# APPENDIX K5
## *Eelgrass CHRMP*

# MISSION BAY PARK IMPROVEMENTS PROGRAM

# Mission Bay Park Eelgrass Conceptual Habitat Restoration and Monitoring Plan San Diego, California

*Prepared for:*

The City of SAN DIEGO

**Engineering and Capital Projects**
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# TABLE OF CONTENTS

**SECTION** **PAGE NO.**

## APPENDIX



## FIGURES

## TABLES

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## SUMMARY

This Eelgrass Conceptual Habitat Restoration and Monitoring Plan (Plan) for the Mission Bay Park Improvements Program (Program) outlines habitat enhancement measures designed to address eelgrass impacts and improve water quality conditions within Mission Bay while enhancing ecosystem function. The Program includes multiple components focused on wetland and water quality improvements, shoreline restoration, upland habitat expansion, recreational infrastructure enhancements, and climate resilience measures in targeted areas of the bay.

The Plan specifically addresses restoration for anticipated impacts to eelgrass (*Zostera marina* and *Z. pacifica*) resulting from implementation of certain Program components, in accordance with the California Eelgrass Mitigation Policy (CEMP) administered by the National Marine Fisheries Service and the City of San Diego Biology Guidelines (SDBG). Based on existing mapping, Program components are expected to impact approximately 1.23 acres of eelgrass habitat. The Plan proposes a 2:1 replacement ratio to meet the requirements of the SDBG. This ratio would ensure sufficient acreage to meet the 1.2:1 final success ratio of the CEMP, assuming restoration is implemented within 135 days of the Program's first impacts to eelgrass. Eelgrass restoration would focus on suitable areas within the bay that offer the highest likelihood of long-term success based on prior mapping, site conditions, tidal hydrology, and long-term management.

Eelgrass mitigation aims to address degraded conditions in the eastern portion of Mission Bay, where limited tidal circulation and poor water quality have historically reduced habitat quality. By enhancing tidal exchange and restoring eelgrass, this Plan supports the long-term recovery of Mission Bay's coastal ecosystems.

This Plan presents the design approach, implementation strategy, and monitoring framework for eelgrass mitigation. These efforts are expected to contribute to the broader ecological uplift of Mission Bay while fulfilling regulatory requirements and advancing the City of San Diego's long-term vision for a resilient, healthy bay ecosystem.

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# 1 PROJECT DESCRIPTION

## 1.1 RESPONSIBLE PARTIES

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## 1.2 PROJECT BACKGROUND AND RESTORATION GOALS

### 1.2.1 MISSION BAY PARK IMPROVEMENTS PROGRAM OVERVIEW

The Mission Bay Park Improvements Program (Program) is intended to address issues related to water quality and water circulation improvements, habitat improvements, and visitor-serving improvements in specifically identified areas within Mission Bay in the City of San Diego. The Program includes the implementation of the following elements: Wetland and Water Quality Improvements, Restoration of Shoreline, Upland Habitat and Preserve Expansion, Bicycle and Pedestrian Improvements, Restoration of the Seawall Bulkhead, deferred maintenance activities, and signage update. Wetland and Water Quality Improvements are focused within three coastal wetlands restoration project locations, including North Fiesta Island Wetland, Tecolote Creek and Fiesta Island Causeway, and Cudahy Creek. Restoration of Shoreline would occur at eight Program locations, including Vacation Island Northwest, Vacation Island Northeast, Vacation Island Southwest, Ventura Cove Restoration, Crown Point, West Sail Bay Restoration, Bonita Cove Restoration, and Bahia Point Restoration. Upland Habitat and Preserve Expansion would occur at four Program locations on Fiesta Island and within three Program locations along the Sea World

Drive/SDRFCC levee. Bicycle and Pedestrian Improvements would occur bay-wide with three main locations identified as key areas; Rose Creek Bike Path, Fiesta Island Causeway Path, Ocean Beach Bike Path; and include several elements, including missing portions or gaps in bicycle and pedestrian paths, signage, sustainable lighting, and parking lot repairs. Restoration of the Seawall Bulkhead would occur along the oceanfront at Pacific Beach and Mission Beach. Deferred maintenance would occur bay-wide and include maintenance of the following facilities: playgrounds, comfort stations, furnishings, and parking lot repairs (including stormwater best management practices).

The following objectives for the Program are based on the goals of Section 55.2 of Article V of the City of San Diego City Charter:

1 Restoration of navigable waters within Mission Bay Park and elimination of navigational hazards. When depth conditions no longer support and ensure safe navigation, those areas that pose a danger or impede the passage of watercraft would be dredged in accordance with the Mission Bay Baseline Chart.

2 Wetland expansion and water quality improvements and the protection and expansion of eelgrass beds as identified in the Mission Bay Park Master Plan.

3 Restoration of shoreline treatments within the Mission Bay Park Improvement Zone including restoration of beach sand and stabilization of erosion control features.

4 Expansion of endangered or threatened species preserves and upland habitats on North Fiesta Island and along the levee of the San Diego River floodway as identified in the Mission Bay Park Master Plan.

5 Completion of bicycle and pedestrian paths and bridges as identified in the Mission Bay Park Master Plan, installation of sustainable lighting in the Mission Bay Park Improvement Zone, installation of signage and landscaping at points of entry to Mission Bay Park and the South Shores, and the repair, resurfacing and restriping of parking lots within the Mission Bay Park Improvement Zone.

6 Deferred maintenance that are also Capital Improvements hereunder on existing assets within the Mission Bay Improvement Zone as may be recommended by the Mission Bay Park Improvement Fund

### 1.2.2 RESTORATION REQUIREMENTS AND GOALS

Implementation of the Program would result in direct impacts to mapped eelgrass (*Zostera marina*) habitats by certain components of the Mission Bay Park Improvements Program. Under the California Eelgrass Mitigation Policy (CEMP) administered by the National Marine Fisheries Service

(NMFS), compensatory mitigation for impacts to eelgrass habitat is required to ensure no net loss of eelgrass habitat function in California (NMFS 2014). Moreover, the City's San Diego Biology Guidelines (SDBG) require a 2:1 replacement ratio for impacts to eelgrass beds.

Additionally, the Program description outlines opportunities for creation of native Olympia oyster (*Ostrea lurida*) habitat at suitable locations of Program components. While oyster habitat improvement and restoration would not be compensatory in nature, it would contribute to the broader ecological goals of the Program and ideally support the eelgrass mitigation effort in the long-term by enhancing water quality and improving estuarine habitat quality. An ecologically informed guide to oyster habitat restoration throughout the Program components is provided as Attachment A.

A Preliminary Engineering Report was prepared for each of the Program's location-specific components to a 30% design level. The preliminary engineering reports provide the basis for eelgrass impact assessment and eelgrass/oyster restoration design associated with this mitigation and monitoring plan (Plan). The Program components and locations are shown in Figure 1.

This Plan outlines the eelgrass restoration effort to offset impacts to eelgrass resulting from Program implementation at certain components.

The goals of eelgrass mitigation within the Mission Bay Plan center on improving water quality and enhancing biodiversity. The effort aims to address longstanding issues in the eastern portion of the bay, particularly east of Fiesta Island, where poor water circulation and limited tidal flushing have degraded aquatic conditions. By enhancing tidal exchange and restoring critical habitats, these actions would contribute to improved water quality and support the long-term resilience of Mission Bay's coastal ecosystems.

These restoration efforts also support the zonation of aquatic habitats essential to a functioning food web. From filter-feeding bivalves and benthic macroinvertebrates to fish and wading birds that rely on specific habitat types for foraging, breeding/spawning, and rearing, the restored mosaic of intertidal and subtidal habitats benefits biodiversity at multiple trophic levels. As a component of mitigation, this work also advances the overarching objectives of the Program by improving baseline ecological conditions, supporting native species, and contributing to the bay's long-term sustainability.

### 1.2.3 LOCATION OF EELGRASS REPLACEMENT

Eelgrass restoration is proposed to occur at three main Program component locations: North Fiesta Island wetland restoration, Cudahy Creek wetlands restoration, and Tecolote Creek wetlands. These locations have not been subject to prior eelgrass restoration efforts. However, previous eelgrass mitigation efforts have been conducted in Mission Bay related to numerous dredging and navigational safety projects. These include at the Mission Bay Entrance Channel and Mariner's Basin associated with a dredging project in 2010 (Merkel 2012) and around numerous portions of Leisure Lagoon, Fiesta Bay, Ventura Island, Sail Bay, and Mission Bay Channel in a dredging project in 2018 (Merkel 2023). None of these previous mitigation areas overlap with the proposed eelgrass mitigation areas outlined in this plan. Additionally, none of the impact areas associated with the Program overlap with previous eelgrass mitigation areas within Mission Bay.

## 1.3 ECOLOGICAL BACKGROUND

### 1.3.1 EELGRASS

Eelgrass species (*Zostera marina* and *Z. pacifica*) are native seagrasses that grow in soft-bottom substrates of shallow, inshore coastal environments, enclosed bays, and estuaries along the west coast of North America. In healthy systems, eelgrass can form dense, submerged meadows that serve as critical habitat for a wide range of marine organisms. These beds support biodiversity by providing structure and shelter for juvenile fish, crustaceans, bivalves, snails, and echinoderms, as well as substrate for diatom and macroalgae growth. Additionally, eelgrass meadows function as foraging and nursery grounds for commercially and ecologically important marine and anadromous fish species.

Two dominant seagrass genera found along the U.S. West Coast are *Zostera* (eelgrass) and *Phyllospadix* (surfgrass), with *Zostera* species being most prevalent in California's bays and estuaries. *Z. marina* commonly occupies lower intertidal and shallow subtidal zones in protected waters, while *Z. pacifica*, considered by some researchers to be a subspecies or ecotype, occupies slightly deeper subtidal habitats (Short et al. 2006; Shafer et al. 2007).

Eelgrass beds have been designated as Essential Fish Habitat (EFH) under the Magnuson-Stevens Fishery Conservation and Management Act for numerous species managed by the Pacific Fishery Management Council. They are also listed as Habitats of Particular Concern (HAPC), due to their ecological value, rarity, and vulnerability to anthropogenic impacts such as dredging, nutrient pollution, shoreline hardening, and sedimentation (NMFS 2014; NOAA 2021).

Beyond providing habitat and food for fish and invertebrates, eelgrass ecosystems support foraging sea turtles and migratory waterfowl and provide spawning surfaces for species such as Pacific herring (*Clupea pallasii*). Eelgrass also plays a crucial role in maintaining coastal geomorphology by trapping sediment, stabilizing the seabed, and attenuating wave energy—functions that help reduce shoreline erosion and improve water clarity (Orth et al. 2006; Fonseca and Cahalan 1992).

As a foundational species in coastal ecosystems, eelgrass forms the base of a highly productive food web and contributes significantly to carbon sequestration and nutrient cycling. Given its ecological importance and sensitivity to environmental stressors, the protection and restoration of eelgrass habitat remain high priorities for coastal management and conservation efforts in California and beyond.

### 1.3.2 HABITAT REQUIREMENTS AND LIMITATIONS: WATER AND SUBSTRATE QUALITY

Eelgrass (*Z. marina* and *Z. pacifica*) is highly sensitive to environmental conditions, particularly water quality and substrate characteristics. Optimal growth occurs in clear, well-circulated waters with high light availability, moderate nutrient concentrations, and relatively stable salinity regimes. Because eelgrass relies on photosynthesis at the leaf surface, water clarity is one of the most critical factors governing its depth distribution and overall health. Excessive turbidity, caused by sediment resuspension, algal blooms, or runoff, reduces light penetration and can severely limit photosynthetic capacity, leading to reduced productivity and bed contraction (Dennison et al. 1993; Kemp et al. 2004).

Eelgrass exhibits optimal growth and survival within moderate salinity (10–25%) and temperature (10–20 °C) ranges. Experimental results by Nejrup and Pedersen (2008) show that low salinity (<10%) and high temperatures (>25 °C) significantly impair photosynthesis, growth, and survival. Salinities below 5% and temperatures above 25 °C increased mortality and suppressed leaf production, while cold temperatures (5 °C) slowed growth without increasing mortality. These findings underscore eelgrass's sensitivity to environmental extremes and the importance of stable water conditions for its persistence.

Substrate quality is equally important. Eelgrass generally prefers soft, unconsolidated sediments—such as sand, silty sand, or fine gravel—with moderate organic content. These substrates allow for secure rhizome anchoring and nutrient uptake while avoiding the anoxic conditions often associated with overly fine, compacted, or organic-rich sediments. Hypoxic or sulfide-rich conditions within the sediment can inhibit root respiration and stunt growth or cause mortality, especially when compounded by high temperatures or low water movement (Holmer and Bondgaard 2001).

Nutrient concentrations must also be balanced. While eelgrass requires nitrogen and phosphorus for growth, excessive nutrient inputs (eutrophication) can stimulate epiphytic algae and phytoplankton, reducing light availability and competing for resources.

Together, these factors make eelgrass an excellent bioindicator of estuarine and coastal ecosystem health. Its presence, condition, and spatial extent often reflect broader patterns in water quality, hydrology, and habitat integrity.

# 2 REGULATORY SETTING

Federal, state, and local agencies enforce jurisdiction over portions of proposed restoration sites of in areas immediately adjacent to restoration sites, In addition, some sites support populations of listed species thar are regulated by federal and/or state agencies. In some cases, these species are covered under the City's MSCP. Where coverage is not provided, an informal consultation would be required with the potential for permit applications and permit acquisition prior to project implementation.

