 2012	Longfin Smelt 2012	Delta Smelt 2013	Longfin Smelt 2013	Delta Smelt 2014	Longfin Smelt 2014	Delta Smelt 2015	Longfin Smelt 2015	Delta Smelt 2016	Longfin Smelt 2016
SLS Survey	609	4	177	0	90	0	77	0	55	0	86
20mm Survey	609	38	162	79	839	1	78	4	13	1	5
Summer Townet	609	14	0	20	13	0	1	0	0	1	0
Fall Midwater Trawl	606	0	0	0	0	0	1	1	0	0	0
UCD Suisun Marsh Fish Survey	Nurse Slough	3	1	0	14	0	2	0	2	0	0

Although metrics of fish presence, abundance, diet, growth, and health are central to all of the Project objectives and hypotheses, the current population estimates of special-status species warrants caution in fish collection. Detailed fish sampling plans for each calendar year will be submitted, by June of the prior year, to the IEP Science Management Team for consideration of inclusion in the IEP Work Plan. Current indicators of population distribution and abundance of Endangered Species Act (ESA)-listed fish species, geographic and temporal coverage of existing sampling programs, and the significance of the results of additional sampling will be weighed in the development of fish sampling plans and estimates of any resulting take of listed species. Any fish sampling would follow the methods described in IEP TWM PWT (2017b).

Other Wildlife Surveys

Salt marsh harvest mouse

Salt marsh harvest mice (*Reithrodontomys raviventris halicoetes*) will be sampled at Bradmoor and Arnold periodically by CDFW and DWR. Surveys will be conducted for 4 consecutive nights using Sherman live-traps set 10 meters apart in a grid configuration suited to the vegetation type present at the site. Traps will be set two hours before sunset and checked two hours before sunrise for any small mammals. Measurements for total length, tail length, tail diameter at 2 cm from the body, sex, reproductive condition, weight, and life stage will be recorded. Any recaptures of individuals will be marked by an ear tag on the right ear for identification. Capture efficiency will be calculated and compared to other survey locations, including at Hill Slough.

Secretive Marsh Birds

CDFW and DWR will be conducting secretive marsh bird surveys on the perimeter of each site, following USFWS approved methods. A recording of 10 minutes with 4 minutes of silence and 2 minutes of rail calls, followed by 4 minutes of silence will be played at each survey point. Any secretive marsh bird calls or detections (rails, bitterns, etc.) will be recorded with the estimated distance from the survey point and direction.

Chloropyron molle

DWR will be monitoring the wetland-upland transition zone for *Chloropyron molle* annually during the bloom period (July-November) for presence/absence, recording locations with a GPS unit, with extent and density if possible. Large groups/populations will have the density and extent recorded, while small groups would have the number of individuals recorded.

4.2.2 Special Studies

Opportunities exist for special studies that require more in-depth investigation than basic monitoring can provide. DWR is open to discussions for studies proposed by prospective researchers that can be incorporated into the monitoring efforts proposed by FRP. Design and implementation of special studies, however, are outside the scope of this monitoring plan and would depend on availability of funding and partners. These studies would ideally be developed with guidance from the Fish Agency Strategy Team and be designed to address unique opportunities provided by the Project site or identified knowledge gaps related to restoration assumptions, questions, hypotheses, or outcomes.

Flux

A major objective of the Fish Restoration Program is to increase primary and secondary productivity, not only on the site, but also in the surrounding areas. Even if the site is not a net exporter, it may increase access to food by making it available to consumers in the adjacent channels during certain points of the tidal cycle (Lehman et al. 2010). Estimates of the contribution of primary and secondary production from a wetland to the surrounding channels will be made by sampling inside the site, in the channel immediately outside the site, and further down the channel beyond the tidal excursion. Tidal excursion may be estimated via hydrodynamic model results or short-term drifter studies. The difference in concentration of the constituent of interest inside and outside the tidal excursion provides an estimate of wetland contribution.

For a more accurate estimate of nutrients and productivity flux on the site, a load study may be conducted over a relatively short term. This will be similar to DWR's Methylmercury study (DWR 2013) and will only occur if time and resources allow.

