LOWER WALNUT CREEK RESTORATION PROJECT
Monitoring and Adaptive Management Plan

Prepared for
Contra Costa County Flood Control &
Water Conservation District

November 2019
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SECTION 1
Introduction

Purpose

This Monitoring and Adaptive Management Plan (MAMP) for the Lower Walnut Creek Restoration Project (Project) describes monitoring actions that will be conducted to evaluate progress toward desired outcomes and ongoing and long-term management actions to ensure sustainable outcomes. Monitoring will serve multiple purposes:

- Assess physical conditions to verify that the Project was constructed as designed and meets permit requirements (compliance monitoring)
- Measure physical outputs and ecological outcomes to track progress towards Project objectives (effectiveness monitoring)
- Inform corrective actions if success criteria are not met. Monitoring results will be used to reduce uncertainties and improve management and future planning (adaptive management).
- Meet regulatory requirements for evaluating and documenting performance. This plan conforms with the requirements of the U.S. Army Corps of Engineers (USACE) Final Compensatory Mitigation and Monitoring Guidelines for the South Pacific Division (USACE, 2015).

Monitoring will document conditions and improve understanding of how proposed manipulations associated with restoration actions can lead to support for target ecosystems and functions. This MAMP is a living document that may be amended from time to time to address changing conditions and new monitoring techniques and technologies.

In addition to monitoring and management actions, the MAMP identifies Project success criteria, responsible parties for execution of this plan and reporting requirements. Monitoring and maintenance specific to levee performance for flood protection will follow existing Contra Costa County Flood Control and Water Conservation District (District) guidance and are not described in detail here.

Project Summary

The Lower Walnut Creek Restoration Project (Project), led by the District, in conjunction with partner John Muir Land Trust, will restore and enhance coastal wetlands and adjacent habitats at the mouth of Walnut Creek and its tributary Pacheco Creek, improving habitat quality, diversity, and connectivity along four miles of creek channel, over approximately 296 acres in total. The Project is located along the southern shoreline of Suisun Bay (Figure 1).
Figure 1
Project Location
The Project will enhance and restore estuarine wetlands and associated wetland-upland transitional habitats that have suffered large historic losses, eliminate expensive and environmentally destructive flood-related dredging, and remedy limited public access. The Project has been designed to provide sustainable benefits in consideration of future environmental changes, particularly sea level rise. The Project will enhance the over-all resilience of wetland habitats within the Project area by providing space for tidal marsh migration with rising sea levels, increasing tidal connectivity, reconnecting sediment flow pathways to promote healthy marsh accretion, and reducing the fragmentation of existing wetlands habitats in the region.

The restoration approach capitalizes on large areas of supratidal elevation lands and existing (degraded) landscape features to restore tidal marsh intergraded with a matrix of lowland terrestrial ecotone habitats (Figure 2). Regional ecosystem goals (Goals Project 2016) call for restoration of this type of habitat matrix and note that opportunities for its creation are rare around San Francisco Bay’s mostly-developed shoreline. These habitats will provide diversity and enhanced ecosystem functions under present day conditions and sustainably evolve with sea-level rise. The connectivity of wetland and lowland terrestrial habitats is important to support contemporary ecosystem functions, including wildlife habitat and biogeochemical functions such as nutrient exchange. In addition, by restoring the conditions that support sustained wetland functions and enhanced upland vegetation, the Project will reduce greenhouse gas emissions, incorporating climate change mitigation with flood and habitat management and restoration. Restoration will be accomplished by breaching and lowering levees and berms to reintroduce the tides to diked former baylands, constructing new setback levees for flood protection, and grading filled areas to create new tidal channels, tidal wetland, ecotonal lowland terrestrial areas, and adjacent upland scrub habitat. The Project includes interim management of non-native invasive plant species that would be selected based upon population size, location relative to restoration design elements, and on feasibility of elimination/control within the available timeframe. Plant material for revegetation of the restored site will be sourced from a combination of onsite collection/propagation/salvage, contract collection and growing of genotypically appropriate native plants at offsite location(s), and purchase of genotypically appropriate seed and of nursery plant stock if needed for replacement plantings during the establishment period. The Project anticipates gradual estuarine transgression, and is designed to provide high ecological value and function through the 21st century. Additional information about the Project is available at www.lowerwalnutcreek.org.

Project Goals and Objectives

The District developed Project goals and objectives, which were refined with input from the community-based planning process.

The Project goal is to:

*Restore and enhance wetlands and associated habitats in Lower Walnut Creek and to provide sustainable flood management, while allowing opportunities for public access and recreation.*

Additional information on the District’s vision for a restored Lower Walnut Creek can be found in the “Resilient Landscape Vision for Lower Walnut Creek” report (SFEI, 2017).
Figure 2

Project Restoration Plan
Project objectives are to:

1. **Restore wetlands to improve ecological function and habitat quantity, quality, and connectivity (including upland transition zones) in the Lower Walnut Creek area for native, resident plant and animal species including special status species.**

Special status species known to occur in the area include the salt marsh harvest mouse, California black rail, Ridgway’s rail, Suisun marsh aster, Delta tule pea, and Mason’s lilaeopsis.

