R E P O R T

CALIFORNIA STATE COASTAL CONSERVANCY

SAN FRANCISCO BAY CREOSOTE REMOVAL AND HERRING HABITAT RESTORATION PROJECT

ATTACHMENT A – PROJECT DESCRIPTION

Prepared for

California State Coastal Conservancy
1330 Broadway, Suite 1300
Oakland, California 94612

October 30, 2015

URS Corporation
1333 Broadway, Suite 800
Oakland, CA 94612

60390453

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Acronyms

BCDC	Bay Conservation and Development Commission
BMP	best management practice
CDFW	California Department of Fish and Wildlife
CESA	California Endangered Species Act
EFH	Essential Fish Habitat
ELVS	Ecological Limits, Viability, and Sustainability
ESA	Federal Endangered Species Act
°F	degrees Fahrenheit
GIS	geographic information systems
MHHW	mean higher high water
MHW	mean high water
MLLW	mean lower low water
MLW	mean low water
MSL	mean sea level
kPA	kilopascal
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NWFW	National Fish and Wildlife Foundation
PAH	polycyclic aromatic hydrocarbon
ppt	parts per thousand
RWQCB	San Francisco Bay Regional Water Quality Control Board
SFEI	San Francisco Estuary Institute
SFEP	San Francisco Estuary Partnership
SPCC	Spill Prevention Control and Countermeasure
SCC	California State Coastal Conservancy

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1.1 PROJECT HISTORY

San Francisco Bay is the largest estuary on the west coast and is a dynamic estuarine environment surrounded by urban areas and developed lands. Since the Gold Rush, San Francisco Bay has lost more than 90% of historic tidal wetlands and the Bay itself is one-third smaller in area due to sedimentation and fill projects along the bay shoreline and in the bay itself, which has caused a substantial amount of subtidal habitat loss. There is reduced three-dimensional structure in the bay, and featureless mud bottoms predominate in many areas due both to increased siltation and dredging, and to removal of existing natural hard substrates because they presented navigational hazards. A large percentage of San Francisco Bay shorelines have been stabilized with hardened structures, such as creosote-treated piles, riprap, breakwaters, seawalls, and bulkheads to create dry lands for development or evaporation ponds for salt production, and to prevent or minimize coastal erosion. San Francisco Bay now has reduced biomass of wetland vegetation, seagrass, and shellfish beds that once provided copious food resources to multiple species in the food chain.

Treated wood piles were historically used to support piers, wharfs, bridges, and navigational aids. Many of these wooden piles were injected with creosote, a substance used from the mid-1800s into the 1950s to preserve wooden marine structures from decay. Creosote is a complex mixture of chemicals, many of which are toxic to fish and other marine organisms. Within San Francisco Bay, creosote-treated piles were the dominant pile material until the use of concrete piles became common in the early 1900’s (Werme et al. 2010). Creosote-treated piles continued to be used in the Bay until 1993, when the California Department of Fish and Wildlife (CDFW) stopped approving its use in state waters, although use of the material after 1970 was limited (Werme et al. 2010). A 2010 study prepared for the SCC identified over 33,000 derelict piles within the Bay (Werme et al. 2010). The study identified four areas where derelict creosote-treated piles were concentrated: Carquinez Strait, Napa River, Point Richmond, and the San Francisco waterfront. In these four locations, derelict pile concentrations ranged from 61 to 384 piles per mile of shoreline.

In recent years, many organizations, including the California State Coastal Conservancy (SCC) has a successful history of working with multiple stakeholders to acquire, restore, enhance, and manage subtidal and tidal wetland habitat in San Francisco Bay. To date, over 50,000 acres have been protected, restored, and enhanced in San Francisco Bay, placing these efforts among the most aggressive wetland habitat conservation programs in the nation. The San Francisco Bay Creosote Removal and Pacific Herring Restoration Project will leverage multiple ongoing coastal wetland conservation efforts in San Francisco Bay.

The SCC acquired a grant from the National Fish and Wildlife Foundation (NFWF) to support a creosote-treated pile removal and Pacific herring restoration pilot project in the San Francisco Bay. This collaborative, innovative project includes final site selection and project design, permitting, creosote-treated pile removal, native eelgrass bed and oyster reef habitat restoration, pre- and post-construction monitoring, public information sharing, and documenting lessons learned with Bay Area resource agencies and environmental groups.

1.2 PROJECT PURPOSE, NEED, AND GOALS

The proposed project is considered to be a pilot project which will be undertaken to further the objectives of or to achieve consistency with requirements of many environmental laws and regulations, including McAteer-Petris Act, which formed the San Francisco Bay Conservation and Development Commission (BCDC) and its adopted Bay Plan; federal and state Endangered Species Acts; Clean Water Act; Magnuson Stevens Fishery Conservation and Management Act; California Fish and Game Code; Fish and Wildlife Coordination Act, and others. This will be achieved by removing sources of contamination from San Francisco Bay and by enhancing subtidal and intertidal habitat for the benefit of spawning herring and other wildlife.

The proposed project would also address the goals set forth in The San Francisco Bay Subtidal Habitat Goals Project. That project is a collaborative effort involving the SCC, the BCDC, the National Oceanic and Atmospheric Administration (NOAA), and the San Francisco Estuary Partnership (SFEP). Lead staff from these agencies worked with more than 75 people and organizations in the broader scientific community, resource managers, restoration practitioners, and stakeholders over several years to develop the goals set forth the San Francisco Subtidal Habitat Goals Report (Subtidal Goals Report; SCC 2010). The Subtidal Goals Report is a non-regulatory, 50-year conservation plan for how to move forward with science-based subtidal research, protection, and restoration of subtidal habitats in the San Francisco Bay.

One of the recommendations in the Subtidal Habitat Goals Project Report is to use a pilot project approach to remove artificial structures, creosote-treated piles, and other marine debris at targeted sites in combination with a living shoreline restoration design that will use natural bioengineering techniques (such as native oyster reefs and eelgrass (*Zostera marina*) plantings) to replace lost habitat structure. The report also states that one large-scale, long-term strategy for the Central Bay and the Richmond shoreline might be to restore eelgrass near sites where creosote-treated piles are being removed, to provide eelgrass as a natural substrate to attract spawning herring. Pacific herring (*Clupea pallasi*) have also spawned on restored oyster reefs in the bay, and are being included as part of an innovative, multi-habitat restoration approach to benefit Pacific herring in the region.

Creosote is an oily product distilled from crude coal tar and contains hundreds of chemical compounds. The primary constituents of creosote are polycyclic aromatic hydrocarbons (PAHs) and alkylated PAHs which account for up to 90% of creosote mixtures (WHO 2004). Many of the PAHs present in creosote mixtures are identified as priority pollutants. While creosote has a relatively low solubility in water, some of its components are highly soluble. Most leaching likely occurs during the first few years after a pile is installed, but leaching may continue for many years (Werme et al. 2010). The decreased level of creosote migration from older piles is largely thought to be due to decreased surface availability. Creosote near the surface of the pile undergoes a “weathering” process, in which individual chemical constituents are adsorbed, evaporated, photo-oxidized, or dissolved (reviewed in Sved et al. 1997). However, the field mapping team during a 2010 study found visible apparent slicks from piles in San Francisco Bay, all of which were installed more than 15 years ago (Werme et al 2010).

PAHs that leach out of creosote-treated piles persist in the environment and are toxic to some organisms. Circulation of water around creosote-treated wood likely disperses PAHs to low enough concentrations that organisms moving through the Bay are unaffected (SCC 2010). However, organisms that come into direct, extended contact with creosote-treated piles may be adversely affected. Harmful levels of contact may occur if organisms feed on prey species inhabiting the surface of the piles or if organisms lay eggs directly on piles, as is the case with Pacific herring.

Creosote-treated wood has been shown to negatively impact the early life stages of Pacific herring. Exposure to creosote-treated wood caused developmental delays, embryo degeneration, edema (accumulation of fluid), changes in movement, and alterations to cardiac function in Pacific herring embryos from the San Francisco Bay (Vines et al. 1998). Creosote exposure led to a significantly lower rate of hatching success, and exposure of 7 micrograms per liter, which typically occur within 10 centimeters of creosote-treated piles, caused skeletal defects and negatively impacted swimming ability in hatched Pacific herring larvae (Vines et al. 1998; Duncan 2014). Over one-third of the piles observed by the San Francisco Estuary Institute (SFEI) and NOAA were located within critical spawning areas and herring in the San Francisco Bay sometimes spawn directly on creosote-treated wood. It is likely that embryos laid directly on creosote-treated piles experience higher rates of mortality. Embryos that survive to hatch are likely to have higher rates of skeletal deformation during development, preventing them from successfully foraging and avoiding predators.

The proposed project would remove artificial structures such as creosote-treated piles and collapsed decking in combination with a living shoreline restoration design that will use natural bioengineering techniques (such as eelgrass plantings and reef structures for native oysters) to replace lost habitat structure. Creating or expanding eelgrass beds would provide substrate for Pacific herring and other organisms to attach their eggs to and food resources for species such as herring and salmon. Fabricated reef structures would not only provide a secondary spawning substrate for herring but would also provide the necessary hard substrate for native Olympia oyster (*Ostrea lurida)* settlement and growth and other species, and help trap and stabilize sediments in the areas formerly occupied by creosote-treated pilings. Finally, extending the range of rockweed (*Fucus gardneri*) in the intertidal zone would further provide an additional spawning substrate for herring and further enhance the overall habitat complexity and diversity at the restoration sites. More background on these details of the restoration project is in the following paragraphs.

Several functions of eelgrass beds, oyster beds, and rockweed are considered helpful in moving the estuary toward a more natural, less uniform state with local heterogeneity benefiting native species and biodiversity. Consistent with the recommendations in the Subtidal Goals Report, the proposed project would implement a pilot creosote-treated pile removal and native herring habitat restoration project in the San Francisco Bay. The project has the support of multiple key partners in the bay, and the goals, purpose, and need of the project are discussed below.

In summary, the purposes of the project are as follows:

- To increase the overall ecological health of portions of San Francisco Bay by removing derelict creosote-treated wooden pilings,
- Improve spawning and development success of Pacific herring through removal of creosote-treated piles, which have been shown to have detrimental effects on early life history stages of Pacific herring;
- Improve spawning success of Pacific herring by providing necessary subtidal structures, including eelgrass beds, rockweed, and oyster reef habitat, on which they can lay eggs;

- Share lessons learned to further inform future planning, management, restoration design practices, and permit procedures for creosote-treated pile removal and subtidal habitat restoration projects bay-wide, and
- To provide additional habitat enhancements that not only bring the herring-related benefits described above but also benefit other species and increase the overall habitat complexity of the Bay.

The need for the project is most effectively demonstrated by examining the case in which the project was not implemented. In such a situation, Pacific herring continue to spawn on derelict creosote-treated piles and be adversely affected by the effects of creosote and PAH. The piles themselves would remain in place and continue to pose a marine debris problem and a navigation hazard and also continue to degrade and impair water quality. The spatial extent of eelgrass and rockweed would not be increased, and the associated benefits that those species bring to the overall ecology of the Bay would not be realized. The benefits of the increased three-dimensional habitat complexity would not be realized. The population size of Olympia oysters in the Bay would remain limited by the lack of hard substrate for oyster settlement and growth, and the ancillary gains of reducing localized scour and stabilizing sediment for eelgrass beds would not be achieved. Finally, this is a pilot project, intended to develop methods for the design, planning, and environmental clearance and permitting of similar pile removal and subtidal habitat restoration efforts in the future, and to test and monitor the successes of those actions and share those with other entities involved in managing and improving conditions in San Francisco Bay. In the absence of this project, those beneficial impacts of this pilot project would not occur.

The project purpose and goals will be achieved through the following project actions:

- Remove approximately 700 individual piles that together are more than 180 tons of creosote-treated wood;
- Remove several thousand square feet of collapsed concrete decking and other types of marine debris ; and
- Establish at least 1 acre of beneficially affected habitat including eelgrass, rockweed, and reef structures for oysters..

1.3 SITE SELECTION PROCESS

To select a site or sites for this pilot project, a three-tier site screening process was used to determine what site or sites would best fit the goals of the project. The screening process identified pile clusters that best fit objectives of (1) removing large amounts (up to 1,200 individual pilings or 180 tons) of creosote-treated piles – as specified by the grant from the NFWF that funded the project) from herring spawning habitat and (2) where restoration of native habitats, including, but not limited to, eelgrass could be accomplished to replace the lost physical structure of the piles which may have been utilized by spawning herring.

From this screening process, two sites were chosen for the proposed project. **Figure 1** shows the locations in San Francisco Bay of those two sites: the Red Rock Warehouse site (**Figure 2**) and the El Campo Marina site (**Figure 3**).

- **The Red Rock Warehouse site** is in San Pablo Bay on the northeastern side of Point San Pablo in Contra Costa County, on parcels owned by the City of Richmond.
- **The El Campo Marina site** is located along the Tiburon Peninsula north of Paradise Beach Park in Marin County, on privately owned parcels.

The main reason for choosing two sites instead of one for the pilot projects is that there was no single site that had a large enough number of creosote-treated piles to meet the criteria of the NFWF grant or the overall goals of the project. It was decided that the removal of derelict creosote-treated piles and habitat restoration at the combination of these two sites would best meet those project goals and also provide comparisons of restoration efforts on two different sides (west and east) of San Francisco Bay.

The details of the proposed pile removal and subsequent habitat restoration at these two sites are presented in the following sections.

2.1 SITE LOCATION AND OVERVIEWS

The Red Rock Warehouse and El Campo Marina sites are generally located within the Central and San Pablo Bay portions of San Francisco Bay (**Figure 1**), as described in detail below.

There are also several portions of City of Richmond-owned land around the tip of Point San Pablo that could be used for staging areas and for drying removed piles. It is unclear yet which of them would be used, but the total acreage of those areas is almost 1.25 acres. These staging areas are all on paved or hard-packed dirt areas that have been used by the landowner and its tenants for similar short- and medium-term stockpiling of similar construction materials. No environmental impacts from use of these staging/stockpiling areas are anticipated, and they are not included in the project footprint areas below. The avoidance and minimization measures discussed in Chapter 4 explain how impacts will be avoided in the staging areas.

2.1.1 Red Rock Warehouse

Red Rock Warehouse is located on the northeastern tip of Point San Pablo in the City of Richmond. This site is in Contra Costa County, and the coordinates of the central point of the site are 37.965507, -122.426429. There are approximately 350 creosote-treated piles and a small amount of collapsing creosote-treated decking that is likely to eventually drop into the Bay. While the heavier portions of the decking are expected to settle in place, much of it is likely to be exported from the site by Bay currents (**Figure 2**). Red Rock Warehouse contains no known piles made of or wrapped in concrete or steel. Other debris near the site includes a large steel lattice structure in the center of the warehouse site, a submerged vessel hull at the northeastern margin of the pile field, and large portions (approximately 10,000 square feet) of the original concrete decking.

There are remnants of the former Del Monte Richmond Whaling Station to the east of the Red Rock Warehouse site itself. The whaling station burnt down and was dismantled in 1998, but the lower portion of the hoisting ramp that was used to slide whales into the building was spared. The station lies far enough east of the piles that it will not interfere with pile removal. The nearest navigational channel is the North Ship Channel, located approximately 0.25 miles northwest of Red Rock Warehouse. Nearby waterfront facilities include the Point San Pablo Yacht Harbor to the southeast and the Richmond-owned Terminal 4 Wharf site around the tip of Point San Pablo on its western side.

The on-land portions of the Red Rock Warehouse site are owned by the City of Richmond. The warehouse was constructed after 1938 and may have integrated some of the pile support structures from existing overwater warehouses and piers. Fill was placed in several areas near the site, resulting in shoreline expansion. Most of the in-water portions of the site are also on parcels owned by the City of Richmond, but some of the parcels are owned by the California State Lands Commission.

There is significant scenic value at Red Rock Warehouse, and the City of Richmond has expressed interest in expanding public shoreline park access. There is currently no land-based recreational or other public use of the site, though boating and fishing does take place in the portions of the Bay near the site. The road leading to Red Rock Warehouse is closed to the public, and derelict structures in the area pose safety risks. The nearest historical site is the East

Brother Island Light Station, located approximately 0.3 miles southwest of Red Rock Warehouse. The nearest recreational sites include the Point San Pablo Yacht Harbor, located approximately 0.4 miles east of Red Rock Warehouse, and Point Molate Beach Park, located approximately 1.7 miles south of the Site. The Point San Pablo area is relatively undeveloped compared to most areas in the City of Richmond. However, there are no areas near Red Rock Warehouse that have been set aside as open space. The nearest restoration project is the completed Wildcat Creek Restoration, located approximately 3.7 miles east of Red Rock Warehouse.

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FIGURE 1
Regional Location of Project Sites

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N 0 300 Feet

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San Quentin Quadrangle, USGS, 2009.