SMHM Telemetry

The gentle, sloping upland at Arnold Slough provides an opportunity to study the use of upland habitat by the SMHM. Radiotracking mice on this site may help determine the extent to which they use uplands and their preferred space for high tide refugia (as in Smith et al. 2014). This study would occur only if researchers had permits for SMHM work and if an adequate population of mice colonizes the site post-restoration.

Vegetation Control

DWR's Division of Environmental Services is in planning stages of a project on revegetation techniques to prevent spread of *P. australis* into tidal wetland restoration sites. During the pre-construction period, researchers will remove *P. australis* from several plots within Bradmoor and test to see whether planting native emergent vegetation can successfully exclude *P. australis* from invading the plots.

A companion study is being planned on control techniques for *P. australis* in tidal environments. Current permits do not permit spraying of herbicides over tidal waters, mowing tidally inundated habitat is often infeasible or prohibitively expensive, and burning is impossible. Therefore, there are currently few options for controlling emergent vegetation once a restoration site is breached. Therefore, a study is being planned on the Blacklock site to assess the impacts of herbicide and mowing on the aquatic community. If successful, this project may identify management tools for controlling *P. australis* at Bradmoor Island and Arnold Slough, after they are breached.

4.2.3 Avoiding Monitoring Impacts

Throughout all field activities, monitoring personnel will be trained and take steps to avoid or minimize take (including harassment) of any state or federally ESA listed species. Specific measures to avoid and minimize take of listed species are proposed in the NMFS and USFWS BAs for the project, any additional measures resulting from the completion of Section 7 consultation will be implemented as required by USFWS or NMFS. Surveys for salt marsh harvest mice, birds, and any other terrestrial animals will be conducted under existing research permits, and no additional take was requested as part of project-specific monitoring.

Estimated take of Delta Smelt and Longfin Smelt incidental to food web sampling was calculated in the USFWS BA using 2016-2017 catch data from SLS station 609, 20mm station 609, Summer Townet station 609, and Fall Midwater Trawl station 606. Both year’s summed monthly catch at each station was divided by the total number of tows to provide an average catch per trawl. The average volume sampled from the SLS, 20mm, Townet, and Midwater Trawl were each divided separately within their sampling time frames for the following gear types’ average volumes: mesozooplankton, mysid net, neuston net, and sweep net, providing a scaling ratio for each gear type. The scaling ratio was multiplied by the average catch per trawl and then by number of our proposed sampling stations, providing an estimate of ESA catch for the mesozooplankton, mysid net, neuston net, and sweep net. All monthly estimated Delta Smelt and Longfin Smelt catches greater than zero were rounded up to the nearest whole number and added together to project ESA take for the year. Take estimates will be included in the project BA.

To minimize the risk of exceeding take estimates, Delta Smelt catches at stations near Bradmoor Island and Arnold Slough (602, 606, 609) will be monitored near real-time. If exceptional catches (>30 individuals in a single tow) are recorded at the stations surrounding Bradmoor Island and Arnold Slough, in the survey prior to a planned sampling event, the event will be postponed until after the next survey. Monitoring personnel will notify the USFWS when take reaches 50% and 90% of annual maximum to discuss options for adaptive management of sampling. Potential actions include cessation of sampling until IEP monitoring shows Delta Smelt have moved out of the area, reduction of monitoring frequency, and modification of gear to result in less harm, injury, or mortality.

Harassment of Delta Smelt or alteration of their habitat through the placement of equipment (e.g., sondes) or use of sampling gear (e.g., ponar grabs) will be brief and not likely to cause lasting damage. When sampling for invertebrates, any fish that are identifiable in the field will be measured and released alive, if possible.