2. **Maintain appropriate levels of flood protection along Lower Walnut and Pacheco creeks, as warranted by the land use.**

This includes protecting the services provided by existing infrastructure (e.g., power lines, railroads, water lines) and maintaining access to infrastructure and adjacent private property. Open space areas may not require maintenance or improvement of flood protection levels.

3. **Allow for future public access, education, and recreational opportunities.**

The District is committed to developing a project that is compatible with regional goals for public access through the Project area, such as a trail segment connecting two regionally-significant trails – the Ironhorse and Bay trails. The District’s charter, however, limits the ability of the District to directly fund the creation and maintenance of public access and recreation facilities.

While the District is not in a position to directly implement public access and recreational facilities, the District will provide opportunities for partners such as the East Bay Regional Park District (EBRPD) and John Muir Land Trust to pursue future public access and recreation projects within the Lower Walnut Creek Project area.

4. **Create sustainable benefits that consider future environmental changes such as sea level rise and sedimentation.**

A guiding principle in planning the Lower Walnut Creek Restoration Project is to design a system that works with nature, not against it. This means anticipating changes associated with estuarine and fluvial sediment deposition and increases in flooding anticipated to result from future sea level rise, and designing a system that is resilient to these changes without expensive and environmentally disruptive management actions.

The District is committed to developing a project that will be resilient to future sea level rise through the year 2050, and adaptable to anticipated changes through 2100. For planning purposes, the Project has adopted a sea level rise projection of 2 feet by 2050 and considers a range of sea level rise extending up to 5 feet by 2100. These values are consistent with the upper range of projected sea level rise indicated in the National Research Council’s 2012 report “Sea level Rise for the Coasts of California, Oregon and Washington” (NRC, 2012) and BCDC’s Adapting to Rising Tides regional sea level rise planning program (AECOM 2016).

### Plan Implementation Strategy

The Plan implementation strategy relies on the following concepts to guide the implementation and development of the site:
1. Utilize natural processes for habitat establishment, as possible.

2. Utilize best available science to manage the site.

3. Practice adaptive management of the site utilizing input from monitoring data in conjunction with adaptive review of restoration goals and objectives.

4. Review monitoring reports to identify any additional management actions needed to promote achievement of restoration goals and objectives.

5. To the extent practicable, minimize effects that would lead to improved conditions for nonnative invasive species such as perennial pepperweed (*Lepidium latifolium*), and stinkwort (*Dittrichia graveolens*), or non-native predators of special status wildlife species.

**Responsible Parties**

The Project site is owned by the Contra Costa County Flood Control and Water Conservation District. After construction is complete, the District will retain responsibility for all management and maintenance activities described in this plan, including reporting. In the North Reach, the District may share some of this responsibility with John Muir Land Trust. Management responsibilities will include:

- Executing the management, monitoring, maintenance, and reporting responsibilities as described in this Plan, including data collection, storage, and transmittal.
- Performing general inspections to ensure restored habitat values are protected and maintained.
- Analyzing portions of the monitoring data resulting from the monitoring activities and implementing any remedial or adaptive management actions as required by regulatory permit conditions.
- Filing reports (annual or as required by regulatory permit and grant conditions) describing the status and evolution of the restored habitats, general plant and tidal area health, presence and abundance of invasive flora and fauna, hydrologic conditions, wildlife utilization, and other management, maintenance, monitoring and reporting activities that have a bearing on successfully meeting regulatory permit requirements.
- Maintaining a file on the Project detailing management, maintenance, monitoring, and reporting activities, correspondence, and determinations.

**Qualified Personnel**

The District will retain professional biologists, botanists, restoration ecologists, or other specialists ("Qualified Personnel") as necessary to conduct tasks and monitoring as described in this Plan. Duties of the Qualified Personnel may include, but are not limited to:

- Monitoring erosion and slope stability
- Identifying and evaluating the presence of invasive species and developing management recommendations
• Conducting surveys that are required by this Plan

• Evaluating site conditions and recommending remedial actions or adaptive management actions to the District

• Assisting in the review or planning of any additional restoration actions following initial construction

• Preparing monitoring reports associated with each monitoring year
SECTION 2  
Success Criteria

The success criteria identified below will provide a basis for determining the need for remedial (corrective) measures and adaptive management. Variable environmental conditions beyond the control of the Project, such as weather patterns, trespassers, and vandalism, may contribute to one or more of the success criteria not being attained, but will not necessarily imply that the restoration has failed. Rather, the entire set of monitoring results will provide a basis for discussion with regulatory agencies as to whether remedial actions are warranted. Despite failure to attain one or more specific success criteria, monitoring results may suggest that the restoration areas are developing properly, overall performance goals are being met, and that no remedial intervention would be warranted. Most importantly the success criteria are intended to be used and interpreted based on professional judgment of the Qualified Personnel monitoring the Project site as well as the professional judgement of regulatory agency staff.