## 2.1 FEDERAL

### 2.1.1 FEDERAL ENDANGERED SPECIES ACT

The federal Endangered Species Act (FESA) of 1973 (16 USC 1531 et seq.), as amended, is administered by the U.S. Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration, and National Marine Fisheries Service. This legislation is intended to provide a means to conserve the ecosystems upon which endangered and threatened species depend and provide programs for the conservation of those species, thus preventing extinction of plants and wildlife. Under provisions of Section 9(a)(1)(B) of FESA, it is unlawful to "take" any listed species. "Take" is defined in Section 3(19) of FESA as, "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." FESA provides for designation of critical habitat for species designated as endangered, defined in Section 3(5)(A) as specific areas within the geographical range occupied by a species where physical or biological features "essential to the conservation of the species" are found and "which may require special management considerations or protection." Critical Habitat may also include areas outside the current geographical area occupied by the species that are nonetheless "essential for the conservation of the species."

The FESA allows for the issuance of "incidental take" permits for listed species under Section 7, which is generally available for components that also require other federal agency permits or other approvals, and under Section 10, which provides for the approval of habitat conservation plans on private property without any other federal agency involvement. Incidental take is defined as "take that results from, but is not the purpose of, carrying out an otherwise lawful activity" (50 CFR, Parts 17.22 and 17.32).

### 2.1.2 MIGRATORY BIRD TREATY ACT

The Migratory Bird Treaty Act (MBTA) prohibits the take of any migratory bird or any part, nest, or eggs of any such bird. Under the MBTA, "take" is defined as pursue, hunt, shoot, wound, kill trap, capture, or collect, or any attempt to carry out these activities (16 USC 703 et seq.). The number of bird species covered by the MBTA is extensive; the species are listed in Title 50 of the Code of Federal Regulations, Part 10.13. The regulatory definition of "migratory bird" is broad and includes any mutation or hybrid of a listed species, and also includes any part, egg, or nest of such birds (50 CFR 10.12). The MBTA, which is enforced by USFWS, makes it unlawful "by any means or in any manner, to pursue, hunt, take, capture, [or] kill" any migratory bird or attempt such actions, except as permitted by regulation. The applicable regulations prohibit the take, possession, import, export, transport, sale, purchase, barter, or offering of these activities, except under a valid permit or as permitted in the implementing regulations (50 CFR 21.11). Additionally, Executive Order 13186, "Responsibilities of Federal Agencies to Protect Migratory Birds," requires that any component with federal involvement address impacts of federal actions on migratory birds with the purpose of promoting conservation of migratory bird populations (66 FR 3853–3856). The Executive Order requires federal agencies to work with USFWS to develop a memorandum of understanding. USFWS reviews actions that might affect these species.

Currently, birds are considered to be nesting under the MBTA only when there are viable eggs or chicks, which are dependent on the nest.

Local implementation of the MBTA typically involves a qualified biologist conducting a nesting bird survey prior to construction activities between February 1 and September 15. Such surveys are required in all construction areas where natural or ornamental trees, shrubs, and ground cover may provide suitable nesting habitat for protected species. A nest avoidance buffer, as determined by the qualified biologist, would be established and serve to protect active nests from direct and indirect disturbance until breeding activities have been completed.

### 2.1.3 COASTAL ZONE MANAGEMENT ACT OF 1972

The Coastal Zone Management Act of 1972 (16 USC Sections 1451–1464, Chapter 33) is administered by the National Oceanic and Atmospheric Administration's Office of Ocean and Resource Management and was established as a national policy to preserve, protect, develop, and – where possible – enhance or restore the coastal zone in the United States. The federal consistency provision, Section 307 of the Coastal Zone Management Act, encourages states to join the Coastal Zone Management Program, which takes a comprehensive approach to coastal resource management by balancing the competing and/or conflicting demands of coastal resource use, economic development, and conservation and allows states to issue the applicable permits. California has a federally approved Coastal Zone Management Program, and the Coastal Zone Management Act is administered by the California Coastal Commission (CCC). Therefore, the Coastal

Zone Management Program and permit requirements are discussed further in the California Coastal Act section below.

#### 2.1.4 MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

Eelgrass beds are designated as Essential Fish Habitat (EFH) under the Magnuson-Stevens Fishery Conservation and Management Act (16 USC 1801 et seq.), which protects habitats necessary for fish spawning, breeding, feeding, or growth to maturity. Due to their ecological value and vulnerability to impacts like dredging and pollution, eelgrass beds are also recognized as Habitats of Particular Concern (NMFS 2014; NOAA 2021). EFH designations in California, including Mission Bay, require federal agencies to consult with NOAA on actions that may adversely affect these habitats.

### 2.2 STATE

#### 2.2.1 CALIFORNIA ENVIRONMENTAL QUALITY ACT

The California Environmental Quality Act (CEQA) requires identification of a project's potentially significant impacts on biological resources and feasible restoration measures and alternatives that could avoid or reduce significant impacts. CEQA Guidelines Section 15380(b)(1) defines endangered animals or plants as species or subspecies whose "survival and reproduction in the wild are in immediate jeopardy from one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, disease, or other factors" (14 CCR 15000 et seq.). A rare animal or plant is defined in CEQA Guidelines Section 15380(b)(2) as a species that, although not presently threatened with extinction, exists "in such small numbers throughout all or a significant portion of its range that it may become endangered if its environment worsens; or … [t]he species is likely to become endangered within the foreseeable future throughout all or a significant portion of its range and may be considered 'threatened' as that term is used in the federal Endangered Species Act." Additionally, an animal or plant may be presumed to be endangered, rare, or threatened if it meets the criteria for listing, as defined further in CEQA Guidelines Section 15380(c). CEQA also requires identification of a project's potentially significant impacts on riparian habitats (such as wetlands, bays, estuaries, and marshes) and other sensitive natural communities, including habitats occupied by endangered, rare, and threatened species.

#### 2.2.2 CALIFORNIA COASTAL ACT

The CCC was established by voter initiative in 1972 and was made permanent by the California Legislature through the adoption of the California Coastal Act of 1976 (CCA; California Public Resources Code Section 30000 et seq.). The CCC, in partnership with coastal cities and counties, plans and regulates the use of land and water in the coastal zone. Under the CCA, cities and counties are responsible for preparing local coastal programs in order to obtain authority to issue coastal development permits for projects within their jurisdiction. Local coastal programs consist of land use plans, zoning ordinances, zoning maps, and other implementing actions that conform to the policies of the CCA. Until an agency has a fully certified local coastal program, the CCC is responsible for issuing coastal development permits.

Under the CCA, Section 30107.5, environmentally sensitive habitat areas are areas within the coastal zone that are "designated based on the presence of rare habitats or areas that support populations of rare, sensitive, or especially valuable species or habitats." In addition, the CCC regulates impacts to coastal wetlands defined in Section 30121 of the CCA as, "lands within the coastal zone which may be covered periodically or permanently with shallow water and include saltwater marshes, freshwater marshes, open or closed brackish water marshes, swamps, mudflats, and fens." The CCA requires that most development avoid and buffer coastal wetland resources in accordance with Sections 301231 and 30233, including limiting the filling of wetlands to certain allowable uses.

The Biological Study Area (BSA) is located entirely within the coastal zone.

### 2.2.3 CALIFORNIA ENDANGERED SPECIES ACT

The California Department of Fish and Wildlife (CDFW) administers the California Endangered Species Act (CESA; California Fish and Game Code [CFGC], Section 2050 et seq.), which prohibits the "take" of plant and animal species designated by the Fish and Game Commission as endangered or threatened in the State of California. Under CESA Section 86, "take" is defined as "hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill." CESA Section 2053 stipulates that state agencies may not approve projects that would "jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat essential to the continued existence of those species, if there are reasonable and prudent alternatives available consistent with conserving the species or its habitat which would prevent jeopardy."

CESA Sections 2080 through 2085 address the taking of threatened, endangered, or candidate species by stating, "No person shall import into this state, export out of this state, or take, possess, purchase, or sell within this state, any species, or any part or product thereof, that the Commission determines to be an endangered species or a threatened species, or attempt any of those acts, except as otherwise provided in this chapter, the Native Plant Protection Act (CFGC, Sections 1900–1913), or the California Desert Native Plants Act (Food and Agricultural Code, Section 80001)." Take authorization for otherwise lawful activities may be obtained from CDFW under Section 2081 of the CFGC.

### 2.2.4 CALIFORNIA FISH AND GAME CODE

According to Sections 3511, 4700, 5050, and 5515 of the CFGC, which regulate birds, mammals, reptiles and amphibian, and fish, respectively, a “fully protected” species may not be taken or possessed without a permit from the CFGC, and, with few exceptions, take of these species is prohibited.

According to Section 3503, it is unlawful to take, possess, or needlessly destroy the nest or eggs of any bird, except as otherwise provided by this code or any regulation made pursuant thereto. Section 3503.5 states that it is unlawful to take, possess, or destroy any birds in the orders Falconiformes or Strigiformes (birds of prey) or to take, possess, or destroy the nest or eggs of any such bird except as otherwise provided by this code or any regulation adopted pursuant thereto. Section 3513 states that it is unlawful to take or possess any migratory nongame bird as designated in the MBTA.

The Native Plant Protection Act of 1977 (CFGC, Section 1900 et seq.) gives CDFW authority to designate state endangered, threatened, and rare plants, and provides specific protection measures for identified populations.

### 2.2.5 CALIFORNIA EELGRASS MITIGATION POLICY (CEMP)

The CEMP, developed by NOAA Fisheries in 2014, provides a standardized framework for protecting eelgrass during coastal development and in-water activities. The policy requires impact avoidance to the extent practicable and establishes mitigation ratios and monitoring requirements when eelgrass loss is unavoidable. It applies to all bays and estuaries in California, promoting regionally consistent protection of eelgrass habitat due to its critical role in supporting fishery resources and coastal ecosystems (NOAA 2014).

## 2.3 LOCAL REGULATIONS AND CONSERVATION PLANS

### 2.3.1 SAN DIEGO MULTIPLE SPECIES CONSERVATION PROGRAM

The City is a participant in the San Diego Multiple Species Conservation Program (MSCP), a comprehensive, regional long-term habitat conservation program designed to provide permit issuance authority for take of covered species to the local regulatory agencies. The MSCP addresses habitat and species conservation within approximately 900 square miles in the southwestern portion of San Diego County. It serves as an approved habitat conservation plan pursuant to an approved Natural Communities Conservation Plan in accordance with the state Natural Communities Conservation Planning Act.

The MSCP establishes a preserve system designed to conserve large blocks of interconnected habitat having high biological value that are delineated in Multi-Habitat Planning Areas (MHPAs). The City MHPA is a “hard line” preserve developed by the City in cooperation with the wildlife agencies, property owners, developers, and environmental groups. The MHPA identifies biological core resource areas and corridors targeted for conservation, in which only limited development may occur (City of San Diego 1997).

The MSCP identifies 85 plants and animals to be “covered” under the plan (termed Covered Species). Many of these Covered Species are subject to one or more protective designations under state and/or federal law and some are endemic to San Diego. The MSCP seeks to provide adequate habitat in the preserve to maintain ecosystem functions and persistence of extant populations of the 85 Covered Species while also allowing participating landowners “take” of Covered Species on lands located outside of the preserve. The purpose of the MSCP is to address species conservation on a regional level and thereby avoid component-by-component biological restoration, which tends to fragment habitat.

### 2.3.2 CITY OF SAN DIEGO MSCP SUBAREA PLAN

The City of San Diego MSCP Subarea Plan (Subarea Plan) (City of San Diego 1997) encompasses 206,124 acres within the MSCP Subregional Plan area. The proposed study area is located within the Urban areas of the Subarea Plan. The Urban habitat areas within the MHPA include existing designated open space such as Mission Bay, Tecolote Canyon, Marian Bear Memorial Park, Rose Canyon, San Diego River, the southern slopes along Mission Valley, Carroll and Rattlesnake Canyons, Florida Canyon, Chollas Creek, and a variety of smaller canyon systems. The Southern area includes Otay Mesa, Otay River Valley, and Tijuana Estuary and Tijuana River Valley. The Eastern area includes East Elliott and Mission Trails Regional Park.

The Subarea Plan is characterized by urban land uses with approximately three-quarters either built out or retained as open space/park system. Portions of the BSA are located within and adjacent to MHPA boundaries (City of San Diego 1997, Figure 33, City of San Diego MSCP Subarea and MHPA). The MHPA is considered an urban preserve that is constrained by existing or approved development and is comprised of habitat linkages connecting several large core areas of habitat. The criteria used to define core and linkage areas involves maintaining ecosystem function and processes, including large animal movement. Each core area is connected to other core areas or to habitat areas outside of the MSCP either through common boundaries or through linkages. Core areas have multiple connections to help ensure that the balance in the ecosystem would be maintained (City of San Diego 1997). Critical habitat linkages between core areas are conserved in a functional manner with a minimum of 75% of the habitat within identified linkages conserved (City of San Diego 1997).

### 2.3.3 CITY OF SAN DIEGO LAND DEVELOPMENT CODE – ENVIRONMENTALLY SENSITIVE LANDS REGULATION AND BIOLOGY GUIDELINES

The City of San Diego Development Services Department (DSD) developed the City of San Diego Biology Guidelines (SDBG) presented in the Land Development Manual "to aid in the implementation and interpretation of ESL [Environmentally Sensitive Lands] Regulations, San Diego LDC [Land Development Code], Chapter 14, Division 1, Section 143.0101 et seq., and the Open Space Residential (OR-1-2) Zone, Chapter 13, Division 2, Section 131.0201 et seq." (City of San Diego 2018a). The guidelines also provide standards for the determination of impact and mitigation under CEQA and the CCA. Sensitive biological resources, as defined by ESL Regulations, include lands within the MHPA, as discussed in Section 1.3.3 of this report, as well as other lands outside of the MHPA that contain wetlands; vegetation communities classifiable as Tier I, II, IIIA, or IIIB; habitat for rare, endangered, or threatened species; or narrow endemic species. The San Diego Municipal Code ranks upland habitat values by rarity and sensitivity. The most sensitive habitats are Tier I, and the least sensitive are Tier IV. The varying restoration ratios and requirements that restoration be either in-tier or in-kind are based on the sensitivity of the habitat being affected.