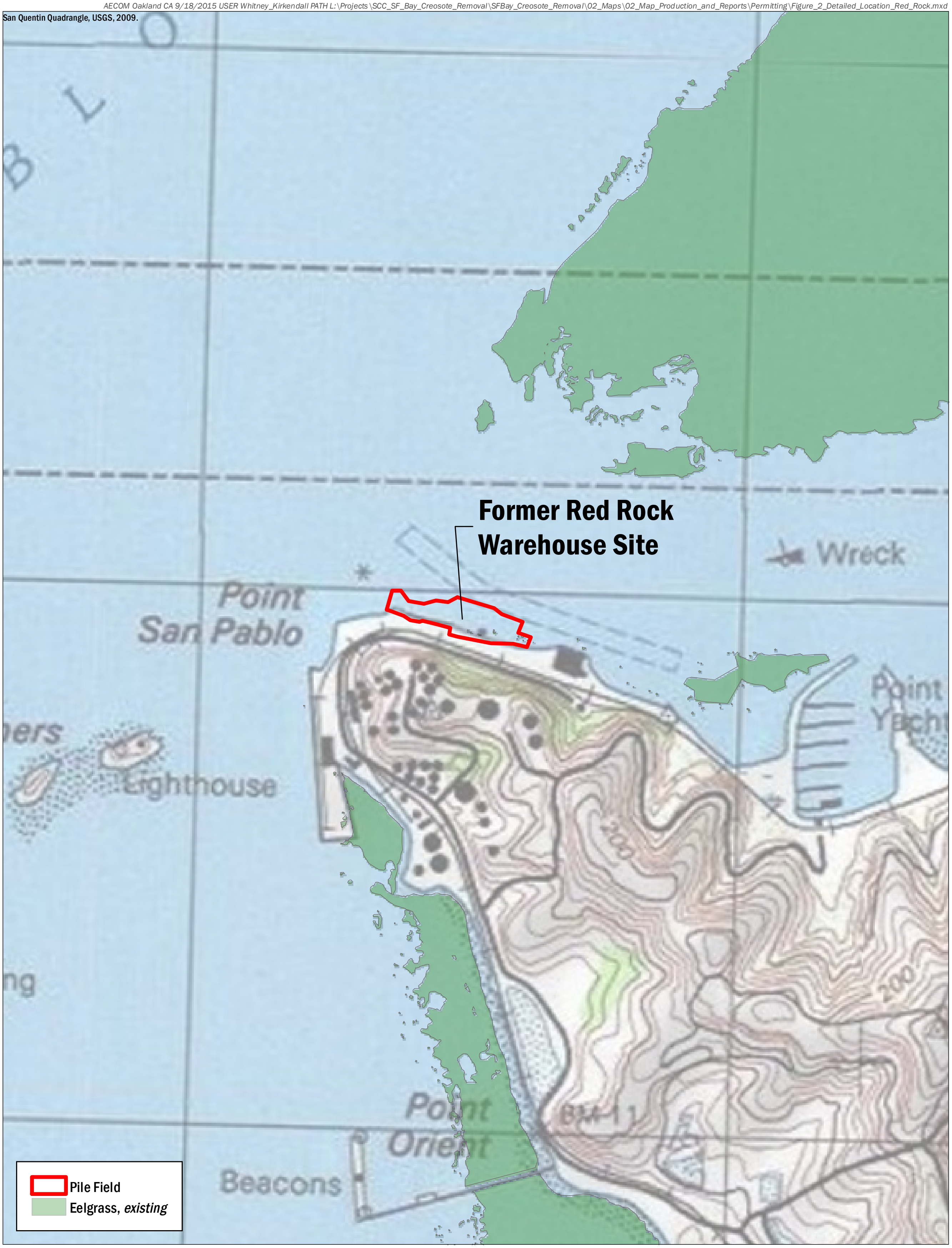

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FIGURE 2

Red Rock Warehouse Site Detail Location

2.1.2 El Campo Marina

The El Campo Marina site is located in Central San Francisco Bay west of Paradise Beach County Park along the northeastern side of the Tiburon Peninsula in Marin County. The coordinates of the central point of the site are 37.898439, -122.464597. The piles are generally in two distinct groups. The larger western group consists of several rows of piles that extend perpendicularly from the shoreline that once supported docks (**Figure 3**) and also includes a bayward row of pile dolphins, (isolated groups of piles used for mooring or navigational guidance) runs parallel to the shoreline on the outermost edge of the site. These likely supported a breakwater (Merkel & Associates, Inc. 2015). The smaller second group consists of an arcing row of pile dolphins on the southeast side of the site. These were likely the base of a buttress structure (Merkel & Associates, Inc. 2015). The property line between the two parcels cuts across the eastern arc of pile dolphins.

The El Campo Marina site contains approximately 250 creosote-treated piles that are visible above the water's surface (**Figure 3**). In addition to those piles, there are numerous subtidal piles lying on the bay floor here. Some of the horizontal subtidal piles are likely to be concrete-wrapped, but neither the total number of these downed piles, nor the proportion of them that are creosote-treated or made of or wrapped in concrete, steel, or other materials, have been estimated because the piles are stacked on top of one another. At least 65 piles were noted during the interferometric sidescan sonar surveys, but there are likely many more that were not detectable past the top pile layers. Therefore, throughout this document, the number of piles at the El Campo Marina site is conservatively assumed to be 315.

Other debris that may be encountered and removed from this site includes rusted I-beam piles, still vertical and upright, that are interspersed between the pile dolphins on the southeastern side of the site. The nearest navigational channel is the North Ship Channel, located approximately 1 mile northeast of the El Campo Marina site. Nearby waterfront facilities include several private docks located to the southeast and northwest of the site.

The El Campo Marina site is located principally within a private trust owned by the Traegers with a small portion of the easterly end of the shoreline pile alignment being owned by another private residential landowner, who is currently being contacted and coordinated with. Bayward of the marina pile field, the waters are owned by the California State Lands Commission. The site was previously owned by the San Francisco & North Pacific Railroad, which established the El Campo Marina in 1891. The marina, including docks and gangways, was constructed around 1963 and was defunct by 1968. It is unclear whether the marina ever went into full operation or when the docks were removed, but the gangways were present through at least 1987. While the history of the marina is somewhat short and unremarkable, the larger El Campo Marina site (i.e., the on-land portions) was a recreational area that contained band stands, a dance pavilion, and piers that were used to bring guests to the site by ferry. The upland structures associated with the El Campo Marina were removed and the area is now in private residential use.

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FIGURE 3

El Campo Marina Site Detail Location

The piles presently provide no function and are a potential navigation and possible environmental liability for the property owner. The presence of eelgrass and shallow waters through the site suggest that the area is unlikely to be suitable for future marina development, thus minimizing the potential value of retaining any portions of the piles on the water. The site has no current land-based recreational use, but has high scenic values for those with access to the private properties along the shore. This portion of the Bay is used by small boats for recreation, fishing, or other purposes. Nearby recreational sites include Paradise Beach County Park and the Tiburon Uplands Nature Preserve to the south. Nearby natural areas include the Tiburon Uplands Nature Preserve. The nearest restoration project is Richardson Bay Audubon Center and Sanctuary's Aramburu Island Enhancement Project, located approximately 2 miles southwest of El Campo Marina.

2.2 PROJECT FOOTPRINTS

There are separate project footprints for each site. The project footprints include the creosote-treated pile fields and a 33-foot buffer distance around them, as well as the areas wherein the various restoration treatments would be placed. These are the types of areas that would be physically disturbed as a result of project activities and thus where impacts such as fill removal or fill placement would occur. But the project footprints also include some areas of the bay or the shoreline that would not be directly affected by project activities but through which the construction barges or the shore-based work may pass. Rather than produce several discontinuous footprints for different phases of the project, the project proponents have decided to present a large, all-encompassing footprint for each site and then describe the areas within them that would be affected during the pile removal and the habitat restoration phases of the project.

Table 1 shows the breakdown of these project footprints into these various sub-areas. Note that the acreages presented include not only the existing or proposed features (such as piles or reef structures for oysters), but the areas between individual piles or restoration treatments and a buffer distance around them. The actual areas of fill added or removed, for example, would be less than the numbers shown here. These and other actual impacts are discussed elsewhere. As noted in the opening paragraphs of Section 2, the potential on-land staging areas adjacent to the Red Rock Warehouse site are not included in the project footprint totals presented here.

Table 1. Project Footprints and Sub-Areas

	Areas (in acres) by Project Site	
Description	**Red Rock Warehouse Site**	**El Campo Marina Site**
Total Footprint	4.18	9.50
In-Bay Footprint (below high-tide line)	3.89	8.92
Upland Footprint (above high-tide line)	0.29	0.57
Pile Field	3.20	6.77
Restoration Areas – All	1.10	0.66
Eelgrass Planting	0.64	0.38

Table 1. Project Footprints and Sub-Areas

	Areas (in acres) by Project Site	
Description	**Red Rock Warehouse Site**	**El Campo Marina Site**
Reef Structures (all types)	0.38	0.17
Rockweed Relocation	0.25	0.35
Shoreline Access and Staging	1.23	0

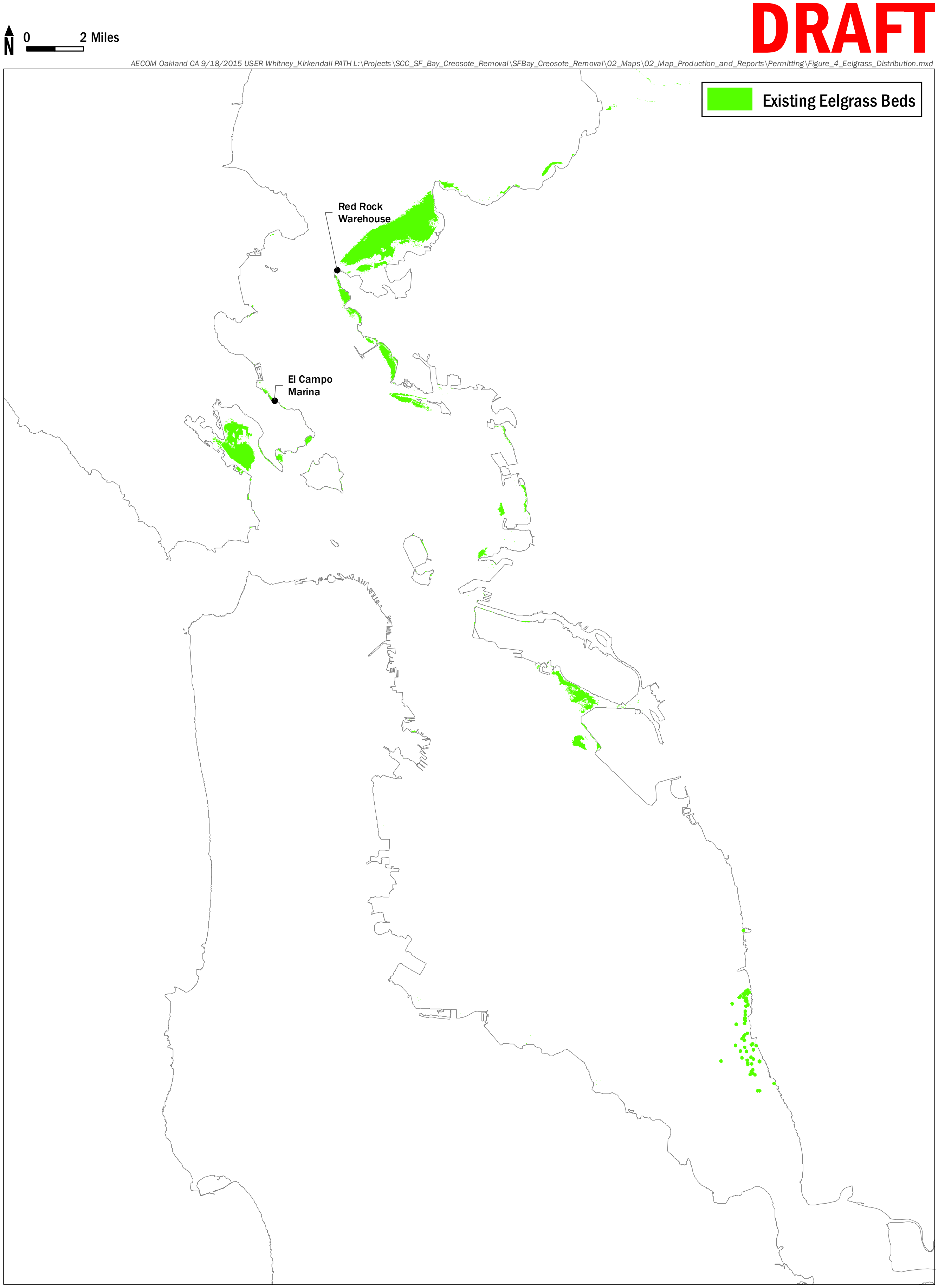

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FIGURE 4

Current Distribution of Eelgrass Beds in San Francisco Bay

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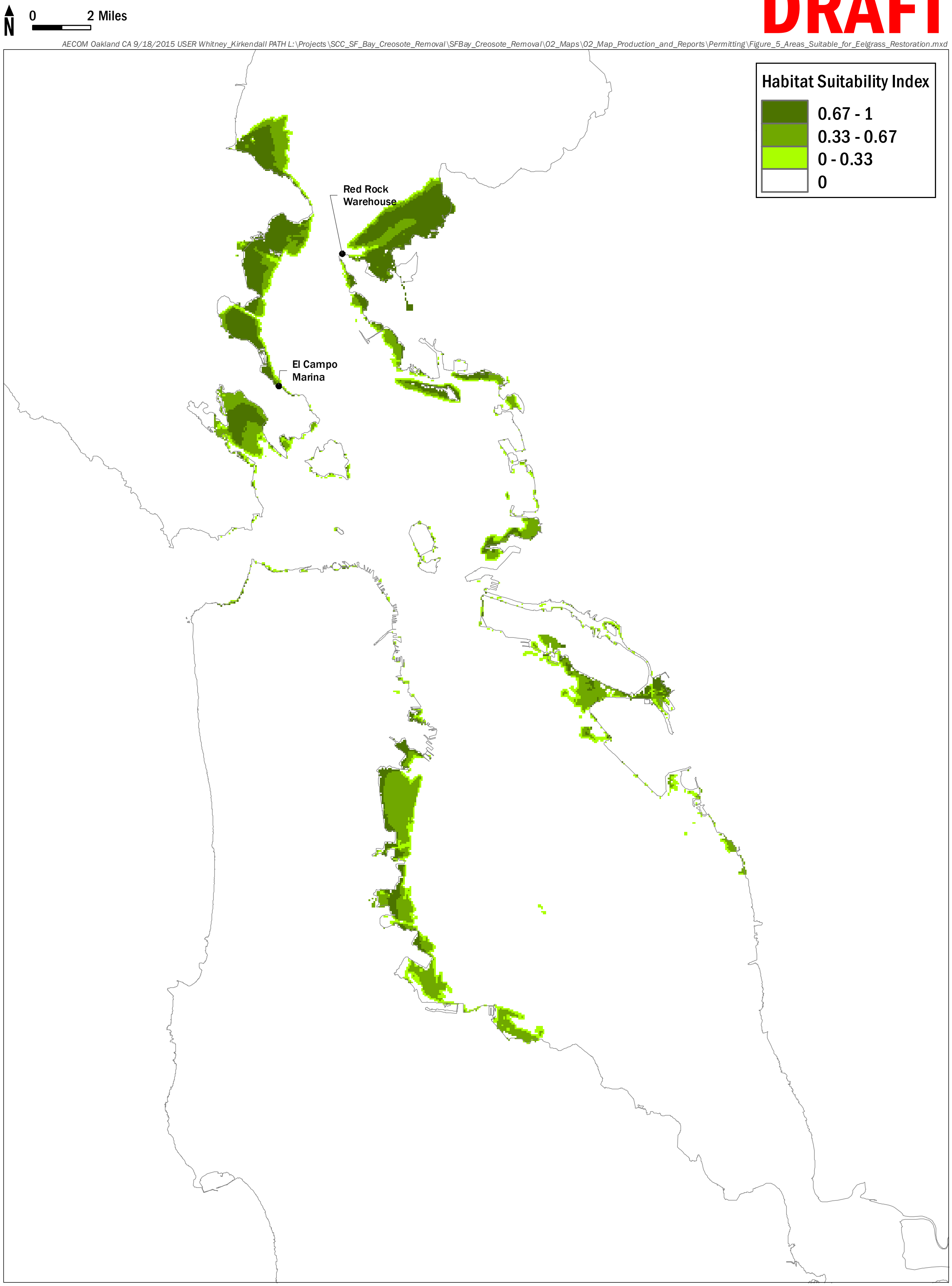

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FIGURE 5

Areas Suitable for Eelgrass Restoration in San Francisco Bay

2.3 ENVIRONMENTAL SETTING / EXISTING CONDITIONS

San Francisco Bay is the largest estuary on the west coast and is a dynamic, urban, estuarine environment. Since the Gold Rush, San Francisco Bay has lost more than 90% of historic tidal wetlands and the Bay itself is one third smaller in area, which has caused a substantial amount of subtidal habitat loss (SCC 2010). Historical events that have drastically altered the physical and ecological characteristics of the Bay include sediment deposition from hydraulic mining and the diking off of intertidal areas to create ponds for salt extraction, both of which have greatly reduced the three-dimensional structure in the bay (SCC 2010; SFEI 2009). A large percentage of San Francisco Bay shorelines have been stabilized with hardened structures, such as creosote-treated piles, riprap, breakwaters, seawalls, and bulkheads to create dry lands for development, and to prevent or minimize coastal erosion in the estuarine environment (SCC 2010). Additionally, the Bay has been colonized by numerous species of invasive organisms, such as mitten crabs and the overbite clam, which has altered communities and food chains throughout the Bay (SCC 2010; Dittel and Epifanio 2009).

Despite these factors, the Bay still supports a diverse and regionally important ecological system, and provides key habitat for a number of special-status plants and animals.

2.3.1 Historical and Current Distribution of Eelgrass, Oyster Beds, and Rockweed in San Francisco Bay

Eelgrass is the primary seagrass in the soft sediments of San Francisco Bay and provides valuable ecological services. The extent of eelgrass within the Bay has been increasing in recent years: the first survey in 1987 reported only 316 acres of eelgrass, while surveys in 2003 and 2009 found 2,900 and 3,700 acres of eelgrass beds respectively (SCC 2010) (**Figure 4**). These more recent surveys suggest not only an increase in overall acreage but also expansion into new areas that may have recently become habitable. Further, biophysical modeling indicates that nearly 30,000 acres of bottom area may now be suitable habitat (Merkel & Associates, Inc. 2004) (**Figure 5**).

The distribution of eelgrass is limited by a variety of physical factors, including substrate suitability, water depth and turbidity, salinity, and current velocities. Seagrasses perform a wide variety of functions, including altering local hydrodynamics, reducing the speed of currents. In doing so, they trap and stabilize fine sediment, reducing the average grain size in the bottom sediments and altering the local sediment chemistry. Globally, they are much more productive per unit area than phytoplankton (SCC 2010). Seagrasses in general, and eelgrass in particular, can transform unstructured shallow-water areas into physically structured habitat that can support a wider variety of organisms. Eelgrass beds also provide a food source, either directly to grazers on the eelgrass (amphipods, snails, etc.) or indirectly, to grazers on epiphytes (plants such as diatoms growing on grass blades) or predators consuming invertebrate grazers, or through detritus formed of dead plant material that supports the estuarine food web. The invertebrate fauna of eelgrass beds may be important resources to both resident and transient fish. Amphipods, a prey item for many species of fish, are the most abundant invertebrates on eelgrass at several sites in San Francisco Bay (SCC 2010). In addition, eelgrass is used as a substrate for spawning by Pacific herring, which lay their sticky eggs on the plant's blades.