The success criteria by which the Project will be evaluated are described below.

Hydrology

Within 10-years post-breach, full tidal inundation will be achieved in the restored tidal marsh areas, with tide range comparable to natural marshes in Suisun Bay. Once achieved, the site is expected to maintain full tidal inundation long-term.

Geomorphology

The total constructed and re-occupied length of tidal channels per area of restored marsh (channel density) will be at least 100 feet per acre as-built. This is within the range observed in reference brackish and freshwater tidal wetlands within San Francisco Estuary (Grossinger 1995; WWR 2006, Orr and Olson 2014). The constructed channel cross sectional geometry will be similar to that of natural reference marsh channels (e.g. Williams et al. 2002; Orr and Olson 2014).

Vegetation

The Project will restore and enhance a mosaic of native wetland, transitional, and upland habitats across the Project site that will provide valuable ecosystem functions. Desired native plant species will populate the restoration site through planting and natural recruitment. The complex of tidal marsh (intertidal marsh, low tidal marsh, high tidal marsh, and marsh pond), lowland terrestrial (sandy alkali playa flats, lowland grassland, and seasonal wetlands) and upland (grassland and scrub) will represent a diversity of native species.
Vegetation Establishment

Vegetation establishment will be monitored over the 10-year monitoring term by monitoring percent cover. Success criteria for percent cover for the target habitats for each monitoring year are presented in Table 1. Criteria are expressed as ranges based on knowledge of the site design, reference site habitats, and existing conditions at the site, for the following reasons:

- Some habitats (e.g. sandy alkali flats) naturally have low cover and/or bare patches and can vary in species composition and distribution from year to year. It is therefore difficult to anticipate cover targets that would indicate that such habitat is on a trajectory to successful establishment in each monitoring year.

- On lands at elevations transitional between tidal wetlands and uplands, a mosaic of interdigitated habitats will be created within a wide ecotonal zone. Boundaries between these habitats are anticipated to shift due to weather patterns (variable year to year), possible settlement or erosion/sedimentation, unanticipated site conditions, and eventually sea level rise. Vegetation distribution and species composition may vary year to year and across habitat “edges”. Maintaining consistent discrete lines around as-built habitat types could significantly alter percent cover measurements within specific habitats and between monitoring years. Such shifts should not necessarily be construed as indicators of success or failure.

Qualified personnel performing vegetation monitoring should consider site conditions and anticipated natural variations and trajectories and apply their professional judgement in determining the relative success for each habitat type during each monitoring year.

**Tidal Wetlands:** Within tidal marsh habitats vegetative cover is expected to become established relatively rapidly. Native high marsh plant species assemblages are expected to increase in extent and diversity in a 5 to 10-foot zone (or wider) around banks of extended, deepened tidal channel networks, continually increasing over the 10-year monitoring period. Within five years, the marsh plain is expected to develop a nearly continuous fringe of native brackish marsh plants along the higher-elevation wetland margins, with intermittent patches of the same species scattered throughout the interior of the site. Within 10 years the vegetation is expected to expand into larger patches within the interior parts of the marsh. Tidal marsh reference sites include some existing tidal marshes around Lower Walnut Creek and Point Edith Wildlife Area. Anticipated ranges for cover success criteria are shown in Table 1.

**Sandy Alkali Playa Flats:** Sandy alkali playa flats are expected to remain relatively bare or sparsely vegetated, as in such naturally occurring habitats, and are expected to develop a highly dynamic, variable vegetation pattern and species composition. The sandy alkali playa flats are expected to support native alkali vernal pool flora and a diversity of other native annual and perennial species. The sandy alkali playa flats are anticipated to have similar (sparse) cover to what currently exists at the site in the sandy scald areas, but with predominantly native plant species rather than the existing non-native cover. These habitats are expected to develop highly dynamic, variable (unstable) vegetation patterns and species composition of local assemblages, including increased diversity of native species introduced with restoration. Reference sites with
similar habitats include portions of Whittell Marsh, Point Pinole, Upper Hill Slough, and Suisun Marsh (Orr et al. 2017). Over decades, the alkali playa habitats will become increasingly modified by episodic extreme high tidal flooding and debris deposition, forming high tidal marsh-terrestrial ecotones incorporating the native alkali pool flora. An anticipated range of cover criteria during the monitoring period has been developed based on vegetative cover observed at reference sites and is shown in Table 1.