The City's definition of wetlands is broader than the definition applied by the U.S. Army Corps of Engineers (USACE). According to the SDBG (City of San Diego 2018a), City wetlands include areas characterized by one or more of the following conditions:

All areas persistently or periodically containing naturally occurring wetland vegetation communities characteristically dominated by hydrophytic vegetation, including but not limited to salt marsh, brackish marsh, freshwater marsh, riparian forest, oak riparian forest, riparian woodlands, riparian scrub, and vernal pools;

- Areas that have hydric soils or wetland hydrology and lack naturally occurring wetland vegetation communities because human activities have removed the historic wetland vegetation or catastrophic or recurring natural events or processes have acted to preclude the establishment of wetland vegetation as in the case of salt pannes and mudflats;
- Areas lacking wetland vegetation communities, hydric soils, and wetland hydrology due to non-permitted filling of previously existing wetlands; or
- Areas mapped as wetlands on Map C-713 as shown in Chapter 13, Article 2, Division 6 (Sensitive Coastal Overlay Zone).

Per the SDBG, areas that contain wetland vegetation, soils, or hydrology created by human activities in historically non-wetland areas do not qualify as wetlands under the City's definition unless they have been delineated as wetlands by the USACE and/or CDFW (City of San Diego 2018a). Artificially created wetlands consist of the following: wetland vegetation growing in brow ditches and similar drainage structures outside of natural drainage courses; wastewater treatment ponds; stock watering, desiltation, and retention basins; water ponding on landfill surfaces and road ruts created by vehicles; and artificially irrigated areas that would revert to uplands if the irrigation ceased. Previously dredged tidal areas, such as Mission Bay, should be considered wetlands under ESL Regulations (City of San Diego 2018a).

Guidelines that supplement the development regulation requirements described in this section are provided in the SDBG (City of San Diego 2018a). The Program is located entirely within the Coastal Overlay Zone (COZ), and therefore wetlands within the BSA would require adherence to the COZ wetland buffer regulations (City of San Diego 2018a). According to the SDBG, a wetland buffer is an area surrounding a wetland that helps protect the function and value of the adjacent wetland by reducing physical disturbance, provides a transition zone where one habitat phases into another, and acts to slow flood waters for flood and erosion control, sediment filtration, water purification, and groundwater recharge (City of San Diego 2018a). Within the COZ, wetland buffers should be provided at a minimum of 100 feet wide adjacent to all identified wetlands within the COZ. The width of the buffer may be either increased or decreased as determined on a case-by-case basis, in consultation with the CDFW, USFWS, and the USACE The width of the buffer is determined by factors such as type and size of development, sensitivity of the wetland resource to edge effects, topography, and the need for upland transition (City of San Diego 2018a). Per ESL Regulations, uses permitted in wetlands within the COZ are limited to aquaculture, wetlands-related scientific research and wetlands-related educational uses; wetland restoration components where the primary purpose is restoration of the habitat; and incidental public service components, where it has been demonstrated that there is no feasible less environmentally damaging location or alternative, and where restoration measures have been provided to minimize adverse environmental effects. Also per ESL Regulations, permitted uses in wetland buffer areas shall be limited to public access paths, fences, restoration and enhancement activities, and other improvements necessary to protect wetlands. ESL Regulations also lists permitted uses and developmental regulations for steep hillsides, coastal bluffs, coastal beaches, and special flood hazard areas.

### 2.3.4 CITY OF SAN DIEGO GENERAL PLAN

The proposed component is located in the City of San Diego and therefore is subject to the goals and policies in the City's General Plan. The General Plan was adopted in March 2008, and was most recently amended in July 2024. The General Plan provides policy guidance to balance the needs of a growing city while enhancing the quality of life for current and future San Diegans. It includes the City of Villages strategy which outlines how the City can enhance its many communities and neighborhoods as growth occurs over time. The General Plan contains 11 elements that provide a comprehensive “blueprint” for the City’s growth over the next 20 plus years. As shown in the General Plan land use map (City of San Diego 2024a, Figure LU-2), the component site is located in an area that is designated as Park, Open Space, and Recreation.

### 2.3.5 Mission Bay Park Master Plan

The component site falls within the boundaries of Mission Bay Park—a regional park that serves the residents of and visitors to San Diego. The MBPMP was adopted on August 2, 1994, and was most recently updated on November 23, 2021 (City of San Diego 2021. The MBPMP serves as the local coastal program for this area of the City. The proposed component is subject to the goals and recommendations established in the MBPMP, and the proposed component would be incorporated into the MBPMP as an amendment. The MBPMP recommends that the proposed study area should serve regional recreation needs, including guest housing (recreational vehicles and other low cost camping facilities); improve the park’s water quality, including creating additional wetlands; facilitate hydrologic improvements to safeguard the viability of marsh areas; provide a waterfront trail, viewing areas, and other passive recreational features to enhance public use of the component area; ensure leaseholds support the Mission Bay recreation use; improve access to recreational uses; and improve play areas for regional recreational needs.

### 2.3.6 THE “WHITEBOOK”

The City of San Diego published *The “Whitebook” Standard Specifications for Public Works Construction* (City of San Diego 2021b), which includes many standard practices that result in minimization of impacts to biological resources, including biological monitoring, materials suitability, safe construction methods, avian nest protection, tree protection, landscape standards, and stormwater protection measures. The “Whitebook” prescribed measures and standards are incorporated into the Program as Environmental Protocols.

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# 3 EXISTING CONDITIONS

## 3.1 ENVIRONMENTAL SETTING

Mission Bay is a public recreational area with open water and beaches for swimming, wading, and water sports. The Program components identified for eelgrass mitigation include: North Fiesta Island wetland restoration, Cudahy Creek wetlands restoration, and Tecolote Creek wetlands. The entire Program area is located within the California Coastal Commission and City of San Diego Coastal Zones (City of San Diego 2018).

**North Fiesta Island Wetland Restoration**

North Fiesta Island wetland restoration would occur in the northernmost portion of Fiesta Island, an artificial island located on the east side of Mission Bay. A least tern preserve is located to the north and the San Diego Youth Aquatic Center is located to the southeast. Topographic data for the North Fiesta Island area was obtained from the U.S. Geological Survey 2014 Light Detection and Ranging survey, and bathymetry data was obtained from the Mission Bay Park 2013 Bathymetry and Eelgrass Inventory (Merkel 2013). The terrestrial elevation ranges from 0 to 23.6 feet (above sea level) on land and 0 (at sea level) to 6.5 feet (below sea level) under water.

North Fiesta Island is within the San Diego watershed Hydrologic Unit Code 8 18070304, sub-watershed Mission Bay, Smiley Lagoon-Mission Bay Hydrologic Unit Code 12 180703041102. The Project site abuts the open water of Mission Bay to the east and west, and disturbed land to the north and south. The restoration area receives water by Pacific Ocean tides and water from precipitation that flows overland to Mission Bay. The open water and adjacent shoreline are subject to tidal influence and the tidal flow patterns of Mission Bay.

Existing habitat and land cover types within the North Fiesta Island wetland restoration area include majority beach and disturbed habitat, with small areas of open water, and disturbed southern coastal salt marsh.

Extensive descriptions of the baseline environmental conditions of North Fiesta Island wetland restoration area are available in the Biological Technical Report for the Mission Bay Park Improvements Program (Dudek 2025a) and the North Fiesta Island Wetlands Restoration Project Mitigation and Monitoring Plan (Dudek 2025b).

**Cudahy Creek Wetlands Restoration**

Cudahy Creek is located along the eastern shoreline of Mission Bay, north of Leisure Lagoon and south of the old Information/Visitor's Center, west of East Mission Bay Drive . Fiesta Bay surrounds the Project site to the west and developed land to the east. Terrestrial elevation ranges from 5 to 0 feet above sea level on land and 0 (at sea level) to 10 feet below sea level under water. Cudahy Creek is within the San Diego watershed Hydrologic Unit Code 8 18070304, subwatershed Mission Bay, Smiley Lagoon–Mission Bay Hydrologic Unit Code 12- 180703041102. Cudahy Creek is surrounded by development to the east and open water to the west. The site receives water by Pacific Ocean tides and receives additional water from precipitation that flows through the surrounding canyons and urbanized areas of the San Diego area and enter Mission Bay through two main outfalls, on the north and south ends of the site.

Existing habitat and land cover types within the Cudahy Creek wetland restoration area include mainly open water and some beach habitat.

Extensive descriptions of the baseline environmental conditions of Cudahy Creek wetland restoration area are available in the Biological Technical Report for the Mission Bay Park Improvements Program (Dudek 2025a) and the Cudahy Creek Wetlands Restoration Project Mitigation and Monitoring Plan (Dudek 2025c).

**Tecolote Creek Wetlands Restoration**

The Tecolote Creek wetland restoration area is located along the eastern shoreline of Mission Bay, east of Fiesta Island along both sides of the Fiesta Island causeway, and west of East Mission Bay Drive at the Tecolote Creek outfall. Fiesta Bay surrounds the Project site to the west and developed land is to the east. Terrestrial elevation ranges from 0 to 14 feet above sea level on land and 0 (at sea level) to 12 feet below sea level under water. Tecolote Creek is within the San Diego watershed Hydrologic Unit Code (HUC) 8 18070304, subwatershed Mission Bay, Smiley Lagoon–Mission Bay HUC 12- 180703041102. Tecolote Creek is surrounded by development and parkland. The Project site abuts the open water of Mission Bay to the north and south, and disturbed land to the east and west. The site receives water from Pacific Ocean tides and from precipitation and irrigation runoff that flows through the surrounding canyons and urbanized areas into Tecolote Creek, which enters Mission Bay just north of the Fiesta Island causeway.

Existing habitat and land cover types within the Tecolote Creek wetland restoration area include mainly open water and some beach and coastal salt marsh habitat in addition to some disturbed and developed lands.

Extensive descriptions of the baseline environmental conditions of Tecolote Creek wetland restoration area are available in the Biological Technical Report for the Mission Bay Park Improvements Program (Dudek 2025a) and the Tecolote Creek Wetlands Restoration Project Mitigation and Monitoring Plan (Dudek 2025d).

## 3.2 EXISTING EELGRASS IN MISSION BAY

The majority of Mission Bay supports a more or less continuous eelgrass bed (Merkel 2013; Dudek 2018; Figure 2). The eelgrass bed begins at approximately 0 feet MLLW and continues out to an additional slope break at approximately -2 feet MLLW where the bay slope steepens to a 4:1 to 7:1 slope that continues until it reaches the bottom of the bay at approximately -8 to -9 feet MLLW. Bathymetry data was obtained from the Mission Bay Park 2013 Bathymetry and Eelgrass Inventory (Merkel 2013).

Eelgrass is less dense in deeper portion of Mission Bay, such as dredge sites and established navigational channels, like the inlet to Mission Bay to the West Mission Bay Bridge over Mission Bay Channel. Mariners Basin is often absent of eelgrass or has minimal eelgrass near the shore.

East of Fiesta Bay, from Fiesta Island Road and Tecolote Creek outlet, Enchanted Cove, and north through the Pacific Passage and Leisure Lagoon, eelgrass was absent in 2018 (Dudek), but during some years occurs in very limited and sparse patches along Fiesta Island and the mainland shoreline near East Mission Bay Drive (Figure 2). Eelgrass beds were found near the Cudahy Creek outlet but were absent from De Anza Cove (Dudek 2018), however, sparse eelgrass was mapped in 2013 in the cove (Merkel 2013, Figure 2). Dense eelgrass distribution is concentrated in the shallow flat to gently sloping benthic habitat in the northeast at De Anza Point and west to Rose Creek outlet and Crown Point, to the northwest of Mission Bay at Sail Bay (Dudek 2018). Dense eelgrass beds continue along the western and southern near-shore portions of the bay but become less dense further away from shore as bay depths increase.

Lack of sufficient tidal circulation and poor water quality are the primary reasons that eelgrass doesn’t flourish east of Fiesta Island (Moffatt & Nichol 2019). The area known as the Northeast Inlet corresponding to the east side of Fiesta Island is one where tidal circulation is limited. Water exchange within the area is very limited, requiring 27 days for complete water exchange (Moffatt & Nichol 2025). The limited tidal circulation in the bay waters east of Fiesta Island further compounds water quality issues and the need for water quality improvements in the area.

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# 4 EELGRASS WORK PLAN

Under the CEMP (NMFS 2014), eelgrass impacts require full replacement of lost eelgrass through mitigation. This includes matching the impacted eelgrass area and density, and accounting for the temporal loss of ecological functions during the time between impact and full restoration of replacement eelgrass to fully mitigate unavoidable impacts of Program Components. Additionally, the SDBG require a 2:1 mitigation ratio for impacts to eelgrass beds. The following section presents the eelgrass mitigation plan for the Program, developed in accordance with CEMP guidelines and the SDBG requirements for eelgrass mitigation.

## 4.1 EELGRASS IMPACTS AND REPLACEMENT

Based on existing Mission Bay eelgrass mapping from Merkel (2013) and Dudek (2018), eelgrass impacts associated with the Program are currently anticipated at the following Program components: Tecolote Creek and Fiesta Island Causeway, Cudahy Creek, Vacation Island NE, Vacation Island SW, and Bonita Cove (Figure 2 and Figure 3).

It should be noted that eelgrass extent and coverage is variable from year to year. The CEMP (NMFS 2014) recommends pre- and post-Program eelgrass surveys/mapping in order to determine accurate impact and mitigation acreages. Accordingly, it is recommended that updated eelgrass mapping is performed throughout the bay as the Program implementation timeline becomes clearer. Impact and mitigation acreage may be updated based on pre-construction survey results.