5. Data and Communication

5.1 Data Quality, Management, and Dissemination

Quality assurance / quality control will be implemented as laid out in the Framework. We support adopting the IEP Data Utilization Work Group’s recommendations whenever possible to facilitate data sharing and compatibility between agencies, which become particularly important during data federation and synthesis. Standard operating procedures (SOPs) documented in the Framework will be used for all field sampling, laboratory processing, and data entry activities (IEP TWM PWT 2017b). When possible, the SOPs used will be comparable to those of long-term regional monitoring programs to maximize data comparability. Metadata will be documented at all stages of data collection and processing, and stored in standard formats along with the data. A relational database will organize all project-related data and metadata. All data manually entered into the database will be cross-checked for transcription errors. Spurious data points will be identified using raw data scatter and box-and-whisker plots, and outliers identified by this method will be dealt with on a case-by-case basis, with full records of any changes. Project monitoring annual reports will include summaries of all monitoring data, along with any analyses completed to-date. Data, their summaries, and/or reports may also be shared with other researchers and the public via the CDFW FTP site, and one or more wetland inventories or hubs (e.g. BIOS, EcoAtlas, and Estuarine Portal). Data will be shared as soon as reasonably possible after collection, not more than one year after collection. Data, analyses, and interpretation will be presented periodically to the IEP Tidal Wetland Monitoring Project Work Team.

5.2 Data Analysis and Project Evaluation

Monitoring metrics will be related to each hypothesis using a variety of established statistical techniques as recommended in the Tidal Wetland Restoration Monitoring Framework. Data will be integrated and compared with IEP long-term monitoring data and any special studies, where applicable. In the annual reports for this project, the data will be graphed, summarized, and any preliminary statistics presented. Many hypotheses and analysis methods will be more appropriate for the Programmatic Monitoring Report, which will synthesize data from all FRP projects.

Hypothesis: The area of substrate and structure suitable for rearing, refuge, and/or adult residence of smelt on-site will increase after restoration.

> **Analysis:** Maps of pre- and post-restoration topography and bathymetry will be presented, with an update to habitat areas. The tidal stage inside and outside the restoration site will be graphed over a representative tidal cycle, with calculation of residuals and lag time between the two stages, if applicable.

Hypothesis: Water quality will be suitable for smelt during the seasons they are likely to be present.

> **Analysis:** Summary statistics will be calculated for all major water quality parameters (DO, pH, temperature, conductivity, etc.). These will be graphed in comparison with at-risk-fishes tolerances (if known), and percentage of time outside the range of tolerances will be calculated.

Hypothesis: Connections between the restoration sites and surrounding sloughs will be characterized by structure, water quality, and flow that allow fish increased opportunity to access high quality habitat.

> **Analysis:** Photos of breach locations will be provided, along with summary statistics and graphs of water quality at the breaches, in relation to fish tolerances.

Hypothesis: Pelagic invertebrate (zooplankton) community composition and size structure will change seasonally and affect fish food availability.

> **Analysis:** Zooplankton catch per unit effort, community composition, and size structure will be summarized and compared over time on the site and in comparison to existing studies of zooplankton in surrounding channels. While fish diet analysis requires a special study, the

analysis will use existing diet studies to estimate what percentage of the pelagic invertebrate community is commonly found in salmon and smelt diets. A more rigorous testing of this hypothesis will be included in the Programmatic Report.

Hypothesis: Restoration of Bradmoor and Arnold will increase the contribution of epiphytic, epibenthic, and drift invertebrates to the food web relative to pre-project conditions and data from Montezuma Slough.

Analysis: Summary statistics and box-plots will be produced for wetland-associated invertebrates (insects, gammarid amphipods, isopods, and other epiphytic and epibenthic invertebrates), comparing abundances before and after restoration, inside and outside the site, and in comparison to the reference wetland. Detecting changes in fish diets from restoration will require special studies.

Hypothesis: Restoration will result in a net increase of primary and secondary production exported from Bradmoor and Arnold, or at a minimum increase access to productivity in Nurse Slough and Little Honker Bay by making it available at certain times in the tidal cycle.

Analysis: Data on concentration and catch of organic carbon, nutrients, phytoplankton, zooplankton, and other invertebrates will be summarized. Comparisons will be made between standing stock inside the site, immediately outside the site, and in channels greater than one tidal excursion from the site to estimate whether the wetland has increased available production in the surrounding area.

Hypothesis: Smelt will be present in restored habitat for some portion of their life history, with a frequency similar to, or higher than Blacklock and Rush Ranch, and reflecting current population trends.