**Seasonal Wetlands:** The created and enhanced seasonal wetlands are expected to support native seasonal wetland plants. The amount of vegetation cover is anticipated to be slightly higher than that of the alkali playa flats, however depending on the location of each seasonal wetland the percent cover may vary depending on elevation, drainage, and adjacent habitats (see Table 1). The seasonal wetlands are expected to vary in species composition, distribution and overall vegetative cover by season and by year, as driven by weather patterns. Reference sites include seasonal wetlands found in Rush Ranch and Suisun Marsh (Orr et al. 2017).

**Lowland Grassland:** Lowland grassland habitats are also anticipated to vary in rate of establishment depending on timing and amount of rainfall in the months after planting. Native perennial wet meadow (lowland grassland) vegetation is expected to develop initially as discrete patches (clonal colonies) within a matrix of native annual cover crops and grasses, gradually spreading into consolidated stands of dominant native perennial vegetation within 5-7 years, but up to 10 years for full establishment if multi-year droughts set back survivorship and growth.

**Upland Grassland and Scrub:** Upland grassland and scrub habitats will support a mix of ruderal and native perennial grassland and native scrub species. These areas are expected to support fairly robust vegetative cover relatively quickly compared to the other habitat types found at the site due to ruderal vegetation filling in gaps where native vegetation doesn’t exist.

For the purposes of monitoring vegetation establishment and percent cover, lowland grassland, upland grassland, and scrub are lumped due to the similar general cover expectations and interdigitated nature of the habitats making it difficult to parse out these habitats within the aerial imagery (see Table 1).

Total cover by this vegetation is expected to progressively increase during the first five-year period. Table 1 shows the performance criteria for vegetation establishment with a cover range for of native and naturalized species in restored and enhanced habitats at the site (based on interpretation of UAS aerial imagery).
2. Success Criteria

### TABLE 1

**VEGETATION SUCCESS CRITERIA**

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 5</th>
<th>Year 7</th>
<th>Year 10</th>
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<tr>
<td>% Total cover</td>
<td>10-25</td>
<td>10-35</td>
<td>15-45</td>
<td>25-60</td>
<td>30-70</td>
<td>35-75</td>
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<td><strong>Sandy Alkali Playa Flats</strong></td>
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<td>% Total cover (variable by season)</td>
<td>5-30</td>
<td>5-20</td>
<td>10-25</td>
<td>10-30</td>
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<tr>
<td>% Total cover (variable by season)</td>
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<td>15-50</td>
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<td><strong>Lowland Grassland, Upland Grassland, and Scrub</strong></td>
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<tr>
<td>% Total cover</td>
<td>25-50</td>
<td>30-65</td>
<td>35-75</td>
<td>45-80</td>
<td>55-85</td>
<td>65-90</td>
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In order for accurate evaluation of vegetation establishment over time the imagery used to evaluate percent cover will be captured during the same season each monitoring year to the extent feasible.

**Invasive Plants**

In the lowland terrestrial and upland habitat there is a potential for rapid colonization by naturalized ruderal plants, some of which are acceptable with respect to project goals (e.g. most non-native grasses and forbs), and some of which are not (e.g. highly invasive grasses, forbs, shrubs, and trees). Control of plants that have potential to become highly invasive at the site (high priority weeds), which may include plants rated as High or Moderate by California Invasive Plant Council (Cal-IPC), will be implemented.

High priority weeds include perennial pepperweed (*Lepidium latifolium*), stinkwort (*Dittrichia graveolens*), and other species that will be identified by a Qualified botanist or restoration ecologist prior to and during monitoring events. High priority weeds will be monitored twice a year, or as needed, throughout the 10-year monitoring period. The acceptable cover of high priority weeds will effectively be 0% within the work limit within the restoration site (areas shown in Figure 2). Identification of high priority weeds will trigger eradication measures. Some invasive plants are established within existing tidal marshes along Lower Walnut Creek and Pacheco Creek, but areas outside of the Project work limit will not be managed as a part of this Project. This management trigger should be actively tracked over the first three years of monitoring and as needed (annually or every other year) throughout the rest of the 10-year monitoring period. Invasive plant eradication measures will be conducted at the proper time of year, using appropriate control measures. Examples of such measures and schedule are shown in Table 3. Prior to commencement of work, the contractor will be required to prepare for approval a weed management plan to provide specific methods for control of specific target species, and employ a certified pest control applicator to implement the approved weed control plan.

However, timing of weed control efforts in highly sensitive habitats may need to be modified due to other restrictions, such as during the nesting season of birds or special status species, or may not be attempted at all where accessing infestations would result in significant disturbance to endangered species habitats.
Wetlands

A re-delineation of jurisdictional wetlands will be performed in Year 5 of the monitoring period to verify that the target wetland acreage has been attained. If the target wetland acreage has not been attained, the District will consult with the agencies and discuss the site function and conditions and determine if remedial actions should be taken.