Based on the existing eelgrass mapping from Merkel (2013) and Dudek (2018), approximately 1.23 acres of impacts are anticipated from Program components, as outlined in Table 1 and Figures 2 and 3. Updated pre-construction eelgrass surveys are required to confirm impact and subsequent mitigation acreages, per MM-BIO-5 of the Program's Biological Technical Report (Dudek 2025a).

### 4.1.1 CEMP MITIGATION RATIOS

According to the CEMP (NMFS 2014), in-kind eelgrass mitigation implemented concurrently with or immediately following Program impacts must result in the successful establishment of 1.2 acres of eelgrass for every acre impacted. This 1.2:1 ratio accounts for both the area and function of lost eelgrass. If there is a delay between impact and mitigation greater than 135 days, the required ratio may increase to account for the temporal loss of ecosystem services, as determined by federal action agencies (NMFS 2014).

The 1.2:1 mitigation ratio outlined in the CEMP (NMFS 2014) is based on several key assumptions:

1. The mitigation site provides no existing eelgrass function prior to restoration;
2. Full eelgrass function is achieved within three years of planting;
3. Mitigation is successful in meeting performance standards; and
4. The mitigation and impact sites are ecologically comparable, with no major differences in factors such as urban influence or proximity to freshwater inputs.

Deviations from these assumptions may justify adjustment of the mitigation ratio—either higher or lower—based on site-specific conditions (NMFS 2014).

To address the risk of planting failure, the CEMP also requires a minimum initial planting effort of 1.38 acres per acre impacted in southern California. This higher initial planting ratio does not change the final success requirement of 1.2:1, but provides a buffer against variable regional success rates (NMFS 2014). Mitigation that is fully installed and functional prior to impact may be credited at a 1:1 ratio, if it meets CEMP success criteria.

For eelgrass mitigation associated with the Program and as outlined in this Plan, the final CEMP mitigation ratio would be 1.2:1, assuming that eelgrass mitigation would occur within 135 days of all eelgrass impacts associated with the Program. Assuming that all eelgrass mitigation is implemented prior to additional impacts, all other impacts would be mitigated at a 1:1 ratio.

The overall Program timeline remains uncertain, but each proposed eelgrass mitigation site—North Fiesta Island, Cudahy Creek, or Tecolote Creek—has sufficient CEMP mitigation acreage to fully offset all eelgrass impacts of all Program components within a single mitigation site. Therefore, eelgrass mitigation can be implemented at whichever Program component is built first if mitigation is implemented within 135 days of the Program's first eelgrass impacts and subsequent Program elements are implemented three years after the initial impact. Once mitigation is implemented at the mitigation site within the first Program component, it would serve as CEMP replacement for all subsequent eelgrass impacts from other Program components at a 1:1 ratio and would meet and exceed the total combined mitigation requirement (see Section 3.2).

### 4.1.2 SDBG MITIGATION RATIO

The Program would follow the required 2:1 mitigation ratio for eelgrass beds as outlined in the SDBG. This would ensure that there is sufficient mitigation to meet both the CEMP and SDBG mitigation requirements.

Table 1 outlines anticipated eelgrass impacts, mitigation ratio, and proposed mitigation acreages for all Program components.

**Table 1**
**Anticipated Impacts, Mitigation Ratio, and Mitigation Acreage Required**

| Component | Anticipated Impacts | SDBG Mitigation Ratio[2] | Mitigation Acreage Required |
|---|---|---|---|
| Bonita Cove Shoreline Restoration | 0.04 | 2:1 | 0.08 |
| Vacation Island NE Shoreline Restoration | 0.02 | 2:1 | 0.04 |
| Vacation Island SW Shoreline Restoration | 0.08 | 2:1 | 0.16 |
| Cudahy Creek Wetlands Restoration | 0.86 | 2:1 | 1.72 |
| Tecolote Creek Wetlands Restoration | 0.23 | 2:1 | 0.46 |
| **Total** | **1.23[1]** | **2:1** | **2.46[1]** |

**Notes:**

1 Acreage may not accurately sum to the total due to rounding.

2 Mitigation ratios follow the SDBG and are higher than the CEMP requirements; accordingly, mitigation at SDBG ratios would meet and exceed CEMP requirements..

Eelgrass mitigation would occur at three main Program component locations: North Fiesta Island wetland restoration, Cudahy Creek wetlands restoration, and Tecolote Creek wetlands restoration (Figures 4 and 5). Eelgrass would be planted and mitigated at appropriate tidal elevations within each Program component design as part of the wetland restoration implementation and construction project, from approximately -1 to -8 feet MLLW (corresponding to approx. -3.5 to -10.5 feet mean sea level [MSL]/ Nation Geodetic Vertical Datum of 1929 [NGVD29]. Mitigation efforts would focus on areas which are expected to receive adequate tidal exchange, in newly created tidal channels and along a berm at Cudahy Creek which is expected to receive much greater tidal exchange than exists currently. The mitigation areas would comprise a combination of benthic eelgrass (e.g., along the bottom of the proposed outer berm at Cudahy Creek that interfaces with open bay water) and subtidal channel eelgrass (within tidal channels at Tecolote Creek and North Fiesta Island).

Table 2 outlines the mitigation acreages available at each proposed Program component mitigation site. The proposed eelgrass restoration acreage for the Program (7.15 acres) exceeds the required 2.46 acres of mitigation. Accordingly, excess eelgrass restoration acreage may be used as mitigation for future projects in Mission Bay such as the Rose Creek/De Anza wetlands restoration project.

**Table 2**
**Eelgrass Mitigation Sites**

| Program Component | Eelgrass Mitigation Area (acres) |
|---|---|
| North Fiesta Island Wetland Restoration Project | 1.64 |
| Cudahy Creek Wetland Restoration Project | 3.00 |
| Tecolote Creek Wetland Restoration Project | 2.51 |
| **Total** | **7.15** |

The sequence of Program component implementation is an important consideration for implementation of eelgrass mitigation and coverage of impacts (Table 1). Implementation of eelgrass restoration in the Cudahy Creek or Tecolote Creek wetlands restoration projects would provide 100% of the eelgrass mitigation for impacts within the entire Program component elements. Implementation of the North Fiesta Island wetland restoration project would provide 67% of the total eelgrass mitigation for the overall Program. However, the available mitigation acreage at the North Fiesta Island wetland mitigation project is sufficient to mitigate all Program components except for Cudahy Creek which has the greatest eelgrass impact (Table 1). Therefore, implementation of the North Fiesta Island wetlands restoration project can provide eelgrass mitigation for most Program components and implementation of Cudahy Creek wetlands would provide eelgrass mitigation for that project alone. As discussed in 3.1.1, a lower 1:1 mitigation ratio may be assigned when pre-mitigation of eelgrass impacts is achieved. Under the North Fiesta Island wetland restoration scenario, eelgrass mitigation at Cudahy Creek would have to be mitigated at a higher 1.2:1 ratio unless the Tecolote Creek wetlands restoration project is implemented prior to Cudahy creek impacts.

## 4.2 EELGRASS RESTORATION RATIONALE FOR SUCCESS

A key rationale for expecting successful mitigation in Mission Bay is the strategic placement of restoration efforts within newly created or enhanced pass-through channels—locations expected to maximize tidal exchange. These channels are specifically designed to increase water circulation in areas east of Fiesta Island, where existing tidal flow is highly restricted. Currently, the Northeast Inlet (east of Fiesta Island) suffers from extremely limited water exchange, with a complete turnover time of approximately 27 days (Moffatt & Nichol 2025). This poor circulation has been directly linked to degraded water quality, reduced water clarity/light availability, and the absence or underperformance of eelgrass beds in the area (Moffatt & Nichol 2019).

By improving tidal connectivity through channel creation or enhancement, these mitigation areas would introduce more frequent and efficient exchange of bay water with the open coast, bringing in cooler, oxygen-rich water and exporting excess nutrients and fine sediments. This flushing effect is expected to substantially improve water quality, including increased clarity/light availability and reduced temperature and salinity fluctuations—conditions critical for the successful establishment and persistence of eelgrass.

Increased tidal exchange would also improve sediment dynamics, potentially reducing sulfide buildup and hypoxia in the benthos, which are known to inhibit eelgrass root development and survival. With these improvements, habitat quality east of Fiesta Island is expected to increase substantially, creating new opportunities for eelgrass colonization in areas where it is currently absent or severely limited. As eelgrass is highly sensitive to environmental stressors but quick to expand in favorable conditions, this targeted hydrologic enhancement sets the stage for both immediate restoration success and long-term habitat expansion.

## 4.3 IMPLEMENTATION/INSTALLATION PLAN

**Personnel/Mitigation Roles and Responsibilities**

- Financially Responsible Party: The City of San Diego would be party that is financially responsible party for the implementation, monitoring, and successful completion of the mitigation effort.
- Installation Contractor: The eelgrass mitigation implementation would be completed by an experienced habitat restoration contractor with scientific diving capabilities and experience in eelgrass restoration in Southern California.
- Project Biologist: A biologist familiar with eelgrass restoration and with scientific diving capabilities would be retained to oversee implementation efforts and conduct monitoring until the final mitigation success criteria are met, as approved by the regulatory agencies.

### 4.3.1 IMPLEMENTATION OVERVIEW AND TIMING

Eelgrass mitigation would primarily involve harvesting eelgrass from large donor beds within Mission Bay and transplanting it into designated mitigation sites (Table 3, Figures 4 and 5). Where feasible, eelgrass impacted by Program activities would be salvaged and relocated, provided this can occur within the required mitigation timeframe. Given the uncertainty in the overall Program timeline, flexibility in the mitigation approach would be essential.

### 4.3.2 PERMISSIONS AND NOTIFICATIONS

Before beginning eelgrass transplantation, a letter of permission to collect and transplant eelgrass would be secured from the California Department of Fish and Wildlife (CDFW). CDFW must also receive at least three days' advance notice and a proposed transplant schedule prior to the start of field activities.

### 4.3.3 TRANSPLANT UNITS AND COLLECTION APPROACH

The proposed eelgrass mitigation plan would employ anchored bare-root transplant units, which are widely regarded as the preferred method for eelgrass restoration, particularly at larger scales. This method has been successfully used in many restoration projects because it provides a balance of ecological viability, logistical practicality, and cost-effectiveness while supporting high transplant survival and long-term meadow development.

A bare-root unit typically consists of 6 to 10 individual eelgrass shoots (also called turions), each with intact rhizomes and roots. These shoots are carefully harvested by hand from donor beds to minimize damage, ensuring that the rhizome segments remain viable for reestablishment. This method has been successfully used in many restoration projects because it provides a balance of ecological viability, logistical practicality, and cost-effectiveness while supporting high transplant survival and long-term meadow development.

Sufficient transplant units must be harvested from donor beds so that they can supply mitigation sites assuming placement at a 0.5-meter square grid interval. These calculations would be performed prior to identification of donor sites and harvesting of transplant units to ensure sufficient harvest can be achieved without damaging the donor bed.

Once collected, the shoots are grouped into small bundles—generally tied together using biodegradable materials such as jute thread or cotton string. To create anchored units, each bundle is affixed to a small, biodegradable anchoring material, such as a wooden dowel, a garden staple, or small gravel-filled mesh bag, which secures the transplant to the substrate during the critical early stages of rooting.

The process begins with divers gently extracting individual eelgrass shoots from healthy donor beds, taking care to preserve rhizome structure. The harvested shoots are then assembled on boats or at staging areas into standardized planting units, often bundled on the same day to ensure freshness and survival. Holding times between harvest from donor/salvage sites and planting within mitigation site would be less than 48 hours to reduce stress on the transplants.

### 4.3.4 HANDLING AND STORAGE OF DONOR EELGRASS PRIOR TO TRANSPLANTING

Following collection from donor sites, bare-root eelgrass shoots are carefully handled to preserve their viability until transplanting. Divers typically place the harvested shoots into mesh bags or tubs filled with ambient seawater, ensuring they remain moist and aerated. If immediate transplanting is not possible, shoots are stored in coolers lined with damp cloths or seawater-soaked paper towels, or held temporarily in aerated seawater tanks, with storage time kept under 24 to 48 hours to minimize stress and mortality. During transport to the transplant site, shoots are kept cool and shaded, often in moistened containers or coolers. Once on site, shoots are bundled into bare-root units if not already prepared, then handed off to divers for placement. This careful chain of custody helps maintain shoot health and maximizes the likelihood of successful eelgrass establishment.

### 4.3.5 SALVAGE SITES

Salvage sites are locations where existing eelgrass may be impacted by implementation of Program components (Figure 2). Updated pre-Program eelgrass mapping would confirm the extent of any anticipated impacts and identify potential salvage opportunities. Eelgrass would be collected solely from Program component impact sites. Because these sites are determined to be 100% impacted, 100% of eelgrass within the site would be salvaged and transplanted to implement eelgrass mitigation within the first Program component project. Subsequent Program component projects may similarly salvage eelgrass from planned impact area with 100% salvage to implement eelgrass restoration/mitigation within those future Program component projects.

Salvage sites may be located within areas of the bay that are subject to frequent and high volume of boating and recreation such as the Tecolote Creek wetlands restoration project area. It is suggested that the timing of harvesting work be limited to early morning hours when boaters are less active. Site closure to the public, buoys and floating lines around the donor areas are recommended during harvest. Coordination with City lifeguards, harbor patrol, and other agencies would also be required.

Salvage may occur on a timeline that allows for the successful implementation of the full eelgrass mitigation acreage (1.48 acres) using a planned impact/salvage area. Overall, the Program is expected to provide more eelgrass mitigation than required, exceeding regulatory mitigation ratios upon completion of all relevant components and providing excess eelgrass mitigation acreage for future projects within Mission Bay.