Historically, native Olympia oysters were an abundant and ecologically important part of the fauna in West Coast estuaries and an important fishery. However, the popularity of the fishery that began in the 1850s, combined with ecological degradation from hydraulic mining, resulted in the almost complete collapse of native oyster populations in San Francisco Bay during the late 19th and early 20th centuries (Baker 1995; Barrett 1963). Like eelgrass beds, oyster beds provide important ecological functions. Oysters settle on natural hard substrate such as rocky outcrops and some artificial structures, creating complex habitat for invertebrates and small fish. The filter feeding activity of oysters may clarify waters, improving light penetration. Removal of oyster reefs in the bay for vessel traffic safety and the large amount of sediment that washed down from hydraulic mining during the Gold Rush may have depleted and/or smothered the hard substrate needed for oyster reef re-establishment (SCC 2010).

Rockweed of the genus *Fucus* is a widely distributed species along the Pacific coast of North America. The most common Fucoid alga in San Francisco Bay is *Fucus gardneri*. Rockweed occurs within the middle intertidal zone of protected and semiprotected rocky shores where it can grow into dense bands of robust plants. Rockweed occupies intertidal areas across wide ranging slopes, aspects, and marine and estuarine salinities. It can occur on large rock and textured concrete surfaces, or small rock and concrete rubble. However, rockweed on small loose rubble typically does not persist to mature size due to the mobility of rubble as the thalli expand and increase hydrodynamic drag. Rockweed consists of a holdfast which anchors it to substrate, a stipe which is analogous to a stem, and the blades, which are flattened leaf-like appendages. The entirety of the organism is referred to as a thallus (thalli plural).

While the normal range of rockweed varies across its range, in San Francisco Bay there is little documentation of the vertical range of rockweed. However, from the Albany Neck to Albany Point, it was determined to occur across a vertical elevation range from +2.1 feet to an extreme of +5.8 feet mean lower low water (MLLW). The majority was found below +4.8 feet MLLW and above +2.5 feet MLLW (Merkel & Associates, Inc. 2012, unpublished data). Rockweed creates a complex intertidal habitat providing shade, evaporative cooling, and vertical structure and complexity to organisms living within the algal beds or in trapped silts and sediments that sometimes accumulate around the dense thalli. While established beds of *Fucus* are relatively stable and persistent, settling zygotes do not travel far from parent plants limiting the ability of *Fucus* to establish in areas currently devoid of the species.

A 1991 study found that eelgrass was limited to depths shallower than -6.5 feet MLLW at five sites studied in the central San Francisco Bay, including Paradise Cove and Keil Cove in Marin County, and Point Molate, Chevron Pier, and Richmond Harbor in Contra Costa County (Zimmerman et al. 1991). The Ecological Limits, Viability, and Sustainability (ELVS) model, developed by Merkel & Associates, Inc. to predict suitability of habitat for eelgrass, estimated a depth range of 1 to -17.7 feet for eelgrass (SCC 2010). The model also predicted that 94 percent of eelgrass occurs between 0.6 to 3.3 feet MLLW. The ELVS model also takes turbidity into consideration, as eelgrass is most successful in habitats with low levels of fluvial sediment suspension (15 to 55 percent). The Subtidal Habitat Goals Report recommends that oyster restoration occur between 0 and -6.5 feet MLLW, and studies in the San Francisco Bay have found that oyster recruitment is higher between -2 to -3 foot depths compared to 0 feet (SCC 2010).

2.3.2 General Biological Setting for San Francisco Bay

Aquatic habitat conditions in the San Francisco Bay vary widely depending on location in the Bay. Water temperatures fluctuate annually between 50°F and 70°F in the Sacramento-San Joaquin Delta and between 50°F and 61°F near the Golden Gate Bridge (SCC 2010). Salinities vary from ocean levels (around 35 parts per thousand [ppt]) at the entrance to the San Francisco Bay to freshwater levels (0 ppt) in the northern estuary. The salinity gradient in the northern estuary is highly variable on a temporal scale, with the "X2" point, the point where near-bottom salinity is 2 ppt, ranging from San Pablo Bay to the Delta depending on freshwater flow (SCC 2010). The San Francisco Bay has high turbidity due to fine suspended sediments consisting primarily of clay particles (~1 micrometer in diameter). However, turbidity may be decreasing as the pulse of sediment from hydraulic mining dissipates and because dams have cut off the supply of fine sediment to the Bay (Schoellhamer 2009).

Habitats types in the San Francisco Bay include rocky intertidal areas, sand beds, macroalgal beds, and eelgrass beds, which have historically supported populations of Pacific herring, various rockfishes (*Sebastes* spp. including brown rockfish (*S. auriculatus*) and lingcod (*Ophiodon elongatus*)), flatfishes (including California halibut (*Paralichthys californicus*) and speckled sanddab (*Citharichthys stigmaeus*)), sharks (including leopard shark (*Triakis semifasciata*) and brown smoothhound (*Mustelus henlei*)), northern anchovy (*Engraulis mordax*), Pacific sardines (*Sardinops sagax*), and Chinook salmon (*Oncorhynchus tshawytscha*) (PFMC 1997; PFMC 2011a; PFMC 2011b; PFMC 2014). These habitats, which provide essential fish habitat (EFH) as defined under the Magnuson-Stevens Fishery Conservation and Management Act, have been reduced or degraded due to development and anthropogenic activities.

The degradation and loss of eelgrass, as well as native oyster beds affects the waters and substrate necessary for fish to spawn, breed, feed, and grow; are likely a factor in declines in fish populations within the San Francisco Estuary. Abundant commercial and recreational fisheries used to exist in San Francisco Bay, including Pacific herring, sardines, anchovy, salmon and steelhead (*Onchrhynchus* spp.), Dungeness crab (*Cancer magister*), shrimp (*Crangon franciscorum*), and others. The remaining fisheries in San Francisco Bay focus on the native Pacific herring and recreational charter fishing for halibut, striped bass (*Morone saxatilis*), and salmon.

2.3.3 Pacific Herring Biology and Use of the San Francisco Bay

Pacific herring are an important component of the San Francisco Bay ecosystem and support one of the few remaining urban fisheries on the Pacific Coast. There are two fisheries that take herring; adult fish are captured using nets, and herring eggs attached to kelp are harvested for consumption. Although the Pacific herring is neither a protected species under the Federal Endangered Species Act (ESA) or California Endangered Species Act (CESA) nor a managed fish species under the Magnuson-Stevens Act, as a state fishery it is regulated under Sections 8550 and 8559 of the California Fish and Game Code. Pacific herring spawn within San Francisco Bay, broadcasting their adhesive eggs over eelgrass, kelp, rocks, or other structures. In San Francisco Bay, spawning typically occurs November through March, with adults typically entering the Bay and holding in deep water areas for several weeks before spawning (Watters et al. 2004).

Herring spawning occurs on marine vegetation or rocky intertidal areas. The optimal herring spawning habitats are eelgrass beds, but other options include red algae (*Graciliaria pacifica*), rockweed, rocky shore, oyster beds, and coastal salt marsh. Herring also spawn on manmade structures like pier piles, riprap, etc., although these are less ideal due to chemical contaminants which may reduce larval survival rates.

Herring may spawn within a bathymetric range of +3 to -10 feet MLLW, but the ideal range is +3 to -3 feet, which is more than twice as likely to support spawning compared to their deeper range (Site Selection Memo). Herring utilize more saline portions of the estuary for spawning, as the salinity range for fertilization is 8-28 ppt, with an optimal range of 12-24 ppt (Griffin et al. 1998). The San Francisco Estuary is a relatively turbid environment, which is of concern to herring spawning activity. High suspended sediment (250 and 500 milligrams/liter) has been shown to cause lethal and sublethal effects in herring eggs during their first 2 hours in water (Griffin et al. 2009).

In the San Francisco Estuary, adult Pacific herring spawn once annually between November and March, with a peak in spawning from December through February (Watters et al. 2004). The majority of Pacific herring spawning has historically occurred in the North-Central Bay region (Point Bonita to the Richmond-San Rafael Bridge, Angel Island, Point San Pablo, and Berkeley Flats) and the San Francisco region (Golden Gate Bridge to Candlestick Point) (Watters et al. 2004) **(Figure 6)**. Adults typically enter the San Francisco Estuary and spend several days in deep waters (>18 meters) preparing to spawn (Watters et al. 2004). Spawning occurs in intertidal and shallow subtidal areas (90% of eggs are deposited between -5 and +2 meters MLLW), where adhesive eggs are laid on complex, silt-free substrates including subtidal vegetation (red algae (*Gracilaria* spp.) and eelgrass), rocks, shell mounds, and man-made structures like pier piles, riprap, and boat hulls (Brown and Carls 1998; Watters et al. 2004). Adults leave the Bay after spawning, eggs hatch after 6 to 10 days, and young of the year remain in the Bay for several months before emigrating to the ocean in August (Watters et al. 2004).

The CDFW maintains data on annual herring spawning locations within San Francisco Bay, and estimated tonnage of spawn dating back to the 1973-1974 (CDFW 2014). The spawning biomass estimate for the 2013-14 season was 60,600 tons, exceeding the historical average (1979 to 2014) of 52,300 tons (CDFW 2014). The 2013-14 season represents the fifth consecutive year of improved spawning biomass estimates since the historic low of 4,800 tons calculated for the 2008-09 season, which resulted in temporary closure of the fishery (CDFW 2014).

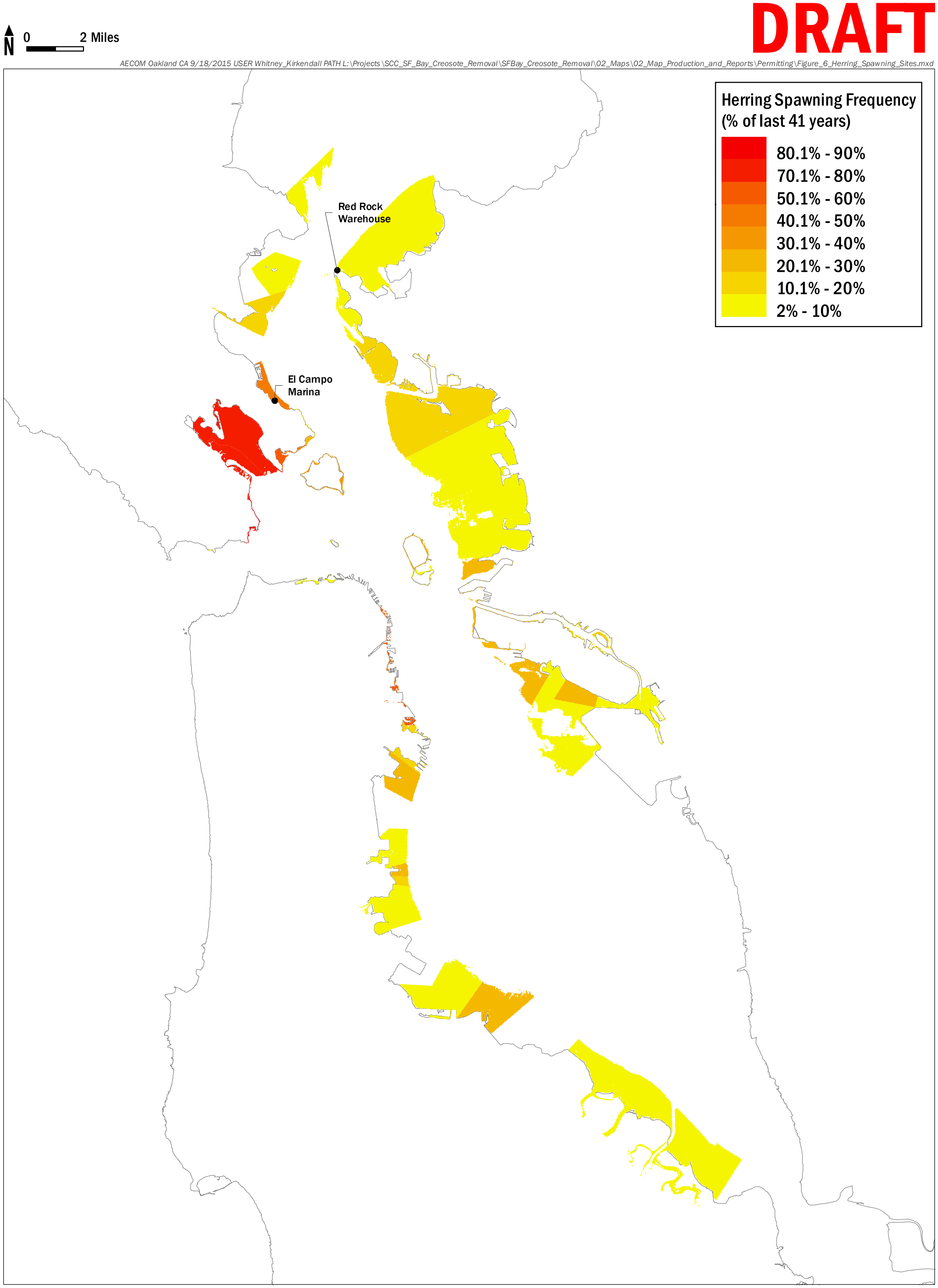

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FIGURE 6

Herring Spawning Sites in Northern San Francisco Bay

2.3.4 Physical and Biological Conditions of Red Rock Warehouse

Water depths at Red Rock Warehouse range from the mean higher high water (MHHW) line to -20 feet MLLW, with an average depth of about -6 feet MLLW. The majority of Red Rock Warehouse is located within the depth range of -2 to -6 feet MLLW, which is a depth at which eelgrass beds are known to occur in San Francisco Bay, but is deeper than ideal conditions (SCC 2010). This depth range is suitable for oysters in San Francisco Bay. Tidal range data for the tide gage station most representative of the site is presented in **Table 2**. The location of the tide gage is shown on **Figure 1**.

Table 2. Tidal Data for the NOAA Point San Pedro Tide Gage #9415009

Tidal Elevations, Point San Pablo Gage (NAVD88)	NAVD88 datum	Local MLLW
Mean Higher High Water (MHHW)	5.70 feet	5.87
Mean High Water (MHW)	5.10 feet	5.27
Mean Sea Level (MSL)	2.90 feet	3.07
Mean Low Water (MLW)	0.88 feet	1.05
Mean Lower Low Water (MLLW)	-0.17 feet	0

Red Rock Warehouse is located at the tip of Point San Pablo where water flowing past the point is accelerated and has maintained a moderately deep scoured channel just north of the warehouse site (**Figure 7**). Historically, this channel allowed short piers to reach depths suited to navigation by moderate draft vessels. Within the pile field, the Site slopes gently to the north from an elevation of 0 feet MLLW at the toe of a rubble-armored bank down to an elevation of -6 feet MLLW at the edge of the scoured channel cut (**Figure 7**). The slope through the pile site is relatively even and gradual at approximately 1:25 (rise:run).

The location of Red Rock Warehouse on the north-facing side of Point San Pablo (**Figure 3**) protects the site from most of the prevailing storms from the west and northwest. However the site is exposed to a 10-mile fetch from the north and longer fetches to the northeast. During strong northerly winds, significant waves impact the rubble armored shoreline at Red Rock Warehouse. The site is also exposed to wakes from vessels traveling along the channel, most specifically in a southward direction past Point San Pablo. The remaining piles at the site have a moderate influence on wave energy passing through the area. This is evidenced by observing the morphing and dampening of ferry wakes as they pass through the pile field (Merkel & Associates, Inc. 2015).

While the majority of the current flows that pass the site travel within the scoured channel located off the edge of the site, there is evidence of high flow velocities through portions of the pile field. This evidence includes scour around the bases of piles at the northern tip of the Site and even at the channel edge piles further to the south.