Public Access Accommodation Space

The current restoration is being implemented consistent with construction of public access as a future Project phase. For the current restoration phase, the Project will grade accommodation space for future trails and public access facilities consistent with public access plans developed by John Muir Land Trust (North Reach) and East Bay Regional Park District (South Reach) in coordination with the Project.
SECTION 3

Monitoring

Pre-Project Conditions

Pre-project conditions are documented in the Lower Walnut Creek Restoration Project Study Report (ESA 2017) and permit applications. The documents provide information on hydrology, geomorphology, wetland and upland habitat types and public access existing prior to project construction.

In addition, low-level aerial photography using an Unmanned Aircraft System (UAS, or drone) will be acquired prior to construction to provide a visual document of pre-project existing conditions.

As-Built Conditions

UAS aerial photography will be acquired immediately following completion of construction to document the as-built conditions. The baseline imagery will also inform assessment of the rate of change within the restored area, and the effectiveness of restoration and subsequent management actions.

A topographic survey of the restoration site will be acquired immediately following the completion of construction to document as-built ground elevations. The construction contractor will apply appropriate survey methods to characterize site conditions, and may use ground based and/or aerial survey techniques.

Monitoring

Table 2 provides a summary of the monitoring activities and schedule planned for the Project site. The monitoring schedule described will be adaptable based upon implementation of adaptive management measures. Figure 3 shows preliminary monitoring locations at the site.
### TABLE 2
SUMMARY OF MONITORING SCHEDULE

<table>
<thead>
<tr>
<th>Category</th>
<th>Aspect</th>
<th>Location</th>
<th>Monitoring Parameter</th>
<th>Time of Year</th>
<th>Monitoring Years</th>
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<td>Hydrology</td>
<td>Water Levels</td>
<td>Install pressure transducer:</td>
<td>Water level</td>
<td>Deployed for a minimum of 30 days, April - October</td>
<td>As built, Years 1, 2, 3, 5, 7, and 10, as needed</td>
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<td></td>
<td></td>
<td>• Representative channel network in North and South Reaches</td>
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<tr>
<td>Geomorphology</td>
<td>Channel Development – Planform</td>
<td>• North and South Reaches</td>
<td>Channel length</td>
<td>Late summer</td>
<td>Pre-construction, As-built, Years 1, 2, 3, 5, 7,</td>
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<td>and 10</td>
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<td>Channel Development – Cross-Sections</td>
<td>• North and South Reaches: cross-sections of channels and adjacent</td>
<td>Elevation</td>
<td>Summer</td>
<td>As-built, Years 1, 2, 3, 5, 7, and 10</td>
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<td>marshplain, thalweg profile of North Reach outboard channel to Suisun</td>
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<td>Invasive Plants</td>
<td>Late spring and/or Late summer</td>
<td>Years 1, 2, 3, 5, 7, and 10</td>
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<td>Photo-Documentation</td>
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<td>• North and South Reaches</td>
<td>Site Development</td>
<td>Late summer</td>
<td>Years 1, 2, 3, 5, 7, and 10</td>
</tr>
<tr>
<td>Wetlands</td>
<td>Wetland Extent</td>
<td>• North and South Reaches</td>
<td>USACE Jurisdictional</td>
<td>Any season</td>
<td>Year 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wetlands</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public Access</td>
<td>Accommodation space for future trail and</td>
<td>• South Reach</td>
<td>Area Length of levee</td>
<td>Any season</td>
<td>As-built</td>
</tr>
<tr>
<td></td>
<td>access facilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Accommodation space for future trail and</td>
<td>• North Reach</td>
<td>Area Length</td>
<td>Any season</td>
<td>As-built</td>
</tr>
<tr>
<td>Sustainable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benefits</td>
<td>Habitat Resilience, accommodation space</td>
<td>• North and South Reaches</td>
<td>Area</td>
<td>Any season</td>
<td>As-built</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Levee</td>
<td>• South Reach</td>
<td>Length</td>
<td>Any season</td>
<td>As-built</td>
</tr>
</tbody>
</table>

Note: Monitoring and maintenance specific to levee performance for flood protection will follow existing Contract Costa County Flood Control District (District) guidance and are not presented in detail here.
Figure 3
Preliminary Monitoring Locations

SOURCE: ESA, 2019
Hydrology

Measurements of tidal water elevations within the Project will be made to assess hydrologic functions and to document the depth and duration of tidal inundation over the marshplain surface.