### 4.3.6 MITIGATION SITE PREPARATION AND PLANTING CONSIDERATIONS

The eelgrass mitigation sites would be located within tidal channels (North Fiesta Island and Tecolote Creek) and along a submerged berm slope (Cudahy). Soil borings in North Fiesta Island, where all fill material would originate for the other Program components, has determined that excavated soils are composed of fine sands, silts, and bay mud that pre-dates the mission bay development. These soils are suitable substrate for eelgrass establishment and long-term survival.

To reduce the risk of soil settlement and early transplant loss, sites would be allowed stabilize for a short period following dredging or fill placement, ideally timed to avoid periods of peak wave or current energy. Water quality at the transplant site would also be assessed to ensure conditions support optimal growth. Specifically, water would have low turbidity to allow adequate light penetration and maintain moderate salinity (10–25‰) and temperature (10–20 °C) ranges (Nejrup and Pedersen 2008). Preparing sites in this way creates the physical and chemical foundation needed for successful eelgrass root establishment and sustained meadow development.

Given the relatively shallow waters and distance from the open areas of the bay where boating and recreation is more common, extensive measures and coordination for planting harvested material into the mitigation sites is not expected, but protocols utilized during harvesting may be employed as necessary to protect restoration contractors, divers, recreating boaters, or the general public.

### 4.3.7 PLANTING

Eelgrass transplanting would be carried out by divers following a structured planting grid marked with temporary boundary lines. This organized layout helps ensure efficient progress tracking and facilitates quality control during the operation. Planting would be at a depth of approximately -1 to - 8 feet MLLW (or approx. -3.5 to -10.5 feet MSL/NGVD29).

Each transplant unit would be installed by hand or using a small trowel to create a hole in the sediment. The root and rhizome bundle would be placed approximately 1 to 2 inches beneath the sediment surface, with the anchoring mechanism inserted to a depth of about 5 inches to secure the plant in place (assuming the anchor is something like a wooden stake or small mesh bag with gravel/rock). Divers would periodically conduct spot checks during planting to verify proper depth and firmness of the installed units.

Eelgrass planting units would be spaced evenly in a grid pattern, with 0.5-meter intervals between each unit in both the horizontal and vertical directions. This means that each planting location would be situated 0.5 meter apart from its neighbors in a regular grid, forming rows and columns across the planting area. This uniform spacing allows the eelgrass to spread naturally over time while ensuring adequate coverage and reducing competition between plants. It also facilitates clear progress tracking and quality control during transplant operations.

## 4.4 EELGRASS MONITORING PROGRAM

### 4.4.1 REFERENCE SITES

A reference site is proposed just north of the northern tip of Fiesta Island, in proximity to the proposed mitigation sites and assumed to be subject to similar salinity, freshwater inputs, and tidal conditions (Figure 4). The reference site is assumed to be representative of environmental conditions and habitat characteristics of high-quality eelgrass beds. The reference site is comparable in size to the North Fiesta Island mitigation site and would enable meaningful comparisons.

The precise location and boundaries of the reference site would be determined during the first post-planting monitoring event, informed by eelgrass distribution patterns observed in the pre-Program eelgrass surveys. Once established, the reference site would be monitored concurrently with the associated mitigation sites throughout the duration of the monitoring program to assess relative performance and ambient conditions.

### 4.4.2 ESTABLISHMENT MONITORING

Following completion of eelgrass planting, a monitoring program would be implemented for a period of five years (60 months) at each Program component with eelgrass mitigation, consistent with the requirements of the CEMP (NMFS 2014). Monitoring would evaluate the eelgrass transplant sites for several key indicators, including areal extent, spatial distribution, percent cover, and turion (shoot) density. Data comparison may be assessed with reference site conditions to determine if performance variances are present. If similar site conditions are present with the mitigation sites and reference site, it may be concluded that the reason for underperformance is more broad-based and not a site-specific mitigation management issue.

To assess eelgrass coverage within the narrow tidal channels and along the relatively shallow Cudahy berm, surveys would be conducted using direct visual observation from a small, shallow-draft boat. Biologists would navigate along pre-established transects within the channel, stopping at systematically spaced sample points (e.g., every 5–10 meters) to visually estimate eelgrass presence and percent cover. At each sample point, observations would be made using a viewscope or underwater camera to minimize disturbance. GPS coordinates of each sampling location would be recorded to allow for consistent annual monitoring. Data would be entered into a GIS and overlaid on base imagery of the mitigation and reference sites to track annual changes in bed distribution and extent.

Turion density would be measured by scientific divers in each mitigation and the reference site using 1/16 $m^2$ quadrats, with all turions counted within each quadrat. A minimum of 20 quadrats would be sampled randomly throughout each site. This sample size is based on statistical power analysis and is sufficient to detect a 25% difference in turion density between mitigation and reference beds with 90% power and a significance level of 0.10.

Monitoring would occur at 6, 12, 24, 36, 48, and 60 months after planting. If a monitoring period falls outside the peak eelgrass growing season/conditions, it would be adjusted to ensure meaningful data collection.

It is assumed that Program components with eelgrass mitigation may be installed at different times. Accordingly, each Program component with eelgrass mitigation would be subject to its own monitoring program to ensure that the CEMP monitoring standards are met.

A draft report would be prepared within 30 days after each monitoring event at each Program component. Reports would include summaries and comparisons from all previous monitoring intervals, changes in bed size and location, and discussion of any observed trends or notable conditions. Each report would also include a brief health forecast for the eelgrass beds and a schedule for the next monitoring effort.

### 4.4.3 MITIGATION SUCCESS CRITERIA

Mitigation would be considered successful when it meets the performance standards outlined in the CEMP (NMFS 2014). Success would be evaluated based on comparisons between mitigation (transplant) and reference sites, using metrics including eelgrass areal extent, percent vegetated cover, and turion (shoot) density.

Areal extent is defined as continuous eelgrass cover with gaps less than 0.5 meter between turion clusters. Turion density refers to the number of shoots per square meter, as measured in representative quadrats within each bed.

**Key Success Criteria:**

- **Month 0:** Monitoring would confirm full coverage of planting areas across the mitigation site at the specified plant spacing.
- **Month 6:** At least 50% of planting units must show survival with even distribution.
- **Month 12:** Minimum of 40% vegetated cover and 20% of reference site density

- **Month 24:** Minimum of 85% cover and 70% of reference site density
- **Months 36, 48, and 60:** Minimum of 100% cover and 85% of reference site density

If any area fails to meet these benchmarks, it may be replanted and re-monitored. If transplant sites do not achieve success, partial reconstruction of the sites may be required. However, if declines in both reference and transplant sites are due to external factors beyond the City's control, the City would not be held responsible for similar declines in the dredge or transplant mitigation areas.

### 4.4.4 ADAPTIVE MANAGEMENT

Adaptive management would be used to guide the mitigation project(s) to a successful conclusion and implemented as needed. Adaptive management would consider such factors that may be found to have negative effects on the establishing eelgrass. These factors may include excessive wind or boat wake wave energy on planted eelgrass beds, excessive sediment deposition, insufficient water clarity, or pest infestation including excessive browse on newly planted beds. Adaptive management would assess site deficiencies and proposed solutions that ameliorate negative effects. For example, excessive wave energy may require an offshore reef or submerged structure to break wave energy before reaching the mitigation site. Adaptive management would be assessed annually after each data collection event and appropriate corrective actions in a timely manner to allow for recovery of the mitigation site to maintain a trajectory toward meeting performance standards.

### 4.4.5 REPORTING

Monitoring reports and spatial data for each Program component’s eelgrass mitigation area would be submitted to NMFS in both hard copy and electronic format within 30 days of each monitoring event (NMFS 2014). Reports must clearly identify the action, responsible parties, mitigation consultants, contact information, and relevant permits. Reports would detail the estimated and actual eelgrass impacts, mitigation requirements, site locations, and all survey, harvest, and transplant methods used. Each report would also include progress toward performance milestones. The initial report (Month 0) must document any deviations from the mitigation plan, donor material sources, and total planted area, while the final report would evaluate overall mitigation success relative to reference site variability.

## 4.5 TENTATIVE EELGRASS MITIGATION PLAN SCHEDULE

Although the overall Program timeline is uncertain, a tentative schedule for the eelgrass mitigation program is presented in Table 3. Any of the three Program components with eelgrass mitigation sites may be implemented first: Tecolote Creek, Cudahy Creek, or North Fiesta Island. Ideally, Shoreline projects with impacts to eelgrass would occur after the establishment of eelgrass mitigation at one of the three Program components with eelgrass mitigation, after which CEMP mitigation requirements would be met and SDBG mitigation requirements would be fulfilled with the establishment of the remaining Program components with eelgrass mitigation.

**Table 3**
**Tentative Eelgrass Mitigation Plan Timeline**

| Mitigation Plan Component | Timing |
|---|---|
| Retain Qualified Restoration Implementation Contractor and Project Biologist | At least 12 months prior to first eelgrass mitigation implementation or first impacts to eelgrass |
| Pre-Program Eelgrass Surveys | At least 6 months prior to first eelgrass mitigation implementation or first impacts to eelgrass |
| Identification of Donor Sites | At least 3 months prior to eelgrass mitigation implementation or first impacts to eelgrass |
| Preparation of Mitigation Site(s) within Program Components | Concurrent with eelgrass mitigation implementation at each Program component with eelgrass mitigation |
| Harvest from Donor Sites and Create/Store Transplant Units | After preparation of mitigation site(s) is completed |
| Plant Transplant Units | Within 48 hours of harvest |
| Initial Report (0 Months) | Within 30 days of planting completion at each Program component with eelgrass mitigation |
| 6-Month Survey and Report | 6 months after planting completion at each Program component with eelgrass mitigation (with report 30 days following) |
| 12-Month Survey and Report | 12 months after planting completion at each Program component with eelgrass mitigation (with report 30 days following) |
| 24-Month Survey and Report | 24 months after planting completion at each Program component with eelgrass mitigation (with report 30 days following) |
| 36-Month Survey and Report | 36 months after planting completion at each Program component with eelgrass mitigation (with report 30 days following) |
| 48-Month Survey and Report | 48 months after planting completion at each Program component with eelgrass mitigation (with report 30 days following) |

**Table 3**
**Tentative Eelgrass Mitigation Plan Timeline**

| Mitigation Plan Component | Timing |
|---|---|
| 60-Month Survey and Report | 60 months after planting completion at each Program component with eelgrass mitigation (with final report 30 days following) |

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# 5 EXPECTED LIFT OF ECOLOGICAL FUNCTIONS AND VALUES

The proposed restoration actions presented in this Plan are anticipated to result in a significant net gain in ecological function and value across the various Program components and the greater Mission Bay. Establishment of eelgrass in newly created or enhanced subtidal habitats would improve habitat complexity, water clarity, and sediment stability while providing critical nursery and foraging grounds for a diverse array of marine species.

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# 6 REFERENCES

Baker, P. 1995. Review of Ecology And Fishery of The Olympia Oyster, Ostrea Lurida With Annotated Bibliography. Journal of Shellfish Research 14:501–518.

Brumbaugh, R.D., M.W. Beck, L.D. Coen, L. Craig and P. Hicks. 2006. *A Practitioners' Guide to the Design and Monitoring of Shellfish Restoration Projects: Ecosystem Services Approach*. Arlington, Virginia: The Nature Conservancy.

Brumbaugh, R.D. and L.D. Coen. 2009. "Contemporary approaches for small scale oyster reef restoration to address substrate versus recruitment limitation: A review and comments relevant for the Olympia oyster, *Ostrea lurida* Carpenter 1864." *Journal of Shellfish Research* 28:147–161.

City of San Diego. 2021. *Mission Bay Park Master Plan Update*. Adopted August 2, 1994. Amended November 23, 2021. https://www.sandiego.gov/sites/default/files/mb_park_master_plan.pdf.

City of San Diego. 2018. San Diego Municipal Code, Land Development Code, Biology Guidelines. Amended February 1, 2018.

Dennison, W. C., et al. 1993. Assessing water quality with submersed aquatic vegetation. *BioScience*, 43(2), 86–94. https://doi.org/10.2307/1311969

Dudek. 2025a. Biological Technical Report for the Mission Bay Park Improvements Program. Prepared for the City of San Diego – Engineering and Capital Projects Department. June 2025.

Dudek. 2025b. North Fiesta Island Wetlands Restoration Project Mitigation and Monitoring Plan. Prepared for the City of San Diego – Engineering and Capital Projects Department. May 2025.

Dudek. 2025c. Cudahy Creek Wetlands Restoration Project Mitigation and Monitoring Plan. Prepared for the City of San Diego – Engineering and Capital Projects Department. July 2025.

Dudek. 2025d. Tecolote Creek Wetlands Restoration Project Mitigation and Monitoring Plan. Prepared for the City of San Diego – Engineering and Capital Projects Department. July 2025.

Elsey, C.R. 1935. On the Structure and Function of the Mantle and Gills of Ostrea gigas (Thunberg) and Ostrea lurida (Carpenter). PhD thesis, Rutgers University, New Jersey.

Fonseca, M. S., & , J. A. Cahalan. 1992. A preliminary evaluation of wave attenuation by four species of seagrass. *Estuarine, Coastal and Shelf Science*, 35(6), 565–576. https://doi.org/10.1016/S0272-7714(05)80039-3

Holmer, M., & , E. J. Bondgaard. 2001. Photosynthetic and growth response of eelgrass to low oxygen and high sulfide concentrations during hypoxic events. *Aquatic Botany*, 70(1), 29–38.