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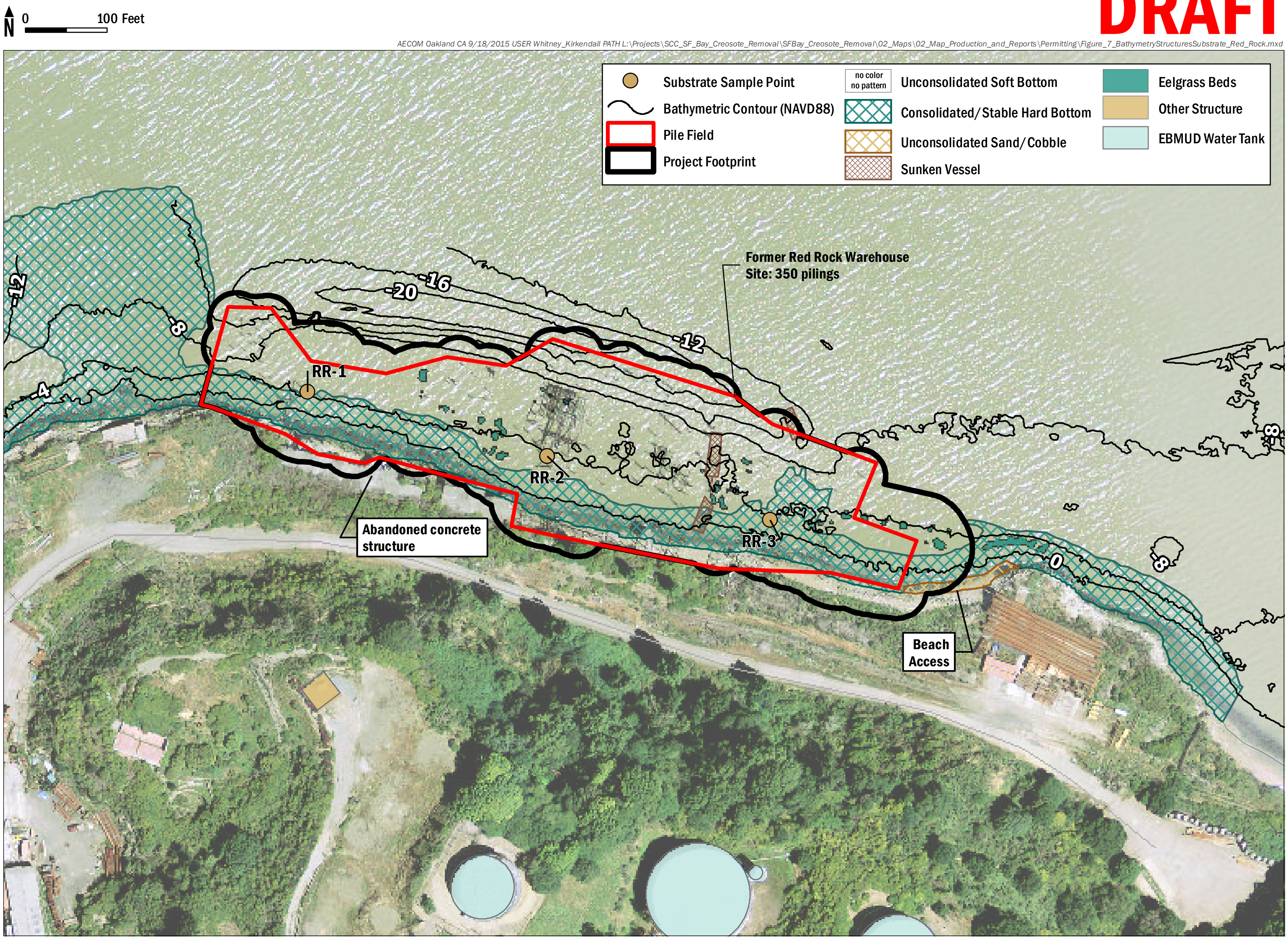

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FIGURE 7

Red Rock Warehouse Site
Bathymetry, Structures, and Subtrate

There are an estimated 350 wooden pilings at the site, as counted by SFEI geographic information systems (GIS) Department in 2009 (Werme et al. 2010). Counts of piles from interferometric sidescan sonar surveys conducted by Merkel & Associates, Inc. (2014) documented approximately 335 to 350 piles; however access limitations and debris interference precluded a precise count. Independent surface counts of piles visible on aerial imagery completed by URS confirmed approximately 350 piles. Many of the piles are large diameter piles suited to the use in supporting the warehouse structures. The average diameter of the piles is approximated to be 16 inches (1.25 feet). In the central core of the warehouse, timber and warehouse debris cover approximately 10,360 square feet of the Bay bottom where the warehouse floor collapsed into the water. Approximately, 16 to 26 broken, submerged pile butts were noted within the original footprint of the larger warehouse complex and outside of the warehouse debris field where individual pile elements were not distinguished. **Figure 7** shows the features of the Red Rock Warehouse site. Other debris near the site includes a large steel lattice structure in the center of the warehouse site and a submerged vessel hull at the northeastern margin of the pile field.

The sediment and benthic habitats present at Red Rock Warehouse have been characterized by Merkel & Associates, Inc. Core and grab samples collected at Red Rock Warehouse have determined that surface sediments are generally composed of shell hash, underlain with stiff clay at depth of 10 to 20 centimeters. Sediment cores were sampled at three locations identified as RR-1 to RR-3 located within Red Rock Warehouse (**Figure 7)**, with additional sediment probing being performed throughout the Site at areas close to the shoreline, mid-distance to the channel, and near the channel edge. Surface sediments throughout the Site were characterized as shell hash, sandy silt, and silty gravel. In general, the surface sediment collections and probing indicates that mollusk shell rubble and gravels are common constituents of the surface sediment within a cementing matrix of silt in some instances exposed silty sand surface substrate was identified on the surface through probing. Subsurface sediments consisted of narrow distinct strata of primarily silts and clays with some areas exhibiting layers of shell hash (**Figure 8**). Probe refusal was met at very shallow sediment depths (20 to 30 centimeters) throughout the site, suggesting that the Point San Pablo formation extends out into the bay just below the sloping bench that extends to the channel. The refusal was met by a dampened resonance rather than a sharp ping, suggesting the underlying resistant layer is not hard rock.

The Point San Pablo-Point Pinole eelgrass bed supports approximately half of the eelgrass present within San Francisco Bay. This bed occurs approximately a quarter mile to the north of Red Rock Warehouse. Within the Red Rock Warehouse site, eelgrass is found in scattered patches at depths from -1 foot MLLW to -6 feet MLLW. Eelgrass in this site may be restricted by the lack of availability of suitable soft sediment at suitable depth ranges given the abundance of shell hash, cobble and gravels within the depth range occupied by eelgrass at Red Rock Warehouse. In addition to eelgrass, the site supports an abundance of hard substrate including bank armoring comprised of rubble and hard bottom consisting of consolidated or semi-stable rubble, cobble, shell hash and debris. The shoreline includes a moderately sloping low intertidal and shallow subtidal rubble revetment slope that supports macroalgae as well as a well-developed community of encrusting invertebrates including Olympia oysters. There is a sunken vessel within the pile field along with a large broken steel lattice structure and fine gravelly rubble that may be the remnants of an asphalt floor that collapsed when the warehouses burned. These hard features provide additional shallow surfaces suitable to support herring spawning.

Figure 8. Surface and Subsurface Sediment Characteristics at Red Rock Warehouse

Site	Richmond Red Rock Warehouse					
Station	**RR-1**		**RR-2**		**RR-3**	
Latitude: Longitude	37.96569	-122.42746	37.96549	-122.42644	37.96529	-122.42549
Surface Characteristics	sandy silt		shell hash		silty gravel	
(USCS)	shell hash		silt interbedded		shell hash	
Shear Strength (kPA)	Shear was sampled at 15 cm below sediment surface					
1	11.23		NA	shell hash	10.875	
2	9.22		NA	precluded	9.435	
3	11.57		NA	clear vane	7.492	
Mean	**10.67**		**NA**	rotation	**9.27**	
Sediment Depth (cm)						
0	shell hash		shell hash		graded gravel	
5	silty clay		silt		stiff	
10	stiff		shell hash		clay	
15	clay		stiff		silt	
20	refusal		clay		refusal	
25			refusal			
30						

Source: Merkel & Associates, Inc. 2015.

In addition to the horizontal substrate, Red Rock Warehouse has extensive vertical pile surface. These piles have considerable exposed surface creosote in areas above the mean high tide line and less obvious surface creosote below the mean high tide line. The piles support a good coverage of ephemeral algae, but very little in the way of encrusting invertebrates. None of the piles at this site are wrapped and given the anticipated age, condition of piles, and lack of marine fouling community development, it is believed that these piles likely are leaching creosote derivatives at a moderately toxic level and the piles pose a moderate risk to herring spawning.

The region in which Red Rock Warehouse is located is infrequently used by Pacific herring for spawning. The region has a 4.9 percent spawning occurrence over the past 41 years. However, spawning has recently increased in the region, with a 33.3 percent spawning occurrence over the last 6 years. This increase may be due to low delta outflows, in which case the rate of herring spawning will likely decrease following the return of more typical delta outflows.

The piles at Red Rock Warehouse provide undisturbed overwater structures suitable for roosting use by a number of avian species that are commonly associated with such structures. These include double-crested cormorant and a number of gulls. However, during the multiple visits made to the site, a surprisingly low level of avian activity was observed, and guano deposits on piles and remaining decking materials suggest the site receives limited roosting use. Two cormorants were observed on the piles during one of the visits made to the site. The areas provide no suitable loafing or haul out areas for marine mammals and none were observed at Red Rock Warehouse during the Tier 3 investigation.

2.3.5 Physical and Biological Conditions of the El Campo Marina Site

Water depths at El Campo Marina range from the mean higher high water line to -4 feet mean lower low water, with an average depth of about -2 feet MLLW. The majority of El Campo Marina is located within the depth range of -2 to -3 feet MLLW, which is an ideal depth for eelgrass growth in San Francisco Bay (SCC 2010). This depth range would also be suitable for oysters. Tidal range data for the tide gage station most representative of the Site is presented in **Table 3**. The location of the tide gage is shown on **Figure 1**.

Table 3. Tidal Data for the NOAA Point Chauncey Tide Gage #9414837

Tidal Elevations, Point Chauncey Gage (NAVD88)	NAVD88 datum	Local MLLW
Mean Higher High Water (MHHW)	6.04 feet	5.75
Mean High Water (MHW)	5.45 feet	5.16
Mean Sea Level (MSL)	3.35 feet	3.06
Mean Low Water (MLW)	1.38 feet	1.09
Mean Lower Low Water (MLLW)	0.29 feet	0

The shoreline orientation of El Campo Marina faces northeast (**Figure 2**). The site is tucked into mainland coves far from deeper waters of the bay, and it is not subject to high current velocities. The lack of significant scour at pile bases even though the upper sediment is comprised of soft silts is indicative of the low current and wave environment at the site.

The location of El Campo Marina is generally well protected against the prevailing wind wave patterns. Wakes generated by passing vessels are typically low due to the nearly half mile separation between the site and the closest navigation channel that is used principally by high speed ferries and not by deep draft vessels.

El Campo Marina ranges from intertidal to slightly subtidal elevations with a gradual gradient sloping downward to the northeast at a 1:125 slope. The marina piles occur in waters from near 0 feet MLLW down to a shallow depth of approximately -3 feet MLLW (**Figure 9**). At the water's edge the site abuts a generally well-constructed rock-revetted slope that rises up to a bench that was notched into the hillside during the 1891 construction of the original El Campo facilities. The rock is thought to have been added much later.

The site contains an estimated 315 creosote piles (from 250 vertical piles visible above the water line plus at least 65 downed piles on the bay floor, as described above), with an approximated average diameter of 16 inches (1.25 feet), that are arranged in rows to support marina docks (Merkel & Associates, Inc. 2014a). Along the northeastern edge of the site, piles are cabled together with a division between piles that suggest that breakwater panels of some type were held in place by this line of pile dolphins. A similar arrangement of pile dolphins extends to the south along the shoreline in what appears to have been a buttress structure that retains many horizontal and vertical piles. Between these pile dolphins there are vertical rusted I-beam piles that also suggest that a buttress wall historically existed at this location. This buttress may have been designed to extend the shoreline outward, but other than the pile structure itself there is no indication of a prior fill. Subtidally, there are numerous piles amassed in a parallel alignment to the vertical pile dolphin arrangement. The horizontal subtidal piles include concrete wrapped and non-wrapped piles with a few piles being visible on the shoreline. The piles scattered along the base of the shoreline dolphin alignment are not visible from the surface and should add significantly to the pile count at this site. However, the relative proportion of these piles that are wrapped and unwrapped and the total number are not known or easily estimated at this time do to their being piled on top of each other. .

The sediment and benthic habitats present at El Campo Marina have been characterized by Merkel & Associates, Inc. Sediment cores were sampled at four locations identified as EC-1 to EC-4 located within pile field (**Figure 9**) with additional sediment probing being performed throughout the Site at areas close to the shoreline, mid-distance to the channel, and near the channel edge.

Surface sediments throughout El Campo Marina were characterized as silts with only one site (EC-4) supporting a grittier sandy silt (**Figure 10**). Eelgrass was found at EC-1 through EC-3. Shear strengths in near surface sediments were very low in all cases falling below the measurable shear of 2.64 kilopascals (kPA) at two stations, slightly above this limit at one station and was not measurable due to shell hash at one station. Broad ranging surface probing suggested similar conditions occur throughout the Site.

Subsurface sediments to 200 centimeters (79 inches) consisted of similar deep silt deposits at three of the stations with occasional layers of limited shell hash. At the EC4 site near the shoreline parallel pile wall, sediments supported stiffer materials classified as stiff and soft clay with a layer beginning at 155 centimeters (61 inches) of depth that was classified as sandy clay (**Table 6**). None of the probes ever met refusal, but were limited at approximately 175-200 centimeters (69-79 inches) of penetration depth by the equipment and tidal elevations during sampling. From the perspective of placing reefs or other enhancement features on the site, there does not appear to be a suitable foundation to support a heavy structure without considerable evaluation and design of a floating foundation.

The pile field at El Campo Marina includes both vertical and horizontal piles. Within the marina proper, all of the piles stand vertically; however, horizontal piles are present within the shoreline-oriented dolphins in a mix of wooden and some concrete piles that exist within subtidal portions of this feature. The presence of horizontal plies within this well flushed but low energy environment provide good conditions for herring spawning, but substrate is limited to creosote impregnated structures.

The piles at El Campo Marina are the youngest of any of the sites investigated dating back to approximately 51 years of age. The piles above the high tide line all show heavy creosote presence at the surface, while piles below the high tide line are more weathered but continue to show creosote on the surface and within the cracks in the wood. The piles themselves are in generally good shape suggesting continued protection against borers by the creosote treatment.

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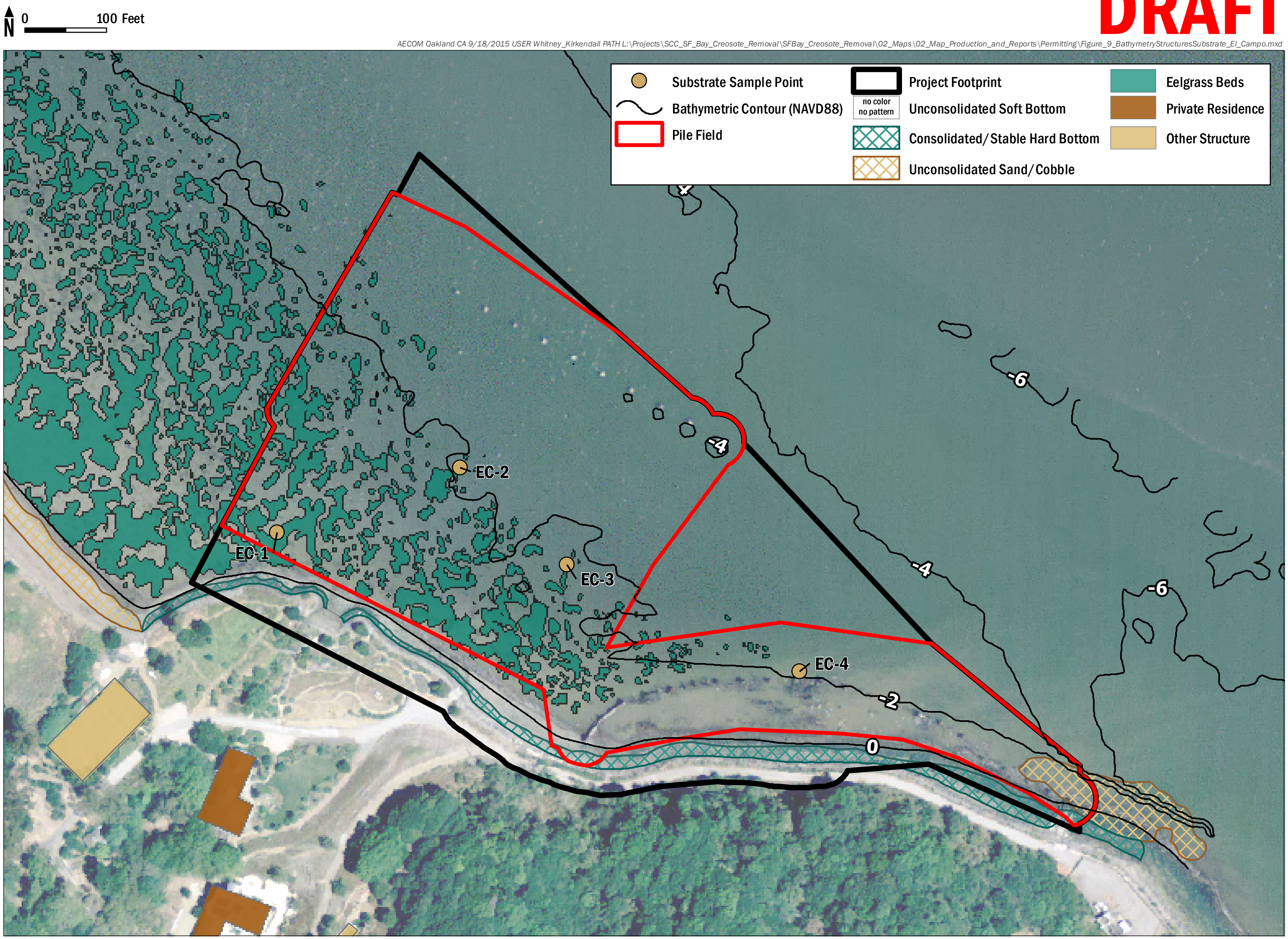

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FIGURE 9

El Campo Marina Site
Bathymetry, Structures, and Substrate

The piles at El Campo Marina support night roosting and loafing use by a number of bird species. Most of the pile tops were observed to be coated in guano and several birds were present roosting on the piles both at night and during daylight visits to the site. Birds observed roosting on the piles included double-crested and pelagic cormorants (*Phalacrocorax auritus* and *P. pelagicus*), brown pelicans (*Pelecanus occidentalis*), elegant terns (*Thalasseus elegans*), and western gulls (*Larus occidentalis*). There are no areas suitable for nesting and the limited pile top space limits the available roosting space to a relatively few number of birds. There are no suitable areas for marine mammals to haul out at the site.

El Campo Marina supports a healthy eelgrass bed and a stable shoreline revetment suitable for use by spawning herring. There is some limited potential for eelgrass habitat expansion at this site following removal of the shoreline parallel piles, which presently isolate waters of suitable depth to support eelgrass from full flushing and cover potential eelgrass restoration areas with horizontal piles.

Unconsolidated sand and gravel beach areas may also receive some use by herring but success in these areas may be low due to sediment mobility with increased drag caused by herring roe.

The region in which El Campo Marina is located is currently utilized by Pacific herring as a spawning site. The stretch of shoreline in which El Campo Marina is located has a 41.5 percent spawning occurrence over the past 41 years and spawning has occurred during 13 of the last 14 years. Spawning has occurred 100 percent of the time over the last 6 years in this region of the Bay.