Water levels will be measured and recorded at two locations in the North Reach and one location in the South Reach using continuous water level recorders. Preliminary gauge locations are shown in Figure 3. The exact locations of gauges will be determined in the field, with consideration given to access for downloading data and protection from vandalism. Water levels within the Project site will be compared to the NOAA Port Chicago Tide Gage, which prior ESA monitoring (ESA 2017) has established to be representative of tidal water levels along Suisun Bay outboard of the Project site. Hydrology monitoring will take place for as-built conditions and during monitoring years 1, 2, 3, 5, 7 and 10. Sensors will be deployed for a minimum of 30 days (to record two neap-spring cycles) between April and October. Monitoring will be discontinued once the success criteria have been met.

Geomorphology

Tidal Wetland Development – Planform

Aerial photographs will be taken of the site at a scale from which the development of the channel networks, and the distribution of marsh and mudflat areas is distinguishable. During monitoring years 0 (as-built condition), 1, 2, 3, 5, 7, and 10, aerial photographs will be taken and changes in wetland development will be compared to the previous aerial photographs. Free satellite photos will also be used when possible. Newly-formed channels and significant changes to the channel layout will be noted in each monitoring year. Aerial photographs will be taken in the late summer and during a tide no greater than +2.0 feet MLLW so that channels are clearly visible and marsh/mudflat areas can be viewed. Mapping will be performed at a minimum scale of 1:2400. The images will be obtained in a digital rectified format to allow use in a GIS system.

At years 1, 2, 3, 5, 7 and 10, UAS imagery will be used to show site development, habitat evolution, and settlement of site features. Aerial photographs taken to evaluate channel development and marsh/mudflat layout will also support the vegetation establishment monitoring.

Tidal Wetland Development – Cross-Sectional

The cross-sectional geometry of the channels and marsh plain will be monitored using ground-surveyed transects and augmented with aerial photographs (described above). Transects will be established at key locations across slough channels, mudflat, and marsh. Preliminary cross-section locations are shown in Figure 3. All transects will be surveyed upon completion of construction (as-built condition) to provide baseline data on the channel and marsh elevations prior to tidal inundation. Transect starting and ending points will be permanently monumented in the field to facilitate reoccupation in subsequent monitoring years. Transects will be resurveyed at years 1, 2, 3, 5, 7 and 10.

Transect data will indicate channel erosion or shoaling and whether or not marsh/mudflat areas are accreting at the expected rates. In particular, the existing outboard channel connecting the
North Reach directly to Suisun Bay is undersized and is expected to erode in response to restored tidal flows. While the restoration Project is not reliant on accretion in order to support tidal marsh vegetation in the near term, sediment accretion will help the restored marshes persist in the future with rising sea-levels. Vegetation cover will also be recorded in the elevation transect surveys to document patterns of vegetation establishment relative to elevation (as an indicator or hydroperiod).

Access within the site may be difficult in some areas due to the soft ground surface, deep channels, and the need to minimize disturbance to the site. Transect elevations will be surveyed during high tides by boat if it is not possible to accomplish the surveys on foot.

Vegetation

Vegetation Establishment

Aerial photographs (UAS imagery discussed above) will be used to monitor vegetation establishment with limited ground-truthing. Limited ground-truthing will include a site visit to take GPS points of algae, mudflat, and different dominant vegetation communities to refine the remote sensing results.

A map of the colonizing and expanding patches of native and non-native vegetation will be produced from the analysis of the aerial images. False color infra-red photography may be used in the identification of plant species that have become established throughout the site. Aerial image interpretation to determine vegetation types and cover will be completed in Years 1, 2, 3, 5, 7, and 10.

Weed Survey

Locations of perennial pepperweed (*Lepidium latifolium*), stinkwort (*Ditrichia graveolens*), and other highly invasive plants that negatively affect tidal marsh and transition zone habitats will be recorded. Populations of non-native and non-naturalized species that are rated High or Moderate according to the Cal IPCs California Invasive Plant Inventory, Online Database (Cal-IPC 2017), as well as other target species identified by a Qualified botanist or restoration ecologist, will be documented and recommended for treatment or other management actions, with an emphasis on controlling weeds that threaten the ability to meet performance criteria specified in the regulatory permits. The initial list of potential target weeds and management methods for those weeds is shown in Table 3. A list of invasive species targeted for management will be developed and updated during each monitoring cycle. Stands of target invasive plants will be mapped using GPS to monitor invasive plant colonization and establishment at the site.

For the first three years, mapping will occur at least twice a year (likely in late spring and late summer) to capture invasive plants species with different growth periods at the site. After three years, it may be determined that more or fewer weed surveys are necessary, or, depending on what invasive species are present, biennial monitoring may continue to be required. Weed

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1 Naturalized weeds that are part of the surrounding landscape and do not present an impediment to meeting the performance criteria will not be included in the weed survey. Examples include many non-native annual grasses or offsite populations of stinkwort or perennial pepperweed.
surveys and mapping will occur in Years 1, 2, 3, 5, 7, and 10, unless it is determined after three years that the monitoring should continue annually in order to inform annual maintenance and invasive plant control work at the site.