Analysis: Without targeted fish sampling, this hypothesis can only be tested through special studies. If there has been fish sampling on the site, fish CPUE will be summarized before and after restoration, and in comparison with reference wetlands and IEP long-term monitoring trends. A more rigorous testing of this hypothesis will be included in the Programmatic Report.

Hypothesis: Bradmoor Island and Arnold Slough will increase in elevation through sediment deposition and organic matter accumulation.

Analysis: Graph change in elevation at transects over time. If detailed LIDAR and/or sonar are available, calculate net change in elevation over the entire site. Compare rate of change in elevation to predicted rates of sea level rise in the Suisun Marsh to estimate whether the site can accrete elevation fast enough to offset sea level rise.

Hypothesis: Bradmoor and Arnold Island tidal will be passively colonized by aquatic vegetation species that are proximate and connected to the restoration site.

Analysis: Coverage of each emergent vegetation class will be calculated and plotted over time across the site. This will be compared to dominant vegetation coverage in the surrounding area as mapped by the most recent Suisun Marsh Vegetation Survey.

Hypothesis: Planting, plant propagation method and propagule size, along with timing of restoration action and initial colonizer species, will influence vegetation community composition.

Analysis: Area of emergent vegetation coverage will be compared pre and post-restoration. Area of invasive vegetation will be compared between ponds on Bradmoor Island with pre-restoration management as a co-factor. Site-wide vegetation surveys will be supplemented by results of any special studies on revegetation techniques.

Hypothesis: Establishment and growth of aquatic vegetation (all types) will influence fish community structure and abundance on the site.

Analysis: The vegetation communities on the site will be mapped, and percent invasive vegetation will be graphed in comparison to reference sites. The influence of the vegetation on fish communities will only be testable with special studies. If there has been fish sampling on the site, fish CPUE will be summarized in different vegetated habitat types. A more rigorous testing of this hypothesis will be included in the Programmatic Report.

5.3 Stakeholder Communication and Reporting

Stakeholder involvement, public outreach, and communication of novel information are important components of restoration and adaptive management. The FRP holds planning meetings throughout the planning and design phases of each project with landowners, stakeholders, local agencies, and other restoration teams to exchange information, discuss concerns, and provide input. Monitoring and adaptive management results will be communicated to regulatory agencies through routine meetings and annual reports. Novel information will be disseminated through conferences like the Bay-Delta Science Conference and State of the Estuary Conference as well as through scientific teams such as the Interagency Ecological Program Tidal Wetland Monitoring Project Work Team.

DWR will submit annual project-specific monitoring reports to the resources agencies for the duration of the monitoring program. The due date for the annual reports will be determined and agreed upon by the resource agencies, DWR and CDFW. The monitoring reports shall include:

a. General project information including: project name; applicant name, address, and phone number, consultant name (if applicable), address, and phone number; acres of impact and types of habitat affected; date project construction commenced; indication of monitoring year;

b. Goals and objectives of the project;

c. Monitoring and maintenance dates with information about activities completed and personnel;

d. Summary of all quantitative and qualitative monitoring data;

e. Color copies of a subset of monitoring photographs;

f. Maps identifying monitoring areas, transects, planting zones, etc. as appropriate;

g. Progress towards meeting Project goals and objectives; and

h. Planned remedial action for the coming monitoring period.

A final report to cover the entire restoration project will be prepared at the end of the 10-year monitoring term. More thorough analyses of the effectiveness of the overall restoration program in meeting the objectives of the 2008 USFWS and 2009 NMFS Biological Opinions (USFWS 2008, NMFS 2009) will be provided in the FRP annual reports.

6. Restoration Objectives: Intervention Thresholds and Responses

While it is not anticipated that major modification to the site will be needed, an objective of this plan is to guide monitoring to identify any thresholds that may compromise the Project objectives, and to propose potential management responses or further focused monitoring efforts. Table 5 summarizes the Project objectives, the expected outcomes related to those objectives, the metrics by which progress towards meeting the objectives is measured, as well as thresholds for undertaking a management response if goals are not being met or problems occur which require intervention. DWR shall consult with the resource agencies before taking any major corrective measures. When no corrective measures are possible, reason behind the lack of progress toward the objectives will be scientifically evaluated, and lessons learned from this project will be used to improve future projects.