Given the high frequency of herring spawning in this area, combined with the abundance and condition of creosote-treated piles at the site, it is anticipated that creosote-treated piles and associated PAHs pose a high threat to spawning herring at El Campo Marina.

Figure 10. Surface and Subsurface Sediment Characteristics at El Campo Marina

Site			El Campo Site Marina					
Station	**EC-1**		**EC-2**		**EC-3**		**EC-4**	
Latitude: Longitude	37.89846	-122.46588	37.89869	-122.46511	37.89838	-122.46465	37.89803	-122.46365
Surface Characteristics	silt		silts		silt		sandy silt	
(USCS)			silt in eelgrass mat					
Shear Strength (kPA)	Shear was sampled at 15 cm below sediment surface							
1	<2.64		<2.64		NA	shell hash	5.23	
2	<2.64		<2.64		NA	interference	3.35	
3	<2.64		<2.64		Na		<2.64	
Mean	**<2.64**		**<2.64**		**NA**		**3.74**	
Sediment Depth (cm)								
0					silt			
5					shell hash			
10							silt	
15								
20			silt					
25								
30								
35								
40							stiff clay	
45			shell hash					
50								
55								
60								
65								
70								
75								
80								
85							soft clay	
90								
95	silt		silt		silt			
100								
105								
110								
115								
120								
125								
130								
135								
140							stiff clay	
145								
150								
155								
160					stiff clay			
165							sandy clay	
170								
175								
180								
185								
190								
195								
200								

Source: Merkel & Associates, Inc. 2015.

The restoration projects at El Campo Marina and Red Rock Warehouse will consist of two distinct phases. Creosote-treated piles will be removed during the first phase (fall of 2016) and habitat will be restored for the purpose of improving habitat for herring spawning and other wildlife during the second phase (spring/early summer of 2017). The following sections provide details about these two phases at the El Campo Marina and Red Rock Warehouse sites.

3.1 ACCESS AND STAGING

As described above, working from land has operational and safety advantages if structures can be accessed from the shoreline and are within the reach of specialized equipment. The Red Rock Warehouse site is owned by the city of Richmond and is easily accessed by land via Stenmark Drive. The City's property is currently fenced in and closed to the public behind a locked gate.

Some of the pilings at the Red Rock Warehouse site could be reached from land, and the design plans call for as much of the pile removal as possible to be done from shore by a long-reach excavator. The rubble-armored shoreline is at 0 feet MLLW, and the outer edge is at -6 feet MLLW. This makes land-based removal of at least some of the pilings at this site a reasonable option assuming the terrestrial vegetation on the shore does not contain special-status plants or wildlife species that would need to be cleared to allow access. The Red Rock Warehouse site has a scoured channel immediately north of the edge of the pile complex. This channel meets the outer edge of the pilings at elevation -6, making barge access to the site practical.

There are suitable locations for staging and for stockpiling and drying removed piles immediately landward (south) of the pile fields shown on **Figure 2**. The exact location of the staging area will be determined in collaboration with the City of Richmond as the project proceeds through future design stages. However, as noted in Section 2, there are at least six distinct areas within the on-land, City of Richmond-owned portions of the site that could be used for staging and stockpiling, as well as for drying removed piles, decking, and other material prior to removal for landfill disposal. These areas are shown on **Figure 11.** The total footprint of the six distinct areas is 1.23 acres, though it is unclear which of them would be used for this project. All of these staging areas are either paved or are hard-packed dirt, and all have been or are being used by the City of its tenants on the land for similar storage and laydown of construction materials and equipment.

The El Campo Marina site has more challenging constraints for access and staging. There is no available land access for staging, drying, or haulout and all of the piles occur in waters shallower than -4 feet MLLW. This means that construction access will be tidally constrained, as shallow draft barges generally have 5 feet of draft. Many of the piles also occur within dense shallow eelgrass beds that have a high potential to be damaged if piles and decking are removed by barge and crane. As a result, it may be necessary to hand cut some of the piles at the mudline and float them out of the eelgrass to deeper water for removal. An offsite staging area may be used for work at the El Campo Marina site, but current plans include using the City of Richmond's staging area for pile removal at the Red Rock Warehouse site to also be used for work at El Campo. Removed piles and other material would be pulled up onto a barge in any case, so the added distance across the Bay is not prohibitively difficult or expensive.

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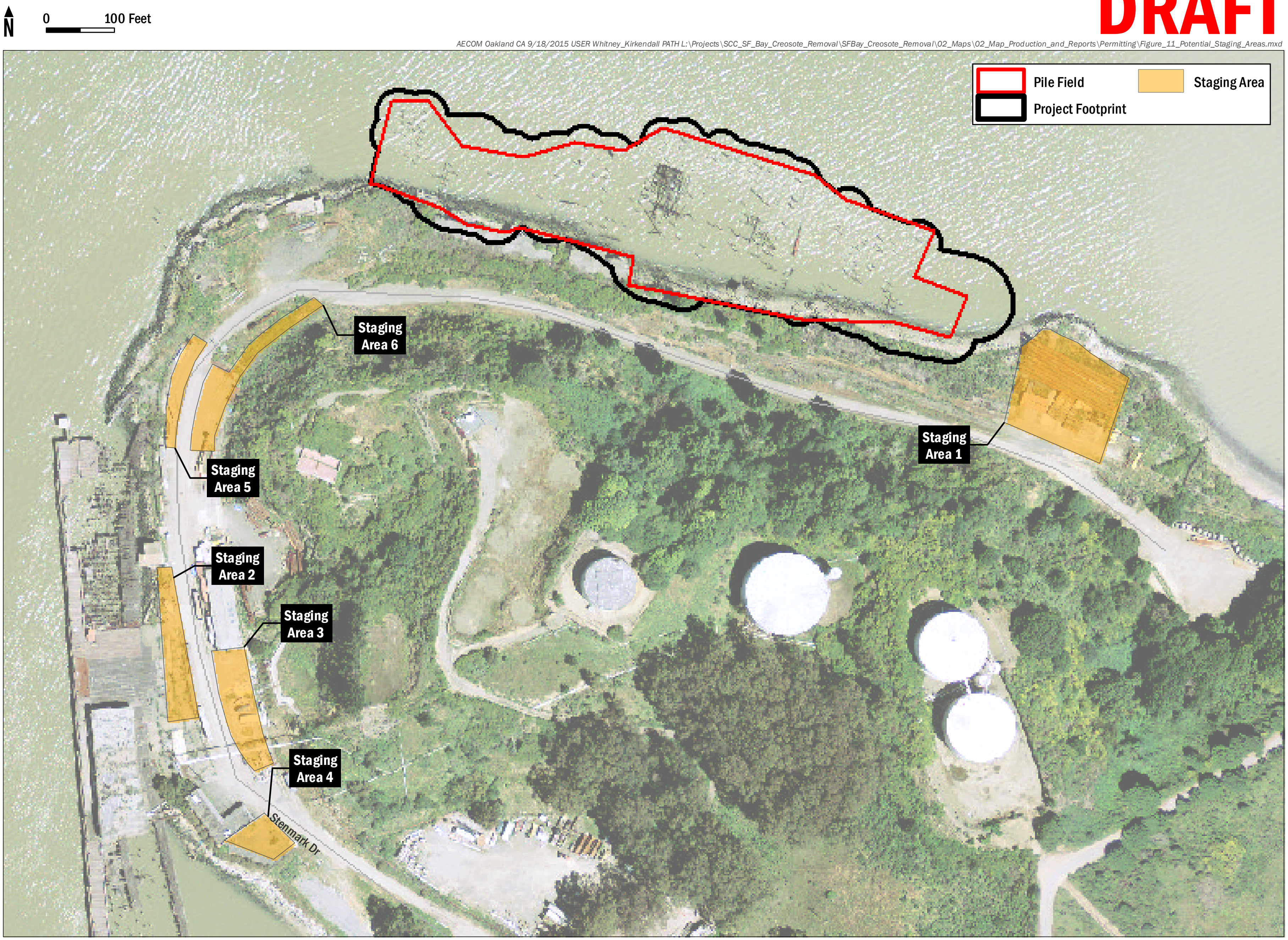

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FIGURE 11
Potential Staging Areas

3.2 CREOSOTE-TREATED PILE REMOVAL

The San Francisco Bay Regional Water Quality Control Board (RWQCB) and the BCDC have provided guidance for removing creosote-treated pilings in the Bay. In that guidance, the construction contractor is to attempt to remove the pilings in a different way, depending on the contamination of the surrounding sediments or muds:

- If the sediment is known or thought to be contaminated, the contractor will cut the piling at the mudline.
- If the sediment is not contaminated, the contractor will attempt to remove the entirety of each piling by pulling the piling straight out. Contractor is prohibited from using vibration or a back-and-forth, rocking movement intended to snap the piling because this generally increases turbidity.
  - However, if, prior to attempting to remove the entire piling, visual inspection of the pilings indicates that the pilings lack the necessary integrity to be pulled without splintering, crumbling, or otherwise disintegrating, contractor will instead cut the remaining pile to a level 2-3 feet below the surrounding existing sediment or mudline.
  - If, during attempts to use direct pulls on the piling to remove it, the piling breaks at a level higher than 2-feet below the mudline, the Contractor will cut the remaining pile to a level 2-3 feet below the surrounding existing sediment or mudline.

Because the condition of the piles' structural integrity is not currently known, the SCC plans to conduct an investigation of pile integrity following the submission of the various permitting documents to the regulatory agencies. A brief memorandum on that investigation will be delivered to the agencies to inform them of the pile conditions and the expectation about whether pilings can be removed by pulling without crumbling. Because of the severely degraded nature of all piles at both sites, it is likely that piles at both sites will necessitate being cut off below the mud line using sawing attachments or by divers using hydraulic chainsaws or hydraulic shears.

The removed piles, decking, and other materials will be loaded onto a barge and transported back to the Contractor's staging area where the concrete shall be separated from the other materials and recycled or disposed of offsite as appropriate at a permitted facility.

Pile removal can be carried out from land or water-based equipment. Much of the pile removal and structure demolition can be carried out from land at the Red Rock Warehouse site using long-reach excavators or cranes and a number of different of grabbing and cutting attachments. Typical long-reach excavators have working limit of approximately 50 feet, but specialized equipment is available with a working reach of up to 100 feet. Use of this large and heavy equipment has limitations, including the need for a stable ground to support excavator outriggers. Also, as the reach distance increases, the lift capacity deceases.

There is no land access to the El Campo Marina site and so all demolition must be performed using barge-mounted equipment or divers supported by a barge, with the pilings and other materials transported to either the Red Rock warehouse site or some other site selected by the contractor, for drying and hauling. Once the removed debris are on land, the pilings and planks are cut to 5-foot lengths and dried out before hauling to a landfill for disposal.

Most pilings and other debris will require removal from the water using barge-mounted equipment. Removal of the pilings and other debris would be carried out using an excavator mounted on a shallow-draft barge equipped with both grappling and shearing attachments. Shallow-draft barges generally require at least 5 feet of water above the sea floor or any submerged debris. Depending on specific site conditions and the construction barge chosen, it may be possible to float the barge into position at high tides, let it settle on the intertidal mudflats to continue working at low tides, and then be lifted by the next high tide. In particular, existing eelgrass or oyster beds must be avoided, which could make this approach less useful at both the Red Rock Warehouse site and El Campo Marina, which have patches of eelgrass and/or other benthic organisms interspersed with the piles.

When depths limit access to barges or sensitive resources are present, piles may be manually cut by divers using a pneumatic or hydraulic saw or shears. Once the piles are cut, they may be towed out to deeper water to a waiting barge or to a landside staging area for loading and removal.

The holes left after pile removal will not be actively filled. Attempting to fill the holes would lead to increased sediment disturbance and unnecessary increases in turbidity. It is expected that sediment deposition will rapidly fill in any holes that are left.

3.2.1 Red Rock Warehouse Pile Removal Summary

The project sequence for the Red Rock warehouse site is relatively straightforward and includes the following tasks:

- Removal of decking above the water
- Removal and disposal of approximately 350 wooden pilings on the beach and in the water.
- Re-grading and stabilization of unstable embankment above the beach where needed
- Selective removal and disposal of wooden and concrete decking and other debris from below the water.
- Trimming and debris removal of piles that have broken or break above the sea floor.

Figure 12 shows areas where pile removal would be performed. The concrete foundation is on the shore and is assumed to remain in place. A BCDC permit application for the piling removal dated 1999 from the City of Richmond shows more decking than is currently visible. Parts of the missing decking have sunk in place, while other portions may have floated away. A large rubble field – approximately 10,360 square feet – containing both timbers and concrete flooring material occurs within the core of the old warehouse footprint. As noted earlier, up to three dozen pile butts extend above the seafloor but below the lowest low tide, and there are some large metal debris items that pose significant navigation hazards if the piles are removed and other debris are left.

Table 4 shows the number of piles that would be removed as well as the individual and combined pile footprint areas, and the area of the overall pile field that is expected to benefit from the removal of these piles. Further, a conservative estimate for the total volume of fill in the water column that would be removed is presented. The volume was calculated assuming that each pile would be an average of 4 feet tall, from the mudline to its top. Many or most of the piles are taller than this, and many others would be cut 2-3 feet below the mudline or removed entirely, so this estimate is conservative; the actual volume of creosote-treated piles is likely to be larger. As noted elsewhere, within the pile field, between the standing piles, there are collapsed piles, decking, and other debris that would also be removed, thus adding an unknown amount to these estimates of the total area and volumes of fill removed.

Table 4. Impacted Area of Pile Removal at Red Rock Warehouse Site

Item	Value
No. piles (standing)	350
Typical pile diameter	1.25 feet
Typical pile area	1.23 square feet
Summed pile footprint area	429.5 square feet (0.010 acre)
Summed pile footprint volume*	1,718 cubic feet (64 cubic yards)
Pile field area	3.2 acres

*Assumes an average pile is 4 feet tall within the water column.

3.2.2 El Campo Marina Site Pile Removal Summary

The El Campo Marina site restoration project is more challenging than the Red Rock Warehouse site restoration due to shallow water depths, soft sediment, and the abundance of eelgrass beds in portions of the site. **Figure 13** shows areas where pile removal would be performed. Pile removal at the El Campo Marina site includes the following tasks:

- Removal of cross beams and hardware tying the dolphin piles together.
- Cutting or pulling and disposal of approximately 250 standing wooden pilings and standing I-beam piles in the water.
- Removal and disposal of at least 65 piles and other debris lying on the Bay floor.
- Trimming and debris removal of piles that have broken or break above the sea floor.

As all of the piles occur in water shallower than -4 feet MLLW, and in some cases shallower than -2 feet MLLW, barge access will be tidally constrained. Many of the piles also occur within dense shallow eelgrass beds that have a high potential to be damaged if piles are removed by barge and crane. It may be necessary to hand cut piles at the mudline with a pneumatic or hydraulic saw and float them out of the eelgrass to deeper water for removal. If barges are used, the wide spacing of the marina piles and the shallow water will adversely impact the cost of removal due to limiting the time of operation and due to the many moves of the barge required.

Table 5 shows the number of piles that would be removed as well as the individual and combined pile footprint areas, and the area of the overall pile field that is expected to benefit from the removal of these piles. Further, a conservative estimate for the total volume of fill in the water column that would be removed is presented. The volume was calculated assuming that each pile would be an average of 4 feet tall, from the mudline to its top. Many or most of the piles are taller than this, and many others would be cut 2-3 feet below the mudline or removed entirely. Further, in the volume calculations, the downed piles on the bay floor are assumed to be standing and of the same dimensions as the vertical piles. Thus, this estimate is quite conservative; the actual volume of creosote-treated piles is likely to be larger. As noted elsewhere, within the pile field, between the standing piles, there are collapsed piles, decking, and other debris that would also be removed, thus adding an unknown amount to these estimates of the total area and volumes of fill removed.

Table 5. Impacted Area of Pile Removal at El Campo Marina Site

Item	Value
No. piles (standing)	250
Typical pile diameter	1.25 feet
Typical pile area	1.23 square feet
Summed pile footprint area	386 square feet (0.009 acre)
Summed pile footprint volume*	1,933 cubic feet (72 cubic yards)
Pile field area	6.8 acres

*Assumes an average pile is 4 feet tall within the water column.

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N 0 100 ft

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Data Sources:
1. Eelgrass, Merkel Sonar Survey, October 2014
2. Bathymetry, Merkel Sonar Survey, October 2014

Notes:
1. Bathymetry (NAVD88), 0 Ft contour roughly equivalent to mean lower low water (MLLW), NGS, June 2015

Creosote Piling
2ft Bathymetric Contour
Sunken Vessel
Steel Lattice
Pile Field
Land-Water Classification
1: Upland
2: Waters of the US
Eelgrass Bed

FIGURE 12

Red Rock Warehouse Site
Pile Removal Approach

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Creosote Piling
2ft Bathymetric Contour
Pile Field

Land-Water Classification
1: Upland
2: Waters of the US
Eelgrass Bed

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Data Sources:
1. Eelgrass, Merkel Sonar Survey, October 2014
2. Bathymetry, Merkel Sonar Survey, October 2014

Notes:
1. Bathymetry (NAVD88), 0 Ft contour roughly equivalent to mean lower low water (MLLW), NGS, June 2015

FIGURE 13

El Campo Marina Site
Pile Removal Approach

3.2.3 Material Disposal

As noted above, the removed creosote-treated piles, decking, and other material would be transported by barge to an on-land drying area. They would be placed into containment basins that would collect the water, residual creosote, and other materials that may drain off of them. The collected water would eventually evaporate, and the residual creosote and other materials would be placed into barrels for disposal at an appropriate Class 2 landfill as described below.

Following drying, the piles themselves would be disposed of at a Class 2 (non-hazardous) landfill, with clean demolition debris disposed of at a Class 3 (inert) landfill. The Keller Canyon Landfill, Pittsburg, California, is the closest landfill to the Red Rock Warehouse site, and accepts both Class 2 and Class 3 waste. Clean wood, metal, and concrete debris will be recycled by the contractor to the extent possible, which should result in cost savings. The closest landfill to the El Campo Marina Site is the Redwood Landfill and Recycling Center in Novato, which only accepts Class 3 waste but has the capacity to recycle concrete, wood and metal debris. Materials disposal options and cost estimates will be further developed in a future memorandum.