Kemp, W. M., et al. 2004. Eutrophication of Chesapeake Bay: historical trends and ecological interactions. *Marine Ecology Progress Series*, 303, 1–29. https://doi.org/10.3354/meps303001

Merkel. 2012. 12-Month Post-Transplant Eelgrass Survey for the Mission Bay Harbor Maintenance Dredging Project, Mission Bay, CA. Prepared for the City of San Diego Parks and Recreation Department. November 2012.

Merkel. 2013. Mission Bay Park Eelgrass Inventory Bathymetric Change Analysis 1988, 1992, 1997, 2001, 2007, and 2013. Prepared for the City of San Diego Public Works Department, E&CP, AEP Divisions.

Merkel. 2023. 60-Month Post-Planting Eelgrass Mitigation Monitoring Report In Support Of The 2018 Mission Bay Navigational Safety Dredging Project. Prepared for City of San Diego Public Works Department, E&CP, AEP Divisions. July 2023

Moffatt & Nichol. 2019. Draft Mission Bay Hydrology Study. Mission Bay PEIR. April 5, 2019.

Moffatt & Nichol. 2025. *Preliminary Engineering Report North Fiesta Island Wetland Restoration*. July 11, 2025.

Nejrup, L. B., & , M. F. Pedersen. (2008). Effects of salinity and water temperature on the ecological performance of *Zostera marina*. *Aquatic Botany*, 88(3), 239–246. https://doi.org/10.1016/j.aquabot.2007.10.006

NMFS (National Marine Fisheries Service) 2014. California Eelgrass Mitigation Policy and Implementing Guidelines. NOAA Fisheries West Coast Region. October 2014. https://media.fisheries.noaa.gov/dam-migration/cemp_oct_2014_final.pdf.

NOAA Office of Habitat Conservation. 2021. *Essential Fish Habitat Mapper*. https://www.habitat.noaa.gov/protection/efh/habitatmapper.html

Orth, R. J., Carruthers, T. J. B., Dennison, W. C., et al. 2006. A global crisis for seagrass ecosystems. *BioScience*, 56(12), 987–996. https://doi.org/10.1641/0006-3568(2006)56[987:AGCFSE]2.0.CO;2

Polson, M. P. and , D. C. Zacherl. 2009. Geographic distribution and intertidal population status for the olympia oyster,ostrea luridacarpenter 1864, from alaska to baja. Journal of Shellfish Research, 28(1), 69-77. https://doi.org/10.2983/035.028.0113

Shafer, D. J., Kaldy, J. E., & , J. L. Gaeckle. 2007. Science-based restoration monitoring of coastal habitats. *NOAA Technical Memorandum NMFS-NWFSC-83*.

Short, F. T., Polidoro, B., Livingstone, S. R., et al. 2011. Extinction risk assessment of the world's seagrass species. *Biological Conservation*, 144(7), 1961–1971. https://doi.org/10.1016/j.biocon.2011.04.010

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**FIGURE 1**

Mission Bay Park Improvements Program

Mission Bay Park Water Quality Improvements Eelgrass Mitigation and Monitoring and Oyster Habitat Restoration Plan

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SOURCE: SANGIS 2023

DUDEK

0 900 1,800 Feet

**FIGURE 2**

Eelgrass Impacts Overview

Mission Bay Park Water Quality Improvements Eelgrass Mitigation and Monitoring and Oyster Habitat Restoration Plan

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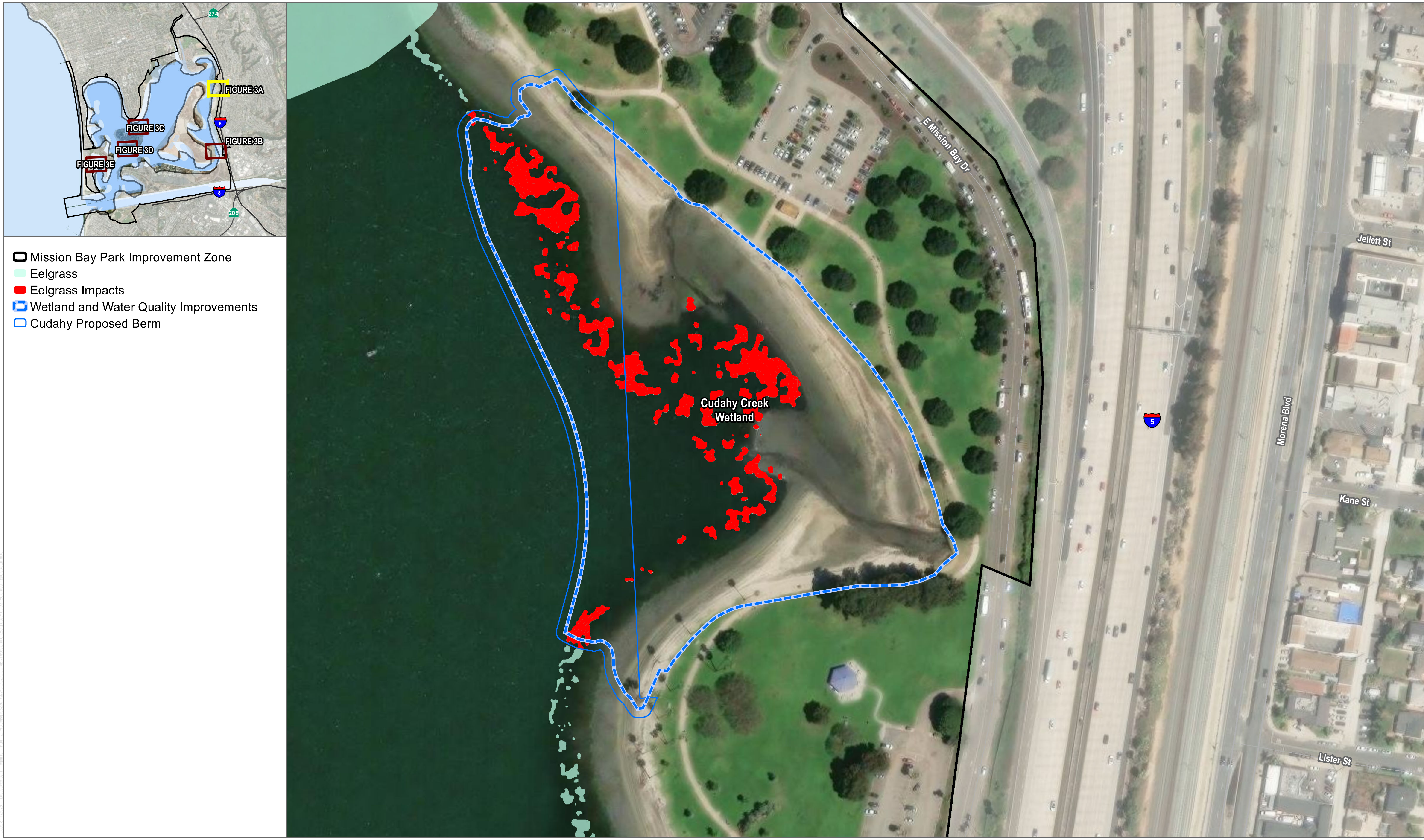


SOURCE: SANGIS 2023

DUDEK

FIGURE 3A

Eelgrass Impacts Detail Series

Mission Bay Park Water Quality Improvements Eelgrass Mitigation and Monitoring and Oyster Habitat Restoration Plan

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Mission Bay Park Improvement Zone
Eelgrass
Eelgrass Impacts
Wetland and Water Quality Improvements
Upland Habitat and Preserve Expansion
Bicycle and Pedestrian Improvements

SOURCE: SANGIS 2023

DUDEK

0 100 200 Feet

**FIGURE 3B**

Eelgrass Impacts Detail Series

Mission Bay Park Water Quality Improvements Eelgrass Mitigation and Monitoring and Oyster Habitat Restoration Plan

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SOURCE: SANGIS 2023

DUDEK

**FIGURE 3C**

Eelgrass Impacts Detail Series

Mission Bay Park Water Quality Improvements Eelgrass Mitigation and Monitoring and Oyster Habitat Restoration Plan

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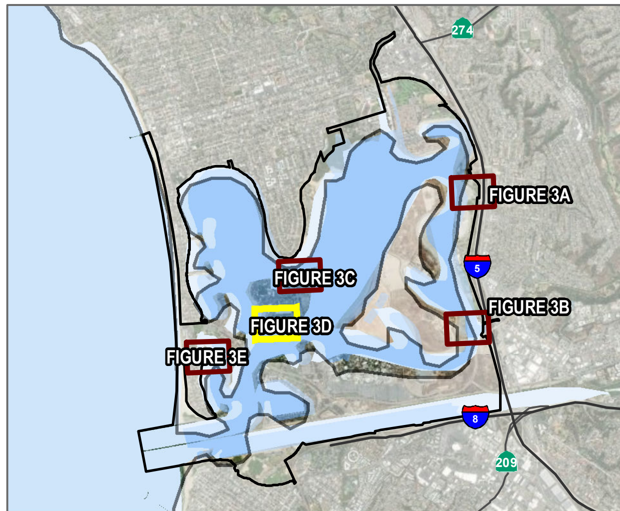


Mission Bay Park Improvement Zone
Eelgrass
Eelgrass Impacts
Restoration of Shoreline


SOURCE: SANGIS 2023

DUDEK

0 75 150 Feet

**FIGURE 3D**

Eelgrass Impacts Detail Series

Mission Bay Park Water Quality Improvements Eelgrass Mitigation and Monitoring and Oyster Habitat Restoration Plan

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SOURCE: SANGIS 2023

DUDEK

**FIGURE 3E**

Eelgrass Impacts Detail Series

Mission Bay Park Water Quality Improvements Eelgrass Mitigation and Monitoring and Oyster Habitat Restoration Plan

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SOURCE: SANGIS 2023

DUDEK

0 900 1,800 Feet

**FIGURE 4**

Eelgrass Mitigation Overview

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SOURCE: SANGIS 2023

DUDEK

0 75 150 Feet

**FIGURE 5A**

Eelgrass Mitigation Detail Series

Mission Bay Park Water Quality Improvements Eelgrass Mitigation and Monitoring and Oyster Habitat Restoration Plan

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SOURCE: SANGIS 2023

DUDEK

0 125 250 Feet

**FIGURE 5B**

Eelgrass Mitigation Detail Series

Mission Bay Park Water Quality Improvements Eelgrass Mitigation and Monitoring and Oyster Habitat Restoration Plan

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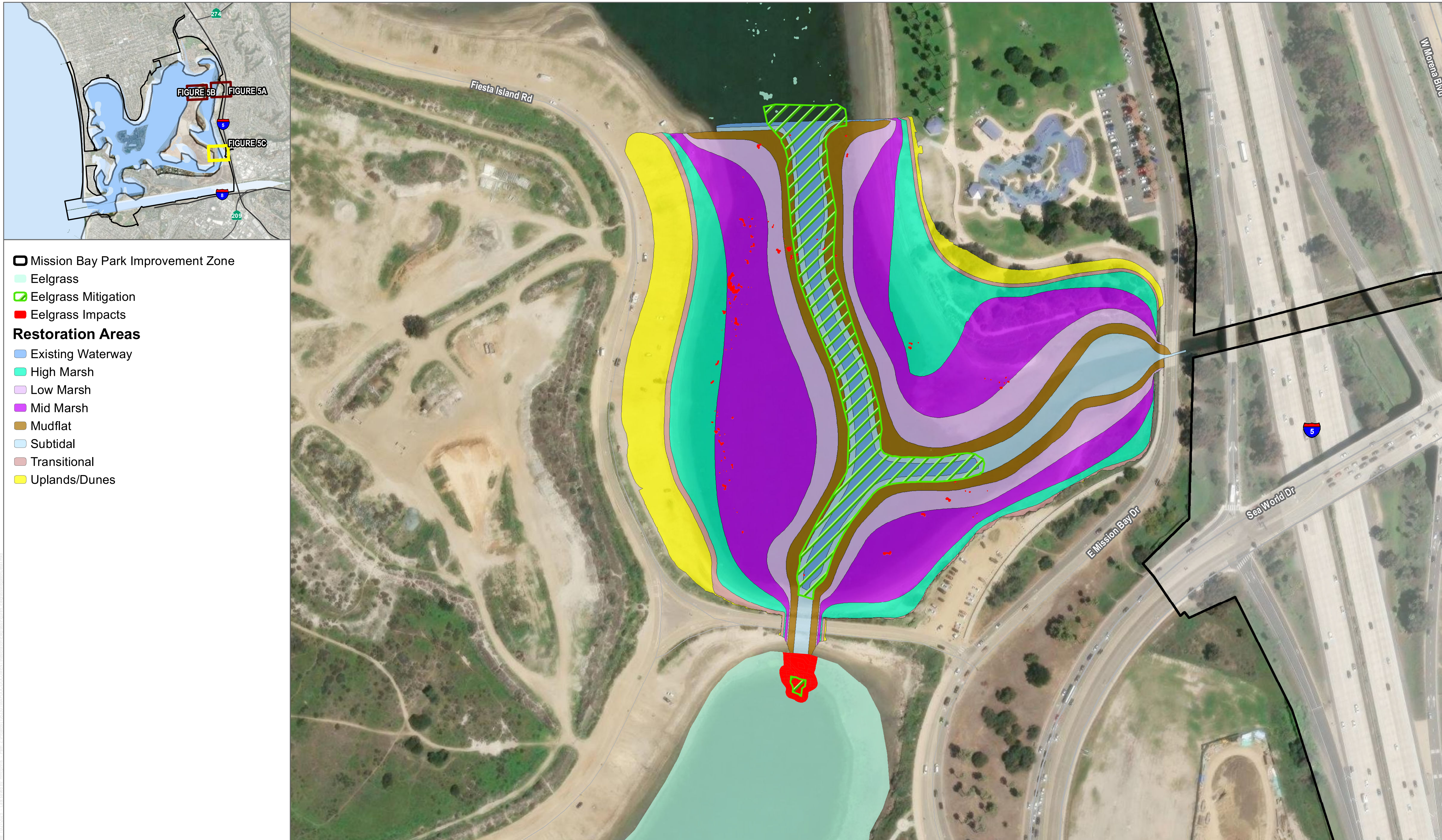


SOURCE: SANGIS 2023

**DUDEK**

0 100 200 Feet

**FIGURE 5C**

Eelgrass Mitigation Detail Series

Mission Bay Park Water Quality Improvements Eelgrass Mitigation and Monitoring and Oyster Habitat Restoration Plan

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# APPENDIX A

## *Oyster Restoration Guide for the Mission Bay Park Improvements Program*

# Appendix A
# Oyster Restoration Guide
# Mission Bay Park Improvements Program

## OYSTER RESTORATION

The Program description outlines opportunities for improvement of native Olympia oyster habitat at suitable locations of Program components. While oyster habitat improvement and restoration would not be compensatory in nature, it would contribute to the broader ecological goals of the Program and ideally support the eelgrass mitigation effort in the long-term by enhancing water quality and improving estuarine habitat quality.