TABLE 5 Potential Bradmoor/Arnold management responses to deficiencies in achieving objectives.

Objective	Expected Outcome	Monitoring Group	Metric	Target	Intervention threshold	Potential Management Response
Objective 1: Increase available Delta Smelt and Longfin Smelt habitat, including enhancement of primary and secondary productivity.	The levee breach and levee degrade would increase tidal exchange, increasing habitat available to smelt, salmonids and other native fishes.	Physical & Hydrological	Topography, Tidal gauges, Photo-point pictures.	Channels formation evolves over time and connectivity to breaches remain, tidal stage in restoration site similar to slough stage.	Levee degrades and/or breach becomes blocked by debris, sediment, or by beaver dams in first 5 years. Blockage severely limits water exchange within the restoration site or with the habitat adjacent to it.	Clearing or re-excavation of the blocked area.
Objective 1	The enhanced tidal exchange would increase primary and secondary productivity at the site and/or adjacent to it, increasing prey abundance for fishes.	Food web	Phytoplankton, Zooplankton, Surface invertebrates, Benthic macroinvertebrates.	Similar food web metrics inside the site and in adjacent sloughs.	CDFW FRP monitoring team find that food web metrics inside the site are much lower than in adjacent sloughs	Consult with subject matter experts and CDFW
Objective 2: Enhance the quality of habitats to support more special status	Tidal restoration would create suitable habitat for *C. molle* and the	Other Monitoring	Population survey	*C. molle hispidum* population present	*C. molle hispidum* extent declines significantly over 5 years.	consult with USFWS and CDFW on potential actions

and native wildlife.	population will expand.					
Objective 2	Tidal restoration would create suitable habitat for rails.	Other Monitoring	Secretive marsh bird survey	No reduction in rail detection.	Severe reduction in rail detection	Consult with CDFW and USFWS on potential actions
Objective 2	Tidal restoration would not cause the SMHM population to decline.	Other Monitoring	SHMH survey	long-term availability in SMHM habitat	Long-term availability in SMHM habitat severely decreases	Consult with CDFW/USFWS on potential actions
Objective 3: To the greatest extent possible, take advantage of natural features of site to promote habitat resiliency for future Suisun Marsh conditions.	Sediment would accrete over time.	Physical & Hydrological	Topography, sedimentation	Elevations rise over time. No scour unless channel formation.	Elevation in different survey points over the years decreases.	Consult with subject matter experts on potential actions
Objective 4: Avoid promoting conditions, such as invasive species infestations, that are in conflict with the above project objectives.	Invasive species composition and spread would be reduced as much as possible.	Vegetation	Aerial imagery, site visit	Invasive weeds cover less than 20% of the site.	*P. australis* invades previously *P. australis* free areas in the site. Invasive weed coverage increases 5% from vegetation composition in year 1 after restoration.	Physical removal, spraying, TBD