To streamline the disposal process, debris and piling removed from the El Campo Marina site are expected to be transported by barge to the Red Rock Warehouse for drying and disposal, where waterside staging areas area available.

3.3 HABITAT RESTORATION

This section described the three methods of habitat restoration/enhancement efforts planned for this project. They are eelgrass beds, reef structures for oysters (three types of reefs, as described below) and rockweed (two types).

3.3.1 Eelgrass

Harvest and Transplant Methods

The eelgrass portion of the habitat restoration project will involve harvesting eelgrass shoots and roots from existing healthy eelgrass donor beds, tying several of them to a light anchor to form a planting unit, and then planting them in a new location. This approach is called a bare-root transplant, and the fabricated planning units themselves are called bare-root planting units.

Harvesting of the eelgrass shoots would done by hand by trained divers who selectively extract shoots from moderate to dense eelgrass beds. To minimize disturbance of substrate and remaining shoots, the collection would be done by using a gentle vibrating motion while lifting the shoots and stems (formally called rhizomes) from the sediments. This liquefies and softens the sediments and allows extraction of healthy and viable plant material. Thick rhizomes, a minimum of 2 to 3 inches long, rather than thinner rhizomes, would be selected. Each harvested shoot would have a minimum of four nodes and internodes on the rhizome. The shoots would be placed in appropriate containers where separation and counting of individual shoots shall occur before placing them in totes for transport.

To reduce overall impact on the source location(s), harvest of donor material from the donor beds would be restricted to 10% or less of total rhizome count per square meter. Extraction density is managed on an area (square footage) basis and not in aggregate.

To fabricate the bare-root planting units, several individual shoots would be aggregated into groups of four shoots and their full rhizome structures, and hand-tied into planting units of shoot bundles attached to a paper-stick anchor. These paper-stick anchors are typically called confectioner sticks or sucker sticks, such as those seen on commercial candy items. They are made of tightly rolled paper and are thus biodegradable, though they are expected to persist in the sediments long enough for the eelgrass itself to become established. The dimensions of the stick anchors would be approximately 3.5 inches long and 1/8-inch in diameter.

The twine used to attach the eelgrass to the anchor sticks would 100 percent cotton twine. The twine would be knotted onto the paper stick anchor firmly and around the top of the rhizome bundle just below the meristem of the plants. The length of twine between the anchor and the shoots would be 3 inches (+/- 0.5 inch). There would be four shoots per planting unit. Following anchor attachment, the leaves of each planting unit would be cut to a length of approximately 30 inches to facilitate handling and planting. Preparation of planting units would be performed in flowing seawater baths to prevent the plants from drying out.

The source material for the eelgrass transplants would be harvested from existing eelgrass beds at Paradise Beach and Pt. Molate/Pt. Orient for the El Campo Marina site and from Pt. San Pablo-Pt. Pinole and Pt. Molate/Pt. Orient for the Red Rock Warehouse site. **Figure 14** shows the general locations of these sources. These are large and healthy beds with sufficient density and extent of eelgrass to provide the numbers of eelgrass shoots necessary for this project. The time from harvest to planting would be less than 72 hours.

Figure 15 and **Figure 16** illustrate the locations of the eelgrass transplanting zones at the Red Rock and El Campo sites, respectively. The eelgrass planting units would be hand-planted into these eelgrass zones but only into areas of suitable substrate (i.e., sand or mud) within those zones. The planting units would be planted with the anchors located horizontally about 3 inches (+/- 0.5 inch) below the rhizome bundles, which in turn would be set 1 inch below the sediment surface. The initial density of plantings is intended to be 1 planting unit per square meter throughout each planting zone.

Table 6 shows those planting zones as well as the maximum number of planting units that would be needed to achieve that density at each of the two sites. However, planting efforts would skip over areas where substrate is not suitable for eelgrass (see below). The planting units that were left over after the initial pass-through would be used to increase the planting density in areas of suitable substrate character.

Table 6. Eelgrass Planting Areas

Item	Red Rock Warehouse Site	El Campo Warehouse Site
Total Eelgrass Planting Area	0.64 acres	0.38 acres
Maximum Number of Planting Units	2,597 units	1,539 units

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FIGURE 14

Potential Locations of Source Eelgrass Material

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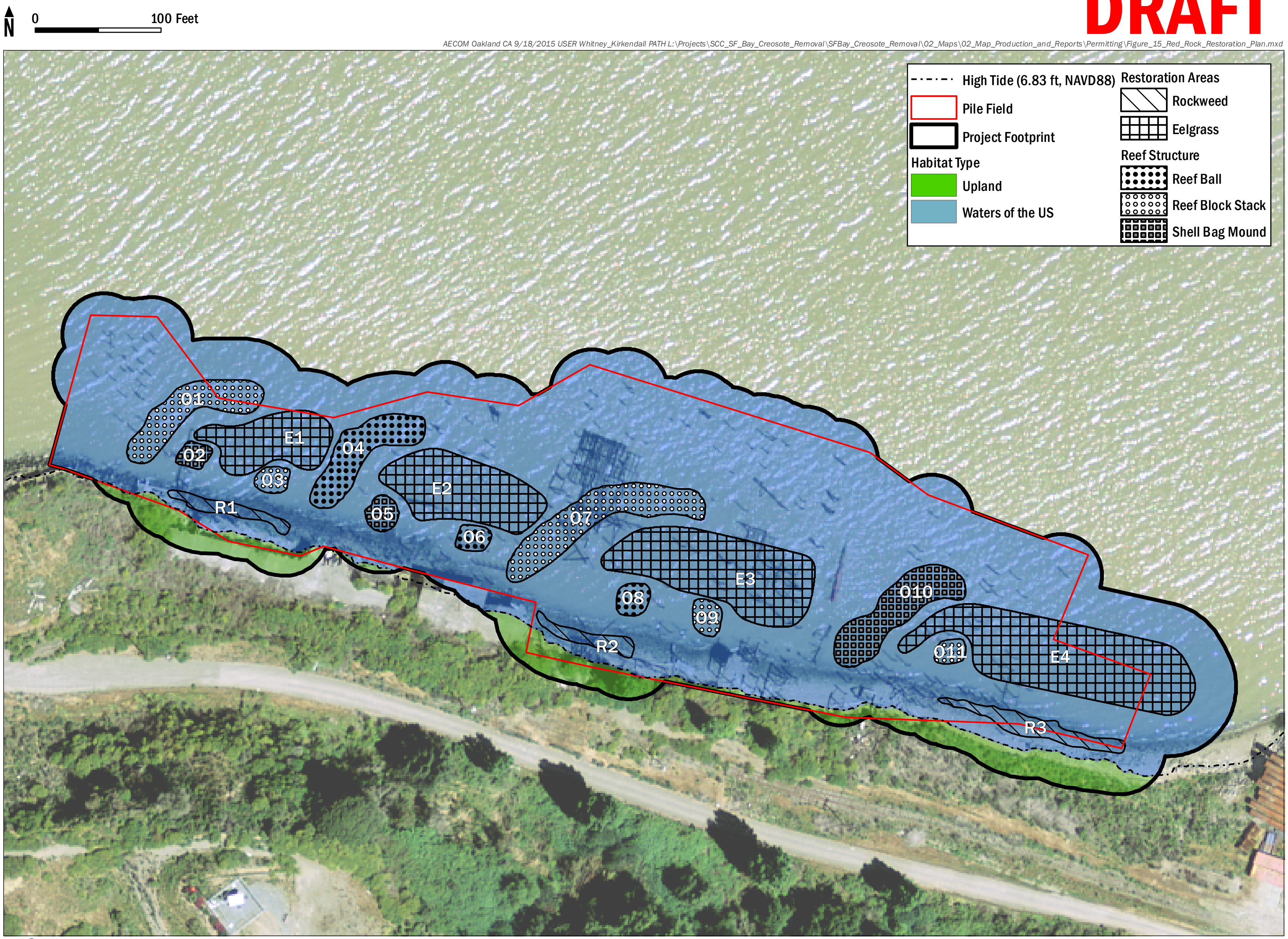

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FIGURE 15

Red Rock Warehouse Site Restoration Plan

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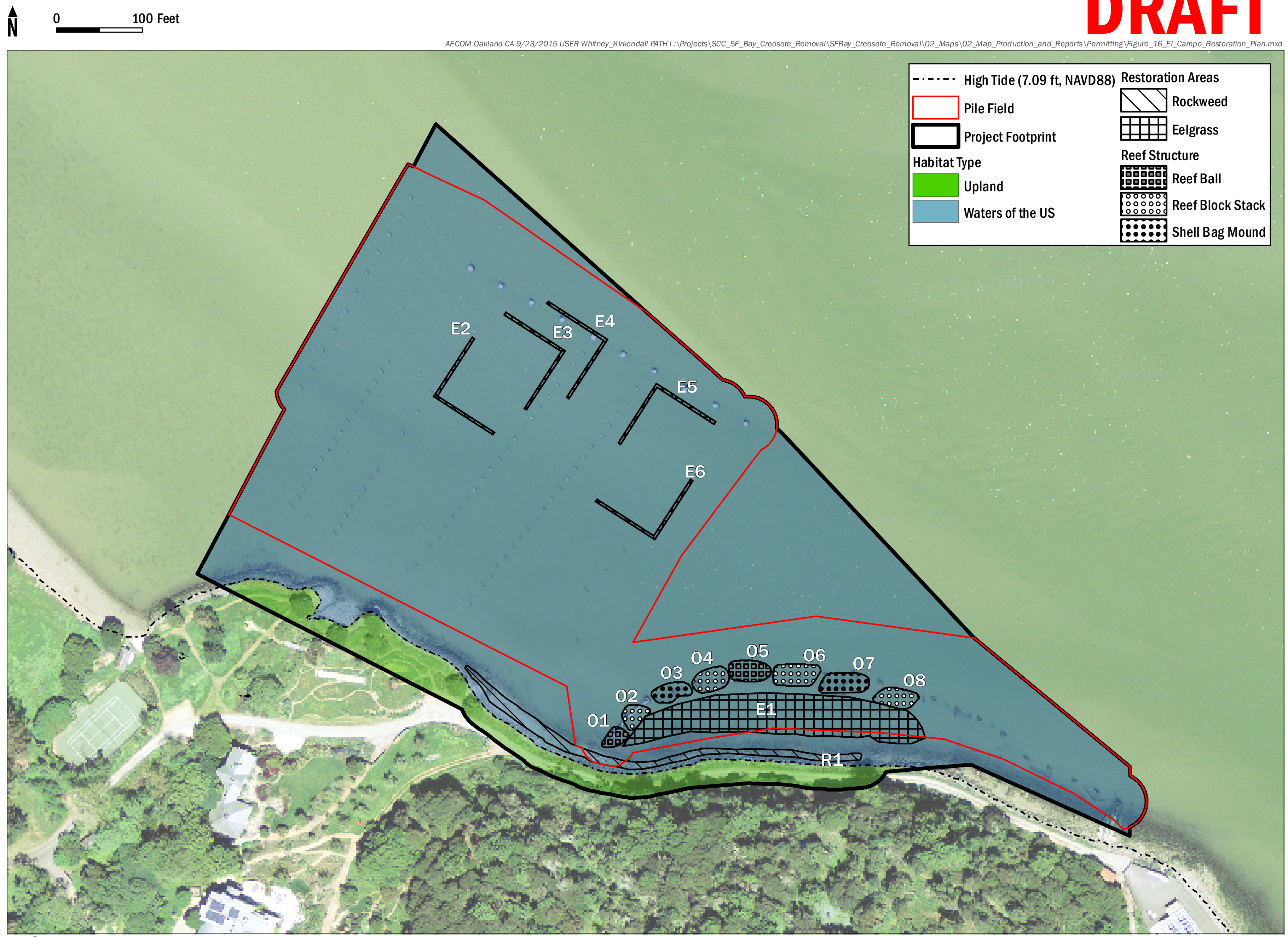

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FIGURE 16

El Campo Marina Site

Restoration Plan

The eelgrass zone elevations are from 0 feet to -2.5 feet MLLW at El Campo and from -2 feet to -6 feet MLLW at Red Rock. At the Red Rock Warehouse site, approximately half of the bottom in the eelgrass zones is likely unsuited to support eelgrass because of the hard bottom habitat or because of downed concrete decking that still remains. However, gaps between hard bottom areas do exist where soft sediment has accumulated and areas could be successfully planted. As shown on **Figure 15**, the eelgrass zones at this site are arrayed to alternate with oyster reef structure zones across a generally west-to-east transect. As discussed in Section 3.3.2, these reef structures would not only provide hard substrate for oysters and other benthic organisms but would also slow the tidal flows and waves along and within the restoration site as a whole. This would reduce scour and help sediment accretion in and around the project footprint. This is important because some initial increase in scour is expected after pile removal; stopping or reversing that initial loss would benefit eelgrass recruitment. The eelgrass zones are separated from the oyster reef zones by about 20 feet to allow for ongoing monitoring access and to prevent scour immediately adjacent to the reef treatments.

At the El Campo Marina site, as shown on **Figure 16**, the bulk of the eelgrass planting would be in a zone on the eastern edge of the site, shoreward of the existing row of dolphin piles that would be removed. The elevation range and substrate are appropriate for eelgrass in the marked area; however, bayward of the eelgrass zone, the restoration design calls for reef structures instead because the substrate is too hard for eelgrass (a mix of rubble and downed concrete piles).

In addition to this main treatment area, there is unvegetated bottom just below (i.e., on the bayward side of) the existing eelgrass beds within the pile field. This area of the site is generally deeper than areas supporting eelgrass both within and adjacent to the pile removal area. In this area, as shown on **Figure 16**, small, L-shaped eelgrass restoration plots (25 meters by 1 meter on each arm of the L) would be planted to further expand the extent of eelgrass habitat by pushing the lower margin of beds slightly deeper.

Finally, in addition to the eelgrass transplant zones, there are portions of the larger pile field in the center of the site where collapsed piles cover portions of the bottom that abut existing eelgrass beds and are within suitable depth ranges to support eelgrass. Following pile removal, eelgrass is expected to spread naturally into those areas and beyond them. Active transplanting is not proposed within existing eelgrass beds.

3.3.2 Reef Structures for Native Olympia Oysters

There are three different reef structure types that would be placed at the Red Rock Warehouse and El Campo Marina sites, as described below. These reef structure installations would provide hard substrate on which oysters, algae, and other benthic organisms could establish and grow. While oysters are the primary species for which these structures are intended, other species would be ancillary beneficiaries, including Dungeness and rock crab; fish such as steelhead and sturgeon; shrimp; and birds, including American black oyster catchers, egrets, and herons. The organisms and algae that establish on these structures provide a complex surface that would be suitable as a secondary herring spawning substrate. The reef structures themselves would also benefit nearby eelgrass by slowing tidal flows through former pile fields and thus increasing the sediment deposition and reducing scour. The layouts of the reef structures at the two sites are shown on **Figure 15** and **Figure 16.**

As shown at the El Campo Marina site, the oyster reef structures are arranged in an arc just bayward of the proposed eelgrass transplant zone near the eastern edge of the site. There are a total of 92 reef structures planned for this site. At the Red Rock Warehouse site, the reef structures are arrayed to alternate with eelgrass zones across a generally west-to-east transect. There are a total of 196 reef structures planned for this site. Other details of the reef structure areas are presented in **Table 7** below.

The spacing of the reef structures would be 9 feet on-center (which would leave about 5 feet between the outer edges of adjacent units) within the oyster zones shown on those map figures. The location of each type of reef structure is shown with a different symbol on the maps. The elevations of the oyster zones range between -2 feet and -3 feet MLLW at El Campo and between 0 feet and -6 feet at Red Rock. The spacing between each oyster zone and the nearest eelgrass zone would be 20 feet to protect the planted eelgrass beds from any localized scour or undue sediment accretion around the bases of the oyster reef structures.

Each unit of the three structure types would be placed on a base prior to placement into the sites. A base is advantageous not only for increasing stability but also to raise the reef structures above the bottom elevation so that they are not adversely affected either by scour or sediment deposition. Each structure would be assembled on land and loaded onto the construction barge where it would be lowered into position on the bay floor with a crane or similar piece of equipment. The reef structures would be placed on 4-foot square bases that would be approximately 8 inches thick. The bases would be made of Baycrete or may be pallet-like wooden frames.

Baycrete is a specialized concrete mix that was used to create reef structures for the State Coastal Conservancy's Living Shorelines Project and several other projects. It is a mixture of 20% Portland cement and almost 80% native bay mined sand and fossilized Olympia oyster shell. There are also small amounts of admixtures and other substances to produce the desired structural and chemical properties for this project (details of the Baycrete composition and fabrication are provided in the design specifications, which are Attachment B to the Joint Aquatic Resource Permit Application). The resultant Baycrete provides a stiff and hardened but pH-neutral and somewhat erodible surface of primarily native bay substrate. Allowing some post-placement erosion is beneficial from a habitat restoration perspective because the rougher texture is more conducive to settlement by oysters, algae, and other benthic organisms.

Table 7. Reef Structure Details

Item Description	**Red Rock Warehouse Site**	**El Campo Marina Site**	**Units**
Number of reef structures	196	92	units
Reef balls (Style 1)	*49*	*23*	*units*
Reef block stacks (Style 2)	*98*	*46*	*units*
Shell bag mounds (Style 3)	*49*	*23*	*units*
Base area - Reef balls (Style 1)	*16*	*16*	*ft^2/unit*
Base area - Reef block stacks (Style 2)	*16*	*16*	*ft^2/unit*
Base area - Shell bag mounds (Style 3)	*16*	*16*	*ft^2/unit*

Table 7. Reef Structure Details

Item Description	Red Rock Warehouse Site	El Campo Marina Site	Units
Footprint - Reef balls (Style 1)	*784*	*368*	*ft^2*
Footprint - Reef block stacks (Style 2)	*1568*	*736*	*ft^2*
Footprint - Shell bag mounds (Style 3)	*784*	*368*	*ft^2*
Total footprint area of reef structures	3,136	1,472	ft^2
Total footprint area of reef structures	0.07	0.03	acre

The specifics of three types of reef structures planned are described in the three subsections that follow.