**Photo-Documentation**

Twelve permanent photo-documentation stations will be established at the site prior to commencement of construction. Preliminary photo-documentation stations are shown in Figure 3. Photographs will be taken to document pre-project conditions and, following construction in monitoring years will provide documentation of vegetation establishment and evolution of marsh, transitional, and upland habitat areas throughout the site. To the extent possible, photopoints will be located in areas that provide good vantage points of the site, representative of site conditions, good distribution around the site, and that can be reoccupied in subsequent years. The location of photopoints will be recorded with GPS and the direction (aspect) and other relevant relocation information will be recorded. A map of photopoint locations and exposure directions as well as a photo appendix with all photos will be included in each monitoring report.
TABLE 3
POTENTIAL TARGET WEEDS AND MANAGEMENT METHODS

<table>
<thead>
<tr>
<th>Species</th>
<th>Common Name</th>
<th>Life Form</th>
<th>Cal-IPC Rating</th>
<th>Mgmt. Methods</th>
<th>Priority for Control</th>
<th>Notes</th>
<th>Schedule</th>
<th>Monitor, No Vegetation Management to Be Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arundo donax</td>
<td>giant reed</td>
<td>P</td>
<td>High</td>
<td>CES</td>
<td>High</td>
<td>Excavate where feasible or cut near ground and immediately spray cut ends</td>
<td>C/E</td>
<td>S</td>
</tr>
<tr>
<td>Brassica nigra</td>
<td>black mustard</td>
<td>A</td>
<td>Mod</td>
<td>CMS</td>
<td>Moderate</td>
<td>Cut/mow in spring before seed set, spray regrowth</td>
<td>C/M</td>
<td>S</td>
</tr>
<tr>
<td>Carduus pycnocephalus</td>
<td>Italian thistle</td>
<td>A</td>
<td>Mod</td>
<td>CMS</td>
<td>High</td>
<td>Cut/mow in spring before seed set, spray regrowth</td>
<td>C/M</td>
<td>S</td>
</tr>
<tr>
<td>Carpobrotus edulis</td>
<td>ice plant</td>
<td>P</td>
<td>High</td>
<td>ES</td>
<td>Moderate</td>
<td>Excavate, place in piles to decompose, spray seedlings</td>
<td>ES</td>
<td></td>
</tr>
<tr>
<td>Centaurea solstitialis</td>
<td>yellow starthistle</td>
<td>A</td>
<td>High</td>
<td>CMS</td>
<td>High</td>
<td>Cut/mow in spring before seed set, spray regrowth</td>
<td>C/M</td>
<td>S, S</td>
</tr>
<tr>
<td>Cirsium vulgare</td>
<td>bull thistle</td>
<td>A</td>
<td>Mod</td>
<td>CMS</td>
<td>Moderate</td>
<td>Cut/mow in spring before seed set, spray regrowth</td>
<td>C/M</td>
<td>S</td>
</tr>
<tr>
<td>Cortaderia selloana</td>
<td>pampas grass</td>
<td>P</td>
<td>High</td>
<td>BES</td>
<td>High</td>
<td>Excavate, pull/spray seedlings, bag seed heads</td>
<td>BES</td>
<td>S</td>
</tr>
<tr>
<td>Ditrichia graveolens</td>
<td>stinkwort</td>
<td>A</td>
<td>Mod - Alert</td>
<td>EMS</td>
<td>High</td>
<td>Excavate, pull/spray seedlings before seed set (in early fall (&lt; 1st week Sept))</td>
<td>ES</td>
<td></td>
</tr>
<tr>
<td>Lepidium latifolium</td>
<td>perennial pepperweed</td>
<td>P</td>
<td>High</td>
<td>CMS</td>
<td>High</td>
<td>Cut/mow in spring before seed set, spray regrowth</td>
<td>C/M</td>
<td>S, S</td>
</tr>
<tr>
<td>Rubus armeniacus</td>
<td>Himalayan blackberry</td>
<td>P</td>
<td>High</td>
<td>CS</td>
<td>Moderate</td>
<td>Cut and spray in spring, spray resprouts</td>
<td>CS</td>
<td>S, S</td>
</tr>
<tr>
<td>Tamarix ramosissima</td>
<td>saltcedar</td>
<td>P</td>
<td>High</td>
<td>CS</td>
<td>High</td>
<td>Cut near ground and spray stump immediately, spray resprouts</td>
<td>CS</td>
<td>S</td>
</tr>
</tbody>
</table>

NOTES:
A = Annual plant, includes biennial plants
B = Bag seed heads
C = Cut with line trimmer, blade or chain saw
E = Excavate by soil knife, shovel or backhoe bucket
M = Mow with high clearance mower set to 6"
P = Perennial plant
S = Spray with herbicide (Herbicides to be applied under the direction of a licensed pest control applicator)