### ECOLOGIAL BACKGROUND ON OYSTERS

On the West Coast of the United States, the Olympia oyster (*Ostrea lurida*) is the only native oyster species (Baker 1995). Found from Alaska to Baja California, it primarily inhabits estuarine bays in low intertidal to shallow subtidal zones. However, rapid coastal development has caused widespread declines in estuarine habitat and Olympia oyster populations.

To support aquaculture, Pacific oysters (*Crassostrea gigas*), originally from Japan, were introduced to the West Coast. This species grows faster and larger than *O. lurida* and quickly became the dominant oyster in commercial production (Conte 1996; Shatkin et al. 1997). Feral populations have since established throughout much of the Olympia oyster's range, with partial overlap in tidal habitat use (Tronske et al. 2018).

Oysters are considered foundation species because they significantly alter their environment in ways that support broader ecological communities (Dayton 1972). Their reef structures create habitat complexity that benefits a variety of species, from invertebrates to fish and birds, helping to restore entire food webs. Oyster reefs also slow wave energy, which reduces shoreline erosion, promotes sediment deposition, and improves coastal stability (Meyer et al. 1997).

Through filter feeding, oysters also contribute to water quality improvement. As water is pumped across their gills, they remove particulate matter such as phytoplankton, detritus, and suspended sediments (Elsey 1935). This filtering process improves water clarity and can reduce the frequency and intensity of harmful algal blooms by lowering excess nutrient levels (Newell and Koch 2004; Piehler and Smyth 2011). Filtered materials are deposited as feces or pseudofeces, which can help sequester pollutants and potentially benefit nearby estuarine vegetation (Everett et al. 1995; Kellogg et al. 2013). Emerging research in Southern California has also begun to show Olympia oyster-mediated benefits for eelgrass growth (Emery, pers. comm. 2021).

### Habitat Requirements and Limitations

Olympia oysters thrive in specific estuarine conditions that support their survival and growth. Native Olympia oysters occupy a lower tidal range than non-native Pacific oysters with a small region of overlap (Tronske et al. 2018). Native oyster restoration must take place within a tidal elevation range of 0 to 1 foot above mean lower low water (MLLW). This range encompasses the area of maximum Olympia oyster colonization while avoiding the small zone of overlapping non-native oyster occupation.

Ideal habitat features include relatively stable salinity levels, with fewer than 9% of days annually dropping below 25 PSU and minimal exposure to freshwater events (less than 15% of years with significant low-salinity episodes). Oxygen levels should remain close to saturation, with average deviations below 2.6 mg/L, and sediment conditions should not inhibit settlement, although no strict sediment depth threshold is defined. Predation pressure should be low, with fewer than one non-native oyster drill per square meter. Optimal water temperatures exceed 16°C during the warm season, while air temperatures above 30°C should be rare (less than 2% of days). Sufficient food availability, indicated by chlorophyll a concentrations above 16 µg/L during warmer months, is also important. These environmental criteria, compiled by Wasson et al. (2014), help guide the selection of suitable restoration sites for this native species.

## EELGRASS AND OYSTER INTEGRATION

Integration of eelgrass and oyster beds within Mission Bay is feasible and desirable. Each species has geographically and ecologically distinct habitat requirements that reduce overlap and intraspecific competition for space and resources. For example, within Mission Bay, eelgrass is most abundant at subsurface elevations of 1 to 8 feet below MLLW while Olympia Oysters naturally occur within a tight elevation range of +0 to 1 foot above MLLW. Each species has different substrate requirements; eelgrass requires a fine silty-sand substrate while oysters require a hardened substrate such as rock or concrete. The resources that each species draw upon for subsistence is also distinct. Eelgrass requires sunlight and nutrients that are found in the benthic substrate and dissolved in the bay water while oysters are filter feeders.

There are many benefits from the co-occurrence of these species. Each species provides habitat and forage for mutually beneficial species. Fish that spawn and rear within eelgrass may also find invertebrates to forage on within oyster beds. Eelgrass beds support algal growth and other organisms that become suspended in bay water and filtered by oysters. Incorporating both habitat types in a manner that creates a matrix of benthic habitat communities that are self-supporting and increase the bay food web that ultimately supports higher trophic levels occupied by fish and coastal avian species such as California least tern.

When implemented in tandem, eelgrass and oyster restoration efforts are expected to generate synergistic benefits. Placement of oysters would occur between 0-1 feet MLLW or approx. -2.5 to - 1.5 feet MSL/NGVD 29 (as referenced in current engineering plans). Eelgrass planting would occur between approximately -1 to -8 feet MLLW (or approx. -3.5 to -10.5 feet MSL/NGVD29 as referenced in current engineering plans). There would be one foot of separation between these two restoration components to ensure adequate establishment of each species within its preferred niche.

The co-location of these foundational species may amplify ecosystem services through complementary habitat functions, such as improved water quality, water clarity, sediment stabilization, and increased resilience to climate-related stressors. Together, these efforts would contribute to the long-term ecological enhancement of Mission Bay, supporting City goals and providing lasting habitat benefits for native species.

## EXISTING OYSTER POPULATIONS IN MISSION BAY

Bay-wide conditions are considered generally suitable for Olympia oysters based on a recent Dudek feasibility study (Dudek 2022) and the fact that Mission Bay is set in the same region as San Diego Bay, which has high numbers of native Olympia oysters (up to 216/$m^2$) (Tronske et al. 2018). However, a much greater level of confidence would be gained with up-to-date and continuously monitored salinity, chlorophyll *a*, dissolved oxygen, temperature, adult oyster density, and larval recruitment data.

Existing oyster populations in Mission Bay exhibit clear spatial and elevation-based distinctions tied closely to substrate availability and tidal elevation. Observations during a low-tide site visit in 2021 (Dudek 2022) indicate that non-native oyster species are currently more widespread in the bay than the native Olympia oyster. These non-native oysters are predominantly found attached to rip-rap and vertical hardscape structures such as seawalls, which are situated higher in the intertidal zone. This positioning aligns with the preferred tidal elevation range of these species, allowing them to successfully colonize and persist on available artificial substrates throughout much of Mission Bay.

In contrast, native Olympia oysters were observed at lower tidal elevations, where hard substrate is significantly less common. During the same survey, Olympia oysters were only found on isolated, displaced rocks embedded in the mud—likely remnants of past structures or shoreline modifications. These low-lying substrates fall within the species' optimal settlement zone, but the scarcity of these resources limit the spatial extent of native oyster colonization. Without sufficient stable substrate at appropriate elevations, Olympia oysters are largely excluded from much of the bay's intertidal zone.

Historically, distribution of Olympia oysters within Mission Bay has not been extensively documented or well-studied. However, a recent study found that native Olympia oysters of varying size classes were present at three sites within Mission Bay, including Kendall Frost marsh, where cover of Olympia oysters was estimated at around 5% and co-occurrence with non-native oysters was noted (Polson and Zacherl 2009). For native Olympia oysters to be considered established and sustainable within Mission Bay, populations should exhibit a large number of adults, high densities on hard substrates (typically 50 to over 200 individuals per square meter), consistent juvenile recruitment, a broad range of size classes, and high survival rates (Wasson et al. 2014). Sustainable populations in Mission Bay would also be well-distributed throughout suitable hard substrate.

**Oyster Feasibility Study**

An oyster restoration feasibility study conducted by Dudek in 2022 evaluated the potential for Olympia oyster restoration across Mission Bay, both at a general bay-wide scale and in relation to planned habitat and shoreline projects (Dudek 2022). The study included a literature review and interviews with experienced restoration practitioners to identify key environmental conditions necessary for Olympia oyster growth and survival. The most critical factors include the placement of hard substrate at or below 0.7 feet MLLW (Tronske et al. 2018), consistent larval recruitment, salinity levels above 25 PSU (Practical Salinity Units), low risk of major freshwater inputs, and low sedimentation risk. The study outlined various restoration techniques, discussing the benefits and constraints of each.

Due to limited quantitative data on specific environmental requirements for Olympia oysters, many factors were assessed qualitatively. An informal visual inspection at multiple locations around the bay observed small adult Olympia oyster populations along the lower edges of riprap, aligning with the upper limit of their preferred tidal range. Based on these findings and qualitative assessments, the study concluded with a medium level of confidence that placing hard substrate within the appropriate elevation range would likely support successful recruitment and restoration of Olympia oysters in Mission Bay.

To improve confidence in this determination, the study recommended additional monitoring, including the deployment of an environmental quality monitoring device to verify site suitability. This device was deployed in December 2021, with monitoring continuing through August 2022. Data collected between December 2021 and May 2022 indicated that salinity, frequency and intensity of freshwater events, dissolved oxygen levels, and air temperature were all within suitable ranges for Olympia oyster restoration.

## OYSTER RESTORATION APPROACHES AND AREAS/COMPONENTS

### Restoration Approaches

The three main restoration approaches outlined in this Plan include the use of shell bags, reef balls, and riprap extension. Shell bags are mesh bags filled with cleaned oyster shells that provide a natural, low-relief substrate for oyster larvae to settle and grow. They are well-suited to integration with marsh restoration projects and pose minimal navigational risk, although they may degrade over time if larval recruitment is insufficient. Reef balls are dome-shaped concrete structures designed to mimic natural reef habitat, offering higher durability and better resistance to wave energy. However, their greater size and visibility require careful placement to avoid conflicts with boating activity. Riprap extension involves the strategic placement of additional rock along the shoreline to create stable, hard substrate at appropriate tidal elevations for oyster settlement. This approach builds on existing armoring and can provide both habitat and erosion control benefits when designed with oyster restoration in mind.

The selection of oyster restoration methods for each Program was guided by site-specific conditions and project goals (Dudek 2022). To determine the appropriate restoration method for each site, planned habitat and shoreline restoration areas were evaluated based on the following criteria:

- Restoration objectives (e.g., full wetland restoration vs. shoreline stabilization or enhancement)
- Exposure to wave energy and erosion
- Proximity to public beaches and potential for human disturbance
- Desired ecosystem services (e.g., water quality improvement, shoreline protection)
- Suitability of environmental conditions (e.g., tidal elevation, sedimentation risk)

In general, shell bags are prioritized in areas supporting complete wetland habitat restoration, where they can enhance the natural subtidal-to-upland transition and provide storm protection. They are recommended along channels, running perpendicular to the shoreline, in regions that are sheltered from high levels of boat wake energy, wave energy, and strong currents. They are most beneficial in back-bay regions where water quality issues are a primary concern. They are also typically recommended in regions where a natural oyster reef is ultimately desired, such as wetland restoration sites, where oyster habitat would align with the overall sea-to-upland continuum.

Reef balls are favored in high-energy areas where shell bags may become dislodged or degrade too quickly. Reef balls are armored due to their concrete construction and can handle higher wake/wave energy and stronger currents. Reef balls may be deployed in areas that are not suitable for shell bags (sandy beaches, high energy areas) but must be placed close enough to the shore that passing boats avoid collision.

Riprap extension is preferred in areas with existing riprap at shoreline restoration areas where existing native oyster populations would be able to colonize and expand onto new hard substrates offered by placement of new large angular rocks.

Site-specific factors may warrant adjustments to these general recommendations. A summary of evaluation criteria and recommended restoration approaches by site is provided for each Program component below.

An overview of Program components with potential oyster restoration and habitat enhancement opportunities is presented in Figure A. Figure B presents a detailed figure series showing oyster restoration implementation concepts at each applicable Program component. The restoration approach for each component, is outlined below and visually summarized in Table 4.

**Table 4**
**Oyster Restoration Approaches for Program Components**

| Program Component | Oyster Restoration Approach |
|---|---|
| Tecolote Creek | Shell Bags |
| Cudahy Creek | Shell Bags (Channels)<br>Reef Balls (Outer Berm Slope) |
| North Fiesta Island | Shell Bags (Tidal Exchange Channel) |
| SW Vacation Island | Riprap Extension |
| Ventura Cove | Riprap Extension |

### Tecolote Creek

The proposed Tecolote Creek wetlands restoration project is located south of Enchanted Island where Tecolote Creek enters Mission Bay (Figure B). This area of open water is presently used by personal watercraft recreators. Similar recreational activities occur on the south side of the Fiesta Island Road causeway. Under the current design of the proposed Tecolote Creek wetlands restoration project, approximately 12 acres of the bay would be filled to create land elevations that are consistent with low-, mid-, and upper tidal salt marsh habitat. The restored marsh would have a main subtidal channel that connects Tecolote Creek channel to the bay. In addition, a new subtidal channel under the Fiesta Island Road causeway would provide enhanced tidal exchange from the south Pacific Passage to the east side of Fiesta Island.