Reef Balls

Reef balls (see **Figure 17**) are hollow and roughly hemispherical structures cast from Baycrete, as described above. The reef balls proposed for this project weigh up to 200 pounds and are 2.5 feet in diameter and 1.75 feet high. As shown in the figure, reef balls have holes on the sides and top to increase flow through them and to enhance the three-dimensional complexity of the habitats they provide. The Baycrete bases for the reef balls would be 4 feet on a side.

Reef balls would be approximately 25% of the total number of reef structures installed for this project. **Table 7** lists the number of reef balls planned for each of the two sites.

Shell Bag Mounds

Shell bag mounds (see **Figure 17**) are the most successful and widely used method to create oyster reefs in San Francisco Bay. To construct these, clean Pacific oyster half shells are placed in plastic mesh bags and stacked directly on the substrate or on a base. The stacked bags are placed in a pyramidal mound and affixed to the base with nylon cords or other ropes. The individual shell bags weigh approximately 12 pounds and are roughly 2.5 feet long, 1 foot wide and 6 inches high. Thus, they can be placed on the bases by hand. The height, width, and length of shell bag mounds are can be adapted to particular site conditions. The mounds proposed for this project would be up to 3 feet in diameter and up to 3 feet high. It would take an estimated 12 bags to create mounds of this size.

Shell bag mounds would be approximately 25% of the total number of reef structures installed for this project. **Table 7** lists the number of shell bag mounds planned for each of the two sites.

Reef Block Stacks

Reef block stacks consist of interlocking blocks cast from Baycrete that can be stacked in a variety of configurations. Each of the interlocking blocks (shown in **Figure 17**) is one foot on a side and eight inches high with cutouts and cavities on two sides and a hole in the middle. This varies shape allows them to be fitted together and also increases the 3-dimensional complexity of the habitat structure. Each block weighs approximately 25 pounds and thus can be easily moved and stacked by hand. The height, width, and length of reef block stacks installations can be varied to meet site-specific considerations. Here, they are expected to be arranged in pyramid shapes that are three levels tall, as shown in **Figure 17**, which would put them at about 3.5 feet on a side and 2 feet tall. This would require 14 individual blocks, though taller stacks requiring more individual blocks could be assembled in deeper water. Reef block stacks would be built on Baycrete bases that are 4 feet on a side.

Reef block stacks would be approximately 50% of the total number of reef structures installed for this project. **Table 7** lists the number of reef blocks stacks planned for each of the two sites.

Figure 17. Reef Structure Examples

Figure 17a. Reef Balls

Figure 17b. Reef Block Stack

Figure 17c. Shell Bag Mound

Position, Orientation, and Spacing of Reef Structures

As noted in earlier sections, the layout of the restoration reef structures would influence the hydrodynamic and sedimentation regimes around the structures. The placement of reef structures is strategic to promote sediment deposition and/or energy reduction to allow the development of other habitats or reduce erosion. This has been the case for the San Francisco Living Shorelines project and many similar projects conducted outside of the Bay. At the two restoration sites, reef structure placement would be expected to influence sediment deposition in a manner dependent upon reef placement configuration and prevailing wave and current energies. To dissipate energy from both short-period wind waves as well as longer period boat wakes that differ between high-speed ferries and larger shipping vessels and barges, a reef array is proposed instead of a single narrow band of reefs (**Figure 18**). This provides greater potential for wave attenuation of a broad spectrum of wave forms. It also facilitates greater dissipation benefits across more variable wave approach vectors. Providing porosity of the reef (gaps between reef units) is important to ensure wave energy dissipation rather than reflection.

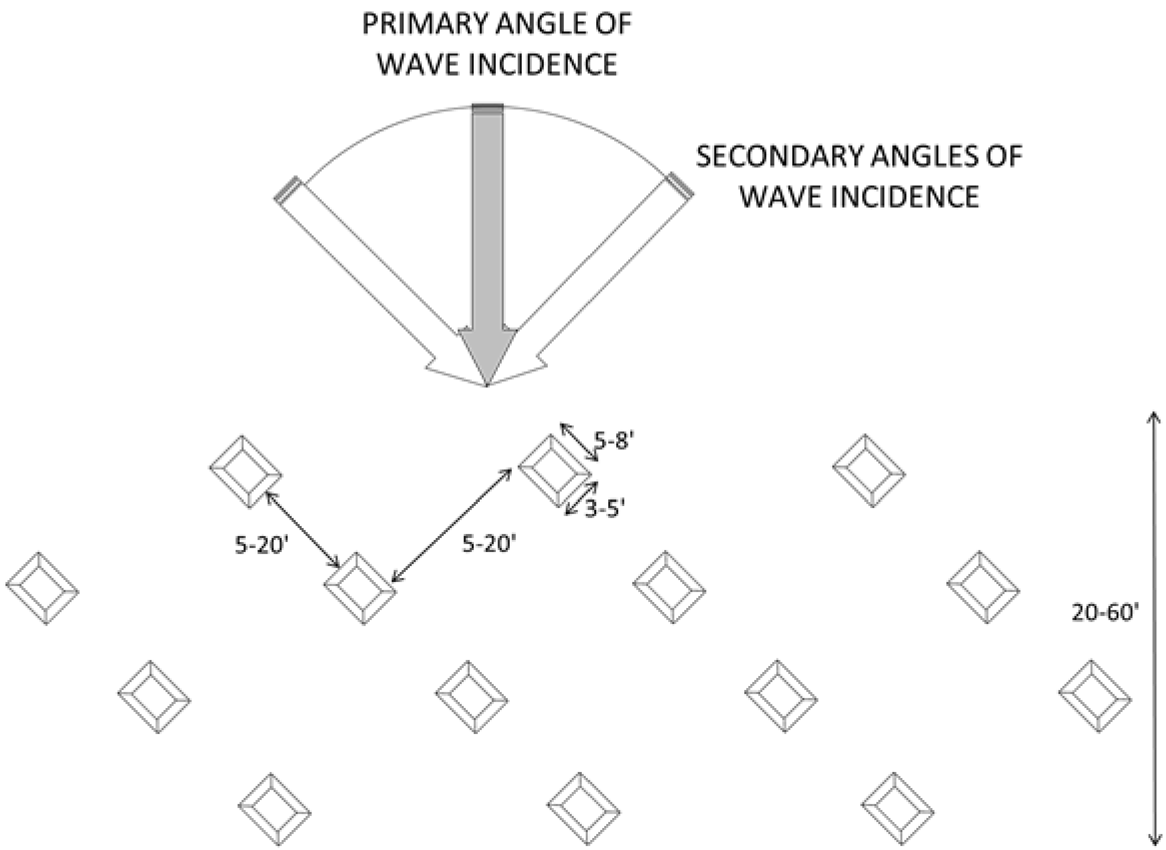
To attenuate forces associated with vessel wakes and wind waves, the reef structures are proposed to be no less than 5 feet apart. Placing the structures with less than 5 feet spacing would risk increasing the velocity of the flows between them and the concomitant scour in the adjacent areas behind them, which is intended for eelgrass. Spacing between 5 feet and 20 feet would bring about the kinds of wave energy-damping discussed above and direct much of the flows around the reef clusters, thus providing protection for the shoreline and the eelgrass planting areas. These distances would be a decrease in the spacing between the existing piles and would thus be expected to increase the amount of protection from high energy waves over the current situation. While a spacing of greater than 5 feet (but less than 20 feet) is still possible, this document conservatively assumes the least distance and thus the greatest number of reef units, and thus the greatest amount of additional fill in the Bay.

The structures would be arranged in rows of three that are offset by 50% relative to the primary angle of wind wave and/or ferry wake incidence on the array. The reef structures themselves are largely symmetric around a central vertical axis, so their orientation is not critical but the bases are rectangular and should be set to have one of their corner points facing into the primary angle of wave incidence, where possible, to maximize stability and reduce scour around the reefs.

This general array of reef structures are arrayed to promote sediment trapping and development of conditions suited to supporting greater amounts of eelgrass. The result of this alignment will be trapping and building of sediment elevations on the leeward side of the reef structures.

The design plans and specifications call for the reef structures to be placed in specific locations within each oyster zone (shown on **Figure 15** and **Figure 16**), and this is likely to be practicable in most cases. However, some latitude must be given to the construction contractor to adjust the precise locations of the reef structures based on substrate conditions. Examples of this may include moving a structure’s placement by 1 or 2 feet to take advantage of an existing piece of residual flat concrete or to avoid large rubble pieces that would make its placement unstable or negatively affect the hydrodynamics.

Figure 18: Reef Array Alignment



Example layout for segment of oyster reef array with a primary intent to serve as an energy disappation system from vessel wakes or wind waves. To trap sediment, the reef should be densified along leaward edge.

3.3.3 Rockweed Restoration

As noted in Section 1, rockweed is part of the overall plan for the proposed habitat restoration of this project. While populations are generally stable once established, rockweed's extent is often limited by its short dispersal distance; it has difficulty spreading to new locations. Therefore, two different types of rockweed enhancements are proposed: whole thallus transplant on existing rocks, and reproductive thalli tip translocation.

In the first of these, whole thalli attached to rock or riprap will be moved to allow colonization of new patches of intertidal shoreline and fill in voids that are too distant from existing plants for effective colonization. The transplant of whole thalli would involve identifying existing shorelines where abundant rockweed occurs to locate readily removable substrate that supports mature plants. The rocks or other substrate supporting mature thalli would be collected and relocated to restoration sites where they would be placed at the appropriate tidal elevations in a manner that wedges the substrate in to hold the transplant unit in place. Multiple transplant units would be aggregated together in an area where available substrate for recruitment of zygotes occurs. This would provide a source for sperm and eggs to be released. Under this method, the transplant aggregations would grow outward from the established nuclei as new rockweed is recruited from the sexual reproduction of donor material.

The second method involves translocation of reproductive material taken from the tips of mature thalli. Reproductive portions of adult Fucus individuals would be clipped and placed in mesh bags. The bags would be secured in the intertidal zone, allowing natural fertilization and zygote establishment processes to occur.

For whole thallus relocation, the rockweed would be harvested from existing rockweed beds on shorelines adjacent to each of the two sites. There are existing populations of readily accessible rockweed along shorelines adjacent to each site. Harvesting would not decrease the existing density of rockweed to below 1 mature thallus per 10 square feet. Individual thalli would be at least 6 inches in length, include at least 5 branching stalks, and carry multiple bladder tips on each stalk. The rocks supporting these transplants should be between 5 and 50 pounds.

Once harvested, rocks and thalli would be kept moist under saltwater-saturated burlap during transport and would be moved directly from the donor to receiver site within one tidal cycle. At the placement site, they would be hand-placed in a manner that locks rocks into existing shoreline rubble in an upright orientation. Transplanting density is one thallus per square meter. The rockweed zones are shown on the design plans and **Figure 15** and **Figure 16**. **Table 8** summarizes the areas of rockweed relocation efforts. The elevations of the rockweed zones are between +3 feet and +1.5 feet MLLW at both sites.

Table 8. Rockweed Relocation Areas

Item	Red Rock Warehouse Site	El Campo Warehouse Site
Total Rockweed Relocation Area	0.08 acre	0.11 acre
Maximum Number of Transplants	310 units	438 units

3.4 SUCCESS CRITERIA

The following success criteria have been adapted from those used in the Final Design documents for the SF Bay Living Shoreline: Near-shore Linkages Project (SCC 2012). The intent of this project is to remove sources of contamination from San Francisco Bay and enhance subtidal and intertidal habitat for the benefit of spawning herring and other wildlife. Because the project proponent expects there to be interannual variation in densities of desired organisms, the project will be deemed successful at each of the sites if one or more of the following criteria are met within the five-year period following construction:

- Eelgrass transplants establish and spread to at least 25% above initial planting densities;
- For each style of reef structure (reef balls, reef block stacks, and shell bag mounds), any of the below criteria apply:
  - native oysters recruit with densities of >10,000 oysters per acre of substrate **or** after 5 years
  - macroalgae and sessile invertebrates colonize the structures with at least 50% surficial coverage

 - o Observation shows that the reef structures are providing the kinds of tidal and wave dampening that allows or enhances successful eelgrass establishment in the zones behind them and/or can be shown to protect the shoreline from undue erosion
- Rockweed will establish and spread to at least 25% above initial planting densities
- If herring spawning occurs within the project site, herring will utilize eelgrass, oyster reef structures, or rockweed as spawning substrate at an equal or greater rate compared to their historic use of the creosote-treated piles during at least one spawning event
- There is no indication of increased shoreline erosion due to removal of the creosote piles
- There is no indication of substantial sedimentation resulting from installation of the reef structures.

The SCC will report the success or failure of the project to the permitting agencies. At each site, unsuccessful oyster reef structure types will be removed after five years. For example, if reef ball structures at Red Rock Warehouse do not recruit >10,000 oysters per acre of substrate during at least one year of the five years following construction **or** after 5 years, macroalgae and invertebrates colonize the structures with at least 50% surficial coverage, they will be removed. Any successful oyster reef structure types will be left in place.

3.5 SUMMARY OF RESTORATION ACTIONS

The proposed project includes a mixed habitat restoration plan with the goal of improving subtidal and intertidal habitat for spawning herring as well as other wildlife. **Table 9** summarizes the quantities and areas associated with the proposed restoration actions at both the Red Rock Warehouse and El Campo Marina sites.

Table 9. Summary of Restoration Action Treatments

Restoration Component		Red Rock Warehouse Site		El Campo Marina Site	
		Number	Area (acre)	Number	Area (acre)
Eelgrass bare-root transplants		2,597	0.64	1,539	0.38
Reef structures	Reef balls	49	0.07 Total	23	0.03 Total
	Reef block stacks	98		46	
	Shell bag mounds	49		23	
Rockweed	Whole thallus transplants and Translocation of mature thalli tips	310	0.08	438	0.11

3.6 PROJECT IMPLEMENTATION SCHEDULE

The construction schedule for this project is subject to regulatory constraints, seasonal weather conditions, and the intent to avoid potential impacts to special-status species by avoiding certain seasonal migrations. Thus, the pile and debris removal phase of the project is intended to take place in September-October of 2016 – to fit within the National Marine Fisheries Service (NMFS) work windows for projects that involve dredging within San Francisco Bay. Even though this project involves no dredging, that general work window does minimize the potential for adverse impacts on marine or estuarine species in the bay. Following that project construction phase, the placement of the reef structures and the transplanting of eelgrass and rockweed would occur the following spring and early summer, in April-June of 2017. During those months, the eelgrass and rockweed would be inflorescence and most obvious for the harvesting of transplant material. Other steps in the construction (e.g., mobilization and demobilization) would start earlier and end later than these listed dates.

Within that general framework, tides and day-to-day winds and weather conditions are an inevitable source of variability and possible changes to this planned project implementation schedule. The approximate schedules for each of the two project phases at each of the two sites are presented in **Figure 19** and **Figure 20**. Note that the pile removal schedule is based on the construction contractor(s) being able to remove 50 piles per day at each site, which is an assumption based on experience from a number of contractors in similar projects in the Bay in recent years. Similarly, the restoration phase of the project is based on assumptions that 10 reef structures could be placed each day at each site and that one acre of eelgrass transplants could be conducted in a 5-day work week.

Figure 19. Estimated Construction Schedule for Pile Removal

Item	Description	Aug 2016		Sep 2016		Oct 2016		Nov 2016	
	RED ROCK WAREHOUSE SITE								
1	Submittals	■	■						
2	Mobilization			■	■				
3	Demo Remaining Wharf Decking					■	■		
4	Demo Pilings*					■	■		
5	Remove Bay Floor Debris					■	■		
6	Site Restoration							■	■
7	Demobilization							■	■
	EL CAMPO MARINA SITE								
1	Submittals	■	■						
2	Mobilization			■	■				
3	Demo Pilings*			■	■	■	■		
4	Remove Bay Floor Debris					■	■		
5	Site Restoration							■	■
6	Demobilization							■	■

*Assumes Contractor can pull 50 piles a day.

Figure 20. Estimated Construction Schedule for Restoration Actions

Item	Description	Feb. 2017		Mar. 2017		Apr. 2017		May 2017		Jun. 2017		Jul. 2017	
	RED ROCK WAREHOUSE SITE												
1	Submittals	■	■										
2	Mobilization		■	■									
3	Fabricate Reef Structures				■	■	■						
4	Place Reef Structures						■	■					
5	Eelgrass Harvest and Transplant							■	■				
6	Rockweed Collection and Relocation								■	■			
7	Site Restoration										■	■	
8	Demobilization											■	■
	EL CAMPO MARINA SITE												
1	Submittals	■	■										
2	Mobilization		■	■									
3	Fabricate Reef Structures				■	■	■						
4	Place Reef Structures						■	■					
5	Eelgrass Harvest and Transplant							■	■				
6	Rockweed Collection and Relocation								■	■			
7	Site Restoration										■	■	
8	Demobilization											■	■

4.1 AVOIDANCE AND MINIMIZATION MEASURES

The following avoidance and minimization measures will be implemented at both project sites. The sedimentation and erosion control measures provided will be applied at the upland staging area at the Red Rock Warehouse, and will apply to any materials stored on barges at either site.