Cal-IPC High = On a state-wide basis have severe ecological impacts on physical processes, plant and animal communities and vegetation structure
Cal-IPC Moderate (Mod) = On a state-wide basis have substantial ecological impacts on physical processes, plant and animal communities and vegetation structure.
Wetlands

A re-delineation of jurisdictional wetlands will be performed five years following construction. The delineation may revisit any data points that have not been altered by construction and are accessible, and will also rely on new data points to identify wetland boundaries. Only the minimum number of sample points necessary to establish the extent of jurisdictional wetlands will be employed. Results of the re-delineation will be summarized in a wetland delineation technical memorandum with maps and data sheets, and will be provided to the USACE.

Public Access Accommodation Space

The Project will grade accommodation space for future trails and public access facilities as documented in Project as-built topographic surveys. Length of levee or other area set aside for future trails and area set aside for facilities will be measured from the as-built surveys.

Sustainable Benefits

The area of potential future transitional ecotone and uplands habitats based on elevation will be surveyed and reported as part of the Project as-built plans. This data will be used in coordination with data collected under vegetation succession and wetland extent to monitor the migration of wetlands and transitional habitats within the potential habitat areas.

The length and height of levee constructed will be surveyed and reported as part of the Project as-built construction plans.
SECTION 4
Reporting

Monitoring reports will be submitted to USACE, RWQCB, CDFW, and BCDC, by January 31 following each monitoring year. Monitoring years include Year 1, 2, 3, 5, 7, and 10. Monitoring reports will include, at the minimum, the following information:

- Summary description of the monitoring methods, including data collection and analysis;
- An overview of the restoration project progression, including a general discussion of site conditions and changes in conditions since the previous report; quantitative and qualitative comparisons of vegetation establishment, marsh conditions, and geomorphic evolution/stability between previous monitoring years;
- Analysis of performance in relation to success criteria;
- Discussion of maintenance actions undertaken that are directly relevant to restoration of wetlands;
- Color photographs taken from the photo-monitoring point locations; and
- A discussion of any corrective measures needed or undertaken (including weed control, replanting or reseeding, regrading for tidal circulation, or erosion control measures).
- The five-year wetland delineation will be provided with the year 6 monitoring report.

Wetland restoration data will also be uploaded to the EcoAtlas Project Tracker and applicable incidental species observations will be reported to the California Natural Diversity Database.
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SECTION 5
Maintenance and Adaptive Management

The overall goal of maintenance and adaptive management of the site is to promote the long-term trajectory of the site in providing functions and services associated with the restored habitats. The approach to adaptive management of the Project will be to conduct regular site visits and monitor selected characteristics to determine the stability of the site and ongoing trends in physical and biological processes. Unexpected trends in the biological or morphological characteristics of the site will require examination to determine if they are compromising the goals and objectives of the restoration Project.

The Project has been designed to minimize the need for active operations and ongoing maintenance. There are no operable facilities within the proposed Project area. The District, in conjunction with its partners, will conduct maintenance of the Project site, consisting of trash collection, security, trail inspections and maintenance as needed. Vegetation maintenance will be focused on restricting the spread of target invasive exotic species and may include mechanical treatment (mowing, manual pull, mechanical scrape) and/or herbicide application, as determined by a qualified biologist/botanist in response to particular site conditions.

To evaluate whether goals are being met, it is necessary to compare the monitoring data and results from the current and previous years with the success criteria, and interpret the trends based on professional judgment. The District, in consultation with Qualified Personnel, will assess monitoring results and, if necessary, evaluate potential adaptive management approaches. Adaptive management actions will be discussed with agency personnel to the extent potential actions may affect permit conditions. All adaptive management recommendations and actions implemented will be documented in the monitoring reports. If general site assessments or monitoring indicate that site maintenance is needed or success criteria outlined in Section 2 are not being met, corrective measures will be implemented. Corrective measures will be directed by the District and may include additional or specific weed control measures, trash and litter control, repair or installation of erosion/sediment controls, and/or supplemental seeding or planting.
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SECTION 6
References

AECOM. 2016. San Francisco Bay Tidal Datums and Extreme Tides Study. Prepared with funding from FEMA and SF BCDC. February.


San Francisco Estuary Institute-Aquatic Science Center (SFEI). 2017. Changing Channels: Regional Information for Developing Multi-benefit Flood Control Channels at the Bay Interface. A SFEI-ASC Resilient Landscape Program report developed in cooperation with the Flood Control 2.0 Regional Science Advisors, Publication #801, San Francisco Estuary Institute-Aquatic Science Center, Richmond, CA. Version 1.1, May 2017 (reflects minor revisions to v1.0)