Objective	Expected outcome	Monitoring group	Metric	Performance criterion	Intervention threshold	Potential management response
Objective 1						
Increase available Delta Smelt and Longfin Smelt habitat, including enhancement of primary and secondary productivity.	The levee breach and levee degrade will increase tidal exchange, increasing habitat available to smelt, salmonids and other native fishes.	Physical & Hydrological	Topography, Tidal gauges, Photo-point pictures.	Channels formation evolves over time and connectivity to breaches remain, tidal stage in restoration site similar to slough stage.	Levee degrades and/or breach becomes blocked by debris, sediment, or by beaver dams in first 5 years. Blockage severely limits water exchange within the restoration site or with the habitat adjacent to it.	Clearing or re-excavation of the blocked area.
	The enhanced tidal exchange will increase primary and secondary productivity at the site and/or adjacent to it, increasing prey abundance for fishes.	Food web	Phytoplankton, Zooplankton, Surface invertebrates, Benthic macroinvertebrates.	Similar food web metrics inside the site and in adjacent sloughs.	CDFW FRP monitoring team find that food web metrics inside the site are much lower than in adjacent sloughs	Consult with subject matter experts and CDFW
Objective 2						
Enhance the quality of habitats to support more special status and native wildlife.	Tidal restoration will create suitable habitat for *C. molle hispidum* and the population will expand.	Other Monitoring	Population survey	*C. molle hispidum* population present	*C. molle hispidum* extent declines significantly over 5 years.	consult with CDFW on potential actions
	Tidal restoration will create suitable habitat for rails.	Other Monitoring	Secretive marsh bird survey	No reduction in rail detection.	Severe reduction in rail detection	Consult with CDFW and USFWS on potential actions
	Tidal restoration will not cause the SMHM population to decline.	Other Monitoring	SMHM survey	long-term availability in SMHM habitat	Long-term availability in SMHM habitat severely decreases	Consult with CDFW/USFWS on potential actions
Objective 3						
To the greatest extent possible, take advantage of natural features of site to promote habitat resiliency for future Suisun Marsh conditions.	Sediment will accrete over time.	Physical & Hydrological	Topography, sedimentation	Elevations rise over time. No scour unless channel formation.	Elevation in different survey points over the years decreases.	Consult with subject matter experts on potential actions

Objective	Expected outcome	Monitoring group	Metric	Performance criterion	Intervention threshold	Potential management response
Objective 4						
Avoid promoting conditions, such as invasive species infestations, that are in conflict with the above project objectives.	Invasive species composition and spread is reduced as much as possible.	Vegetation	Aerial imagery, site visit	Invasive weeds cover less than 20% of the site.	*P. australis* invades previously *P. australis* free areas in the site. More than 15% cover at each site.	Physical removal, spraying, TBD

7. Responsible Parties

Bradmoor Island, Arnold Slough, and Blacklock are all owned by DWR. Bradmoor Island's access road that connects to Shiloh Road is privately owned, but DWR has an easement to use it.

DWR is the party responsible for ensuring execution of the restoration, management, and certain monitoring of the site. Management activities are outlined in the Long Term Management Plan, and specific monitoring activities are described in Table 6. Generally, DWR is responsible for ensuring management and monitoring activities are completed, maintaining records, reporting, and coordinating and approving any research activities proposed on the site. DWR will plan, permit if necessary, and execute any potential management actions deemed necessary in consultation with the FAST, as described above.

Various groups within CDFW and DWR, as well as qualified consultants are responsible for specialized monitoring as described in this plan. The monitoring biologists shall be familiar with wetland biology and have knowledge relative to monitoring protocols, management techniques, endangered species needs, and fisheries ecology. Significant personnel changes will be noted in annual reports to the FAST.

~~**TABLE 6.** Parties responsible for specific monitoring and adaptive management tasks.~~