4.1.1 Protected Species

- Standard best management practices (BMPs) will be applied to protect species and their habitat(s) from pollution due to fuels, oils, lubricants, and other harmful materials. Vehicles and equipment that are used during the course of the Project will be fueled and serviced in a manner that will not affect federally protected species in the action area or their habitats.
- A Spill Prevention Control and Countermeasure (SPCC) plan will be prepared to address the emergency cleanup of any hazardous material and will be available on site. The SPCC plan will incorporate SPCC, hazardous waste, stormwater and other emergency planning requirements.
- Well-maintained equipment will be used to perform the work and, except in the case of a failure or breakdown, equipment maintenance will be performed off site. Equipment will be inspected daily by the operator for leaks or spills. If leaks or spills are encountered, the source of the leak will be identified, leaked material will be cleaned up, and the cleaning materials will be collected and properly disposed.
- Fueling of land and marine-based equipment will be conducted in accordance with procedures to be developed in the SPCC.
- Contractors will exercise every reasonable precaution to protect listed species and EFH-protected species and their habitat(s) from construction byproducts and pollutants such as construction chemicals, fresh cement, saw-water, or other deleterious materials.
- Precast concrete items will be allowed to fully cure before placement in San Francisco Bay. Construction waste will be collected and transported to an authorized upland disposal area, as appropriate, and per federal, state, and local laws and regulations.
- All hazardous materials will be stored upland in storage trailers and/or shipping containers designed to provide adequate containment. Short-term laydown of hazardous materials for immediate use will be permitted with the same anti-spill precautions..
- All construction materials, wastes, debris, sediment, rubbish, trash, fencing, etc., will be removed from the site once project construction is complete and transported to an authorized disposal area, as appropriate, in compliance with applicable federal, state, and local laws and regulations.
- Preconstruction surveys for terrestrial and avian special-status species will be performed by a biologist approved by NMFS and/or CDFW for such surveys.
- Presence of a biological monitor during any work activities that will occur within natural habitat.

- The following BMPs will be implemented by the Contractor for ballast water management and biofouling removal to reduce the potential for introducing aquatic invasive species to a less-than significant level:
  - Vessels over 300 gross tons in size will be regulated under the State's Marine Invasive Species Program.
  - Project vessels less than 300 gross tons in size will be inspected and biofouling will be removed from vessels less than 300 gross tons prior to travelling to the Project area.

4.1.2 Biological Monitoring during Construction

- The Owner's Biologist will be present to monitor impacts to eelgrass and benthic habitat during pile removal and restoration activities. A summary of impacts will be provided within 30 days of demolition completion, and within 30 days of restoration completion.
- The Owner's Biologist will be on-site during eelgrass planting, fucus planting, and the placement of reef structures to ensure that restoration is properly implemented.
- The contractor will record daily observations and note estimated work completed daily at each active work area. Information will be collected and presented on the daily form provided in the plans and specifications or in an alternate format approved by the Owner's Representative. Forms will be compiled on a daily basis, converted to a single file in pdf format, and provided via email to the Owner's representative the following day. The Owner's Representative will be notified immediately if any adverse conditions (floating or suspended materials, unusual discoloration or turbidity, or odors) are noted or any special status species are observed adjacent to or within the work area. Contractor will conduct daily inspections of the water outside of the containment silt curtains to ensure that discharge of construction sediments or materials do not cause the following conditions:
  1. Floating, suspended, or deposited macroscopic particulate matter or foams;
  2. Bottom deposits or aquatic growths to the extent that such deposits or growths cause nuisance or adversely affect beneficial uses;
  3. Alteration of temperature, turbidity, or apparent color beyond present natural background levels;
  4. Visible, floating, suspended, or deposited oil or other products of petroleum origin; and
  5. Toxic or other deleterious substances to be present in concentrations or quantities that cause deleterious effects on wildlife, waterfowl, or other aquatic biota, or that render any of these unfit for human consumption, either at levels created in the receiving waters or as a result of biological concentration.

4.1.3 Seasonal avoidance

- Pile removal activities will be conducted from June 1 to November 30 when migrating salmonids are not present in the Bay. This work window also avoids the herring spawning season.

- Green sturgeon has the potential to be present near the shoreline throughout the year (Miller and Kaplan 2001); and creosote piling removal activities may have an effect to the species.

4.1.4 Cultural resources

- There are known submerged vessels at the Red Rock site, and other unknown vessels may be encountered during project work. The Contractor will mark the extent of sunken vessels with buoys and avoid damaging it.

4.1.5 Erosion and Sedimentation Control

- All stockpiled materials will be covered prior to forecast storm events using polyethylene covers and/or other appropriate cover systems.
- Any disturbed areas will be treated prior to forecast storm events using geotextile blankets, straw rolls, and/or other appropriate blanket systems. Protect disturbed areas from overland sheet flow from adjacent areas prior to forecasted storm events using curbs, swales, dikes, berms, inlets, drains, and/or other appropriate stormwater diversion systems. Erosion control elements will be used to trap any loose sediment from disturbed areas before discharging any stormwater using silt fences, filter fabric, straw rolls, and/or other appropriate sediment trapping systems.
- The velocity of the discharged stormwater will be properly dissipated to prevent erosion using rock, grouted rip rap, rubble, and/or other appropriate stormwater velocity dissipation systems.
- Proper confinement for will be provided for garbage and construction materials that have the potential to contribute pollutants – including removed piles – to staging, storage, and handling areas shown on **Figure 11** Provide adequate cover from the rain and wind to these storage areas using polyethylene covers and/or other appropriate cover systems. Contain areas where liquids are stored and handled using geomembranes, sandbags, berms, dikes, and/or other liquid containment systems.
- Existing vegetation will be preserved to the extent feasible to minimize surface area of exposed soil and inactive disturbed areas will be stabilized as soon as feasible after the cessation of construction activities.
- Preserve condition of haul routes and access roads from tracked sediment using vehicle tire washers, street sweepers, and/or other appropriate sediment tracking control systems.
- Immediately notify the City Representative of any situation requiring additional erosion control devices to prevent soil erosion or sedimentation into any area beyond the project limits.
- The contractor will immediately repair, restore, and/or replace any low performing BMP identified and will repair, restore, and/or replace any deficiencies noted in scheduled inspections prior to forecast storm events, including the following:

  - Inspect straw rolls after significant storms. Ensure straw rolls are in contact with the soil. Replace straw rolls after 1 year or sooner if required. Remove sediment from behind silt fences and straw rolls to prevent overtopping.
  - Seed and protect any areas that remain unworked for more than 30 days.
  - At no time will the Contractor apply fertilizers, pesticides, or herbicides other than those specified to any of the planted or hydro seeded areas unless directed by the City Representative.
  - Prevent sediments from being flushed to the downstream system during cleaning.
  - Sediment, trash, and debris will be removed from catch basin grate surfaces when blocking more than 20 percent of the grate surface.
  - Sediment, trash, and debris will be removed from catch basin interiors when debris exceeds 1/3 of the depth from bottom to pipe invert.
  - Sediment, trash, and debris will be removed from rock dams, ponds, and traps when more than 1 foot of sediment has accumulated.
- During dry weather conditions, take preventative measures to minimize the wind transport of soil. Use water sprinkling, temporary enclosures, and other methods to minimize dust and dirt migration.

4.1.6 Pile Removal Best Management Practices

The piling removal approach in this project is as required by the RWQCB. The Contractor will attempt to remove the pilings in a different way, depending on the contamination of the surrounding sediments or muds.

- If the sediment is known or thought to be contaminated, the Contractor will cut the piling at the mudline.
- If the sediment is not contaminated, the Contractor will attempt to remove the entirety of each piling by pulling the piling straight out. Contractor is prohibited from using vibration or a back-and-forth, rocking movement intended to snap the piling because this increases turbidity.
- If, prior to attempting to remove the entire piling, visual inspection of the pilings indicates that the pilings lack the necessary integrity to be pulled without splintering, crumbling, or otherwise disintegrating, Contractor will change to the cutting method described below.
- If, during attempts to use direct pulls on the piling to remove it, the piling breaks at a level higher than 2 feet below the mudline, the Contractor will cut the remaining pile to a level 2-3 feet below the surrounding existing sediment or mudline.
- The removal method(s) utilized for each site will be described for Owner approval in the Demolition and Bay Floor Debris Removal Plan.
- The removed piles will be loaded onto a barge and transported back to the Contractor's staging area where the concrete will be separated from the other materials and recycled or disposed of offsite as appropriate at a permitted facility.

- The barge will be designed in such a way as to prohibit sediment or debris from falling back into the water. The work surface on the barge deck will include a containment basin for piles, concrete, and any mud or sediment removed during pulling. Upon removal from substrate, the piles will be moved expeditiously from the water into the containment basin.
- Jetting away the sediments around the piles is not allowed. Where the method selected is expected to generate concrete chips or dust in the water, a special curtain will be deployed around the individual pile so the contractor may capture any concrete pieces for offsite disposal.
- Intentional breaking of timber piles above the mudline is prohibited.
- The piles will not be shaken, hosed-off, stripped or scraped off, left hanging to drip or any other action intended to clean or remove adhering material from the pile.
- Any sediment accumulated from the pile removal operations will be assumed to contain creosote and will be contained and eventually tested and disposed offsite in an appropriate landfill.
- Upon completion of wharf, decking, and piling demolition and removal, the Contractor will perform a post-demolition diver survey within the project areas. The survey will document the quantity and type of pilings stubs above the mudline, the condition of the Bay's floor and identify quantities and types of debris from previous operations and/or from the demolition activities remaining on the Bay floor. The Contractor will submit the results of the survey to the Owner with descriptions of their approach to removal of the piling stubs and debris. The Owner may elect to leave some debris in place if it has established eelgrass growing on it. After this submittal is approved by the Owner, then the Contractor can proceed with piling stub and debris removal.
- Identified piling stubs will be cut off at 2-3 feet below mudline if possible.

4.1.7 Bay Floor and Shoreline Debris Removal

- Bay floor debris including above water timber piles, underwater timber piles, fallen timber piles, steel piping, and other miscellaneous items, as shown on the Plans or as encountered during demolition activities, will be removed.
- All the Bay floor debris within the project limits will be removed unless it will involve the disturbance of eelgrass. Timber piles not shown on the Plans encountered during operations will be removed. Other items not shown on the Plans or mentioned in the specifications, which are encountered during the Contractor's operations, will be brought to the attention of the Engineer. The Engineer will determine the disposition of the items.
- All removed debris will be transported to the Contractor's staging area and recycled or disposed at a permitted landfill facility.
- The Owner will confirm bay floor debris removal by conducting a post-construction side-scan sonar study in accordance with Section 02950 – Site Restoration.

- Existing concrete slabs and concrete debris along the shoreline will be left in place to avoid destabilizing the embankment. All other timber and metal debris along shoreline will be removed and disposed.
- On-shore piping will be removed or left in-place as indicated in the Plans.

4.1.8 Eelgrass-Specific Measures

- The eelgrass established in the project footprints a Red Rock Warehouse and El Campo Marina sites, as shown in **Figure 2** and **Figure 3**, is subject to protection and will be avoided to the maximum extent feasible.
- Contractor is required to perform water quality monitoring to monitor turbidity. The contractor will prepare a turbidity monitoring plan, including product information on monitoring equipment, proposed monitoring locations and procedures to follow, should turbidity increase above background levels. The turbidity monitoring plan will include the following provisions:
  - Prior to beginning work, Contractor will monitor turbidity and light levels at the level of the eelgrass to establish a baseline. Contractor will also set buoys out to establish background water quality monitoring points upstream and downstream (based on existing currents and tides at the site) of the site. Contractor will monitor turbidity and light at low, middle, and high tide during typical work hours for several days prior to beginning work. The Owner's Representative will review and approve the background monitoring station locations prior to monitoring.
  - During piling removal, Contractor will monitor turbidity and light levels at the frequency required by the project permits, at the same locations as the baseline monitoring plus within the work area.
  - In accordance with the project permits, light level (H_{sat}) must not fall below 5 hours a day or turbidity will not rise to more than 10% above background levels. Contractor will notify Engineer immediately when permit water quality criteria are exceeded. If the Engineer determines that the water quality criteria have indeed been exceeded, demolition activities must cease until turbidity is reduced and Hsat increases above 5 hours. The Owner may elect to exercise deployment of the silt curtain.
- Eelgrass beds will be surveyed and the boundary between the eelgrass beds and the work area will be marked with buoys before work begins. Work activities within the perimeter marked by the buoys are prohibited unless necessary to complete pile removal activities. The Owner's biologist will inspect the eelgrass bed prior to buoy installation to make sure it has not changed substantially from the 2014 survey shown on the drawings.
- The Owner's biologist will be onsite during all marine construction activities to monitor the eelgrass beds and ensure that they are not impacted by Contractor activities.
- It is anticipated that since the bay water at the project site is already turbid, that turbidity impacts to the eelgrass will not be significant. There is an Optional Bid Item for the Contractor to deploy a silt curtain around the eelgrass beds. The Owner may exercise this

Optional Bid Item if observations or turbidity monitoring during the work indicate that the silt curtain is needed to protect the eelgrass.

4.1.9 Staff Training

- Before any work occurs, the Contractor's field staff will attend a mandatory environmental-education program for construction personnel, designed and conducted in the field by the Engineer. The training is to cover all of the special-status species that could potentially occur on-site (e.g., osprey, green sturgeon, longfin smelt, Chinook salmon, and steelhead). That program will include a description, representative photographs, and the legal status of each of species; terms and conditions of the permits; and the penalties for not complying with biological conservation measures. The program will cover the restrictions and guidelines that must be followed by all construction personnel to avoid or reduce effects on special-status species during project implementation. The program will also cover cultural or archaeological resources that may be uncovered on-site and what to do in the event any such resources are found.
- All construction workers of the Contractor or its Subcontractors will be required to receive the training, and when new workers are added to the crew, they will receive the training before being allowed to work on-site.

  The training will be up to 1 hour in duration and held at the meeting room in the Contractor's or Engineer's construction trailer.

  After each training session is administered, the Contractor will submit the sign-in sheets showing which employees and subcontractor employees received the training, when the training was conducted and who conducted the training. Construction workers identified onsite as not having had the training can be removed from the worksite by the Engineer.

4.2 RESTORATION MONITORING

4.2.1 Monitoring of Eelgrass Plantings

After planting of eelgrass is completed, monitoring will be conducted to determine the level of successful establishment and to determine if any remedial actions are necessary to improve establishment success. Three forms of monitoring will be conducted over a five-year monitoring period, as described below:

Intensive plant monitoring – Intensive monitoring is generally performed for research, or to evaluate plant establishment or failure in a manner that targets determination of factors leading to success or failure of the restoration effort. By close and frequent observation of restoration sites, insight is garnered into how subsequent restoration at the site or other sites may be enhanced. The concept of detailed monitoring often underpins restoration efforts that are designed as adaptive approaches. By close plant evaluation it is generally possible to determine if plants suffer from low light conditions, herbivory, disease, or poor sediment conditions. It is possible to evaluate reproductive development in plants and the establishment and maturation of new recruits through seed. For evaluation of early plant establishment, it is generally good to observe the plants with a diminishing frequency over the first and second growing season following planting. Plant survival counts, health and vigor observations, reproductive state, and growth and expansion observations are typically made at a schedule of 0 month (starting condition), and 1, 3, 6 and 12 months for the first year and once during the second season, typically 24 months post-planting.

Establishment monitoring – Where eelgrass restoration is initially completed or after initial successful establishment is met, monitoring would shift from an individual plant evaluation to a bed establishment monitoring program. As beds coalesce and seedling establishment occurs, it becomes difficult to track initial plantings. Further, it becomes much less relevant from restoration or an ecological perspective. For this reason, plantings would be evaluated based on bed area and density on an annual basis. Monitoring would be performed for a period of five years. For restoration conducted for mitigation purposes (not the case on this project), a monitoring schedule has been adopted within the California Eelgrass Mitigation Policy of 0, 6, 12, 24, 36, 48, and 60 months post-restoration, with flexibility for seasonal dormancy.

Functional monitoring – Functional monitoring would be completed to assess the influence of eelgrass restoration on the environment. This type of monitoring would include evaluation of physical and biological parameters within and outside of eelgrass beds over a long period – in this case, 5 years. For the current project, the primary objective is to provide suitable spawning habitat for Pacific herring. As such, it is proposed that eelgrass success be measured by the following:

- Herring spawning on restored eelgrass when herring spawn within the creosote removal site;
- Diversity and density of fish and invertebrates utilizing the restored area; and
- Expansion of eelgrass beds at the creosote removal site.

4.2.2 Monitoring of Reef Installations

Monitoring of oyster restoration will be completed at multiple stages to serve differing assessment functions. These are briefly identified as follows:

- **Physical integrity** – Assess settlement of the unit and degradation of physical structure over time
- **Sedimentation/scour** - Assess the accumulation and purging of sediment on the surfaces of the structure as a controlling factor in the settlement and growth of oysters and other sessile organisms
- **Benthic community development –** Directly evaluate settlement and growth of oysters, kelp, mussels, and other organisms as a self-propagating habitat feature, assessment of mortality and causative agents
- **Pacific herring spawning –** Evaluate use of reef installations by Pacific herring as spawning substrate
- **Associated community development –** Evaluate the development of associated fish, invertebrate, and algal communities around the reef structures relative to reference conditions.

The frequency and timing of monitoring for these various functions differs. Physical integrity monitoring will start upon initial construction and will be completed at a diminishing schedule as early stability of the units is achieved. It is recommended that this monitoring be performed at a frequency of 0, 1, 3, 6, 12, and 24 months. Sedimentation/scour, benthic community development, and oyster recruitment and survival may be effectively evaluated during the same schedule. Long-term benthic community development should be evaluated annually for several years, while Pacific herring spawning use of the reefs should similarly be evaluated during winter months for multiple years. It is proposed that the same long-term monitoring over 5 years be applied to oyster reefs as to eelgrass habitats.

4.2.3 Rockweed Enhancement Monitoring

The monitoring of rockweed restoration and enhancement would be focused on these elements:

- **Transplant Unit Survival –** Experimental transplant monitoring to determine the level of success achieved in moving different planting units and planting at different elevation ranges. Monitoring should be conducted early in the restoration period to capture short-term recruitment and young thalli mortality events associated with the restoration methods (quarterly sampling)
- **Long-term Establishment –** Establishment monitoring to determine which units survive and expand over multiple growing seasons and develop increased algal cover on the shoreline at elevations suitable to support Pacific herring spawning
- **Pacific herring spawning –** Pacific herring spawning use of the rockweed relative to spawning in the area and on other substrates. Monitoring for expansion and densification of algal habitat within spawning zones and for Pacific herring spawning use should be extended over a 5-year period to match that of other habitat monitoring recommendations

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