~~Task~~	~~Method~~	~~Responsible Party~~
~~**Physical Processes Monitoring**~~		
~~Topography and Bathymetry~~	~~Ground-based GPS survey, or LIDAR if available, aerial photos~~	~~DWR~~
~~Tidal Regime~~	~~Gauges or water level loggers~~	~~DWR~~
~~**Water Quality Monitoring**~~		
~~Water quality (temperature, EC, turbidity, pH, DO)~~	~~Sonde and/or discrete measurements~~	~~CDFW – FRP Monitoring~~
~~Nutrients~~	~~Grab samples, standard lab methods~~	~~CDFW – FRP Monitoring and contracting lab~~
~~Particulate and Dissolved Organic Matter~~	~~Grab samples, standard lab methods~~	~~CDFW – FRP Monitoring and contracting lab~~
~~**Food Web Productivity Monitoring**~~		
~~Chlorophyll a~~	~~Optical sensor, grab samples~~	~~CDFW – FRP Monitoring and contracting lab~~
~~Phytoplankton~~	~~Grab samples~~	~~CDFW – FRP Monitoring and contracting lab~~
~~Zooplankton~~	~~Zooplankton tows~~	~~CDFW – FRP Monitoring~~
~~Benthic macroinvertebrates~~	~~Benthic grabs or cores~~	~~CDFW – FRP Monitoring~~
~~Surface invertebrates~~	~~Neuston tows~~	~~CDFW – FRP Monitoring~~
~~Epibenthic/epiphytic macroinvertebrates~~	~~Sweep nets~~	~~CDFW – FRP Monitoring~~
~~**Wetlands and vegetation**~~		
~~General habitat conditions~~	~~Photo points~~	~~CDFW – FRP Monitoring~~
~~EPA recommended level II assessment~~	~~CRAM~~	~~CDFW – FRP Monitoring~~
~~Vegetation composition and Cover~~	~~Suisun vegetation surveys~~	~~DWR~~
~~Rare plants~~	~~Suisun vegetation surveys~~	~~DWR~~
~~Invasive plants~~	~~Visual surveys~~	~~DWR~~
~~**Other wildlife**~~		
~~Suisun Marsh Harvest Mouse~~	~~Trapping~~	~~DWR and CDFW Suisun Marsh Group~~
~~Secretive marsh birds~~	~~Point counts~~	~~DWR and CDFW Suisun Marsh Group~~
~~**Adaptive Management**~~		
~~Planning and Permitting~~	~~-~~	~~DWR~~
~~Construction~~	~~-~~	~~DWR~~
~~Construction Monitoring~~	~~-~~	~~DWR~~
~~Annual Report~~	~~N/A~~	~~DWR, with assistance from CDFW~~
~~Maintenance and General Inspections~~	~~Visual surveys~~	~~DWR, CDFW FRP Implementation~~

Table 6. Parties Responsible for Specific Monitoring and Adaptive Management

Task Category	**Task**	**Method**	**Responsible Party**

Physical Processes Monitoring	Topography and Bathymetry	Ground-based GPS survey, or LIDAR if available, aerial photos	DWR
Physical Processes Monitoring	Tidal Regime	Gauges or water level loggers	DWR
Water Quality Monitoring	Water quality (temperature, EC, turbidity, pH, DO)	Sonde and/or discrete measurements	CDFW – FRP Monitoring
Water Quality Monitoring	Nutrients	Grab samples, standard lab methods	CDFW – FRP Monitoring and contracting lab
Water Quality Monitoring	Particulate and Dissolved Organic Matter	Grab samples, standard lab methods	CDFW – FRP Monitoring and contracting lab
Food Web Productivity Monitoring	Chlorophyll a	Optical sensor, grab samples	CDFW – FRP Monitoring and contracting lab
Food Web Productivity Monitoring	Phytoplankton	Grab samples	CDFW – FRP Monitoring and contracting lab
Food Web Productivity Monitoring	Zooplankton	Zooplankton tows	CDFW – FRP Monitoring and contracting lab
Food Web Productivity Monitoring	Benthic macroinvertebrates	Benthic grabs or cores	CDFW – FRP Monitoring and contracting lab
Food Web Productivity Monitoring	Surface invertebrates	Neuston tows	CDFW – FRP Monitoring and contracting lab
Food Web Productivity Monitoring	Epibenthic/epiphytic macroinvertebrates	Sweep nets	CDFW – FRP Monitoring and contracting lab
Wetlands and vegetation	General habitat conditions	Photo points	CDFW – FRP Monitoring
Wetlands and vegetation	EPA recommended level II assessment	CRAM	CDFW – FRP Monitoring
Wetlands and vegetation	Vegetation composition and Cover	Suisun vegetation surveys	DWR
Wetlands and vegetation	Rare plants	Suisun vegetation surveys	DWR
Wetlands and vegetation	Invasive plants	Visual surveys	DWR
Other wildlife	Suisun Marsh Harvest Mouse	Trapping	DWR and CDFW Suisun Marsh Group
Other wildlife	Secretive marsh birds	Point counts	DWR and CDFW Suisun Marsh Group
Adaptive Management	Planning and Permitting	-	DWR
Adaptive Management	Construction	-	DWR
Adaptive Management	Construction Monitoring	-	DWR
Adaptive Management	Annual Report	N/A	DWR, with assistance from CDFW
Adaptive Management	Maintenance and General Inspections	Visual surveys	DWR, CDFW FRP Implementation

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