Sedimentation from Tecolote Creek discharges may occur over time within the restored subtidal channels. However, the upper channel side slopes, where suitable conditions for Olympia oyster habitat restoration are located, are less likely to experience sediment accumulations. Water quality is likely to improve over existing conditions with increased circulation provided by the new causeway tidal conduit. Water salinity may decrease during storm events due to the restored main tidal channel conveyance of freshwater discharge from Tecolote Creek. However, periods of lower salinity are expected to be transitory due to the increased tidal exchange from the open bay water north and south of the wetland, relatively small size of the Tecolote Creek watershed, and arid climate of San Diego.

Suitable oyster habitat could be created along the upper banks of the restored subtidal channels (Figure B). Localized oyster habitat may also be possible at the confluence of the restored tidal channels where mudflat is expected to form. Other opportunities for oyster restoration are located at the northern edge of the restored wetlands that would interface with the bay open water. Oyster shell bags are likely the most suitable restoration method to create oyster habitat along the restored subtidal channels because of low creek flow velocity and the lack of wind waves and absence of boat wakes. Tecolote Creek restoration plans include a fully functioning salt marsh. Oyster habitat placement within subtidal channels would prevent damage by human activity. Water quality concerns that are most evident at the back of the bay and storm surge protection would be best addressed with natural oyster habitat. Constraints at the Tecolote Creek habitat restoration site include the risk of sedimentation that may be mitigated through oyster bed placement (higher elevation placement and inclusion of intermediate drainage channels between shell bags). The potential for harmful freshwater events would be determined by future data collection. It is possible that low salinity within the Tecolote Creek subtidal channel may preclude oyster placement in this area, but subtidal channels closer proximity to bay water would likely remain suitable for Olympia oysters.

**Cudahy Creek**

Cudahy Creek is located north of Leisure Lagoon on the eastern shore of the Southeast Passage (Figure B). The proposed water quality improvement project at Cudahy Creek includes the creation of a tidal basin through the import of fill to create an outer berm that impounds stormwater discharges from two existing stormwater outfalls. Land created behind the berm would allow for restoration of salt marsh at appropriate elevations relative to the tidal prism resulting in suitable conditions that support tidal salt marsh habitat. Two sub-tidal channels would connect the stormwater outfalls to a low point in the berm where stormwater would exit into Mission Bay open waters after a brief resident time within the basin. Normal tidal fluctuation of water levels would prevail in the absence of stormwater flows.

The potential for sediment accumulation is greatest within the restored subtidal channels. Normal tidal flows in and out of the basin are expected to create periods of tidal inundation that would support salt marsh habitat and would be suitable for oysters at appropriate tidal elevations. Within the project area, oyster establishment appears to be best suited along the upper slope of the basin tidal channels and along the outer berm that interfaces with open water. Tidal channels would supply oyster habitat with low velocity tidal flow and tidal exchange that would make available appropriate oyster forage resources that are suspended within the tidal water. Sedimentation may occur periodically within the basin; however, the urbanized sub-watershed is not expected to develop substantial sediment supply and transport. Tidal and stormwater flow should be sufficient to wash sediment off hard substrates. Water salinity would be regulated by daily tidal exchange, with temporary periods of reduced salinity expected to be ephemeral following stormwater events. These periods of lower salinity within the basin last no more than 72 hours after rain events of 1-inch or more. More prolonged salinity reduction may occur during a series of rain events when multiple back-to-back storms sweep through the region. This wet season scenario is infrequent in San Diego County, and the period of reduced water salinity is expected to remain within the tolerance range of Olympia oysters.

Figure B depicts the areas that are most likely to support sustainable oyster populations. Appropriate substrates are required for oyster establishment. Reef balls or an equivalent hard substrate is recommended within the outer berm slope of the Cudahy Creek restoration site. Shell bags are recommended on interior subtidal channels within the wetland restoration. Reef balls are recommended along the outer berm because the high relief and structural resilience of these features can better-withstand physical conditions at the interface with open water. The outer berm site location would be subject to wind wave energy depending upon the direction of prevailing winds and the degree of fetch. Reef balls would retain the berm fill material and protect the fill from wind wave erosion. Constraints at this site include increased restoration costs associated with reef ball deployment and the inability of reef balls to migrate upshore with sea level rise.

**North Fiesta Island**

The wetland restoration project on the eastern side of North Fiesta Island would involve the excavation of several subtidal channels across Fiesta Island along with a main tidal exchange channel to permit water passage between open bay water west and east of the island (Figure B). The interior area of the habitat restoration site along the eastern side of the island would be graded to elevations that would support low-, mid- and upper saltmarsh habitats that are supported by subtidal channels. Hydrology within the site would be entirely tidal in nature with no stormwater influences. Therefore, water quality conditions are expected to be similar to open bay water. Sedimentation is expected to be minor and localized based on deposition of bottom sediments that are transported by tidal currents. Deposition sites are expected to establish after project construction.

Locations for potential oyster habitat establishment within the North Fiesta Island project area include the tidal exchange channel that links the open waters to the west and east of Fiesta Island. No motorized boats or intense waves are expected within the tidal exchange channel. Therefore, the area would provide calm water conditions for oyster habitat suitable for oyster shell bags (Figure B). The channel is an integral part of a complete wetland habitat, so natural oyster habitat would align well with the subtidal-to-upland continuum. Oyster habitat placed in this channel would provide added filtration services for water passing through the channel between Fiesta Bay and the North Pacific Passage.

**Vacation Island Southwest**

The southwest tip of Vacation Island is heavily eroded due to exposure to a combination of water currents and wind waves. Repair of the shoreline involves building back the original shoreline and adding a partially buried rock revetment. The revetment is designed with a top elevation that would accommodate sea level rise. Areas of the revetment at or below 0-1 feet MLLW would be suitable for oyster habitat (Tronske et al. 2018; Figure B). The design of the rock revetment should consider interlocking revetment rock to provide a rock surface that is as continuous and unbroken as possible to allow oyster recruitment and colony establishment. The continuous vertical rock surface would provide oyster recruitment opportunities under sea level rise conditions.

Additional oyster restoration options are feasible at Vacation Island. Relative suitability and selection of the best restoration method would depend on ultimate restoration goals at this site. Shell bag placement should generally be prioritized at locations where restoration of natural wetlands is planned because they are most suitable when part of a natural habitat continuum. Wetland restoration is not planned at this location, but site conditions may allow shell bags to persist. This area is near passing boats but is within a low-speed zone. Therefore, risk of premature reef breakdown is lower than in other areas with nearby boat traffic. Additionally, this region of the island is at a sufficient distance from public beaches to avoid injuries to people as a result of shell spreading. The large amount of riprap upshore of the restoration area would allow oyster populations to migrate upshore with projected increasing sea level. Reef balls may also be considered at this site if additional armoring is desired, but this benefit must be weighed against the risk they carry as a potential hazard for passing boats. Ultimately, if there is no outstanding desire for a natural oyster reef habitat or additional armoring, the rock revetment described above would provide sufficient hard substrate for oyster colonization.

**Ventura Cove**

Shoreline erosion at Ventura Cove is similar to conditions at Vacation Island. A section of rock revetment is planned for repairs. In addition, the shallow slope of the bay bottom may provide for horizontal oyster habitat establishment at the foot of the revetment (Figure B). Armoring the bay bottom in this area would protect the toe of the revetment. Tidal currents in this area would scour sediment and maintain the area free of sediment accumulations. The resulting water quality would be advantageous for oyster recruitment and survival.

Shell bags may also be deployed here, if desired, due to the sufficient distance from high energy boat wakes and proximity to riprap that can be colonized as sea level rises. In addition, a footpath is proposed to increase public access/recreation so a natural oyster reef may provide aesthetic and educational benefits for the public. However, the location the oyster habitat is proposed at is very close to a public beach. Post-restoration shell migration may create a safety hazard for members of the public walking barefoot on the beach, and easy public access to the reef may result in increased trampling and organism collection. If the restoration area cannot be shielded from public access reef balls may be placed as an alternative, so long as they do not create a hazard for passing boats. Due to the risks described, restoration via shell bags or reef balls should not be prioritized at this site. As planned, the toe of the rock revetment would be extended to the appropriate lower tidal elevation (0-1 feet MLLW or lower) and would provide sufficient hard substrate for oyster colonization.

## OYSTER RESTORATION IMPLEMENTATION PLAN

### Implementation Personnel

The oyster restoration implementation should be completed by an experience habitat restoration contractor with experience in marine habitat restoration in Southern California.

### Timing and Substrate Preparation

Oyster restoration activities may be initiated following the installation of applicable Program components, once the underlying substrate within designated restoration areas has been compacted and stabilized to adequately support restoration materials. Placement of shell bags or reef balls would proceed only after site preparation confirms substrate readiness, ensuring long-term structural integrity and optimal conditions for oyster recruitment. In locations where riprap extension is employed, oyster colonization is expected to occur through natural recruitment processes following completion of construction, provided that tidal elevations and environmental conditions remain within suitable ranges for Olympia oyster settlement and growth.

Prior to the start of any oyster restoration work in Mission Bay, the City should conduct a pre-activity survey for sensitive biological resources on or near the shorelines of applicable Program components.

### Shell Bag Implementation

Before construction of shell bag units begins it is important to ensure there is available outdoor storage space for large amounts of Pacific oyster shell. Shell must be sun-cured for a minimum of 3 months to remove any potential pathogens or “hitchhiking” organisms. Movement of shell into bags also produces a large amount of suspended dust, so bagging is best completed outside.

Coconut coir is the preferred material for shell bags due to its natural origin, full biodegradability, and strong public acceptance. Biodegradable plastic/cellulose mesh bags may offer a more cost-effective alternative in some cases, but they typically degrade more slowly and may be viewed less favorably by the public. Coconut coir used for shell bags arrives in large sheets and must be hand-woven into individual mesh bag units. Each bag is then filled with cured shell and sewn shut prior to bed construction. Bags should be of appropriate size to be carried by one person.

Construction of beds should occur during a low King tide series, ideally during the day (late Fall–early Spring). One day before construction, several individuals should mark the end points of each bed unit by flagging the shore at the waterline when the tide falls to the correct level. Sections of PVC are then driven into the flagged locations so that they may be found on the day of construction. The following day, pre-constructed shell bags are transported to the site and technicians/volunteers form a line and pass each shell bag unit down in a "chain gang" style. Individuals at the end of the line place shell bag units along the length of the planned bed area, anchoring units with stakes as needed. Approximate height measurements are taken at multiple points along the bed upon completion to ensure the appropriate starting height is achieved.

Shell bags would be deployed in double rows parallel to the shoreline within the optimal tidal range for Olympia oysters, ensuring the top of each structure remains at or below the ideal Olympia oyster zone (between 0-1 feet MLLW or approx. -2.5 to -1.5 ft MSL/NGVD29 as referenced in current engineering plans). Elevation verification should be performed via RTK-GPS to ensure compliance with tidal datum constraints. Bags would be anchored using J-stakes and positioned near the lower edge of the suitable range to reduce desiccation risk.

Drainage channels between bags should be occasionally incorporated into the placement design to prevent sediment accumulation. A minimum starting relief of 12 centimeters is required to avoid premature bed degradation, particularly in high-sedimentation areas like Tecolote Creek, where greater relief and drainage are especially important.

Deployment extent would vary by funding and site conditions, with preference given to areas closer to open water to enhance larval recruitment and reduce freshwater stress. Design and placement follow best practices for Olympia oyster restoration in Southern California, emphasizing appropriate tidal elevation and structural stability.

**Reef Ball Implementation**

Reef balls would be deployed in one or more rows along the shoreline within the suitable tidal elevation range for Olympia oysters. Placement would occur between 0-1 feet MLLW or approx. -2.5 to -1.5 feet MSL/NGVD 29 (as referenced in current engineering plans), ensuring structures remain below the upper boundary of the optimal intertidal zone for Olympia oyster recruitment and survival.

The ideal reef ball model—Bay Ball by Reef Innovations—is designed for shallow water applications and has a footprint of approximately 1 square meter per unit. These units are made of pH-neutral marine-grade concrete and feature multiple openings that enhance water circulation and larval access while providing stable, three-dimensional substrate for oyster attachment and growth.

Reef balls are particularly well-suited to sites with moderate wave energy or boat wake, offering durable and long-lasting substrate that resists scour. To maximize effectiveness:

- Reef balls would be spaced with sufficient interstitial distance to promote water flow.
- Placement would avoid elevation zones above oyster habitat tolerance, where desiccation risk or competition with macroalgae or invasive species may be higher.
- Deployment would prioritize areas with lower freshwater influence and proximity to open water to optimize larval supply and water quality.

Because reef balls provide durable but low surface area per unit cost, their use is substantially more expensive than shell bags for achieving the same initial footprint. However, they may be favored in locations where longer-term structural stability, minimal maintenance, and habitat complexity are priorities. Integration of reef balls with other substrates (e.g., shell bags) may be considered for hybrid approaches, balancing cost-efficiency and resilience.

All installations would be conducted in accordance with Olympia oyster restoration best practices, including elevation verification via RTK-GPS, compliance with tidal datum constraints, and design strategies that minimize ecological disturbance and facilitate monitoring access.

**Riprap Extension**

Repair of the shoreline components involves building back the original shoreline and adding a partially buried rock revetment (composed of riprap). The revetment is designed with a top elevation that would accommodate sea level rise. Areas of the revetment at or below 0-1 feet MLLW would be suitable for oyster habitat. The design of the rock revetment should consider interlocking revetment rock to provide a rock surface that is as continuous and unbroken as possible to allow oyster recruitment and colony establishment. The continuous vertical rock surface would provide oyster recruitment opportunities naturally.

No additional oyster restoration is required at these locations, but implementation of shell bags or reef balls may be considered if oyster recruitment on the new revetment substrate is low.

## POST-RESTORATION MONITORING

A post-restoration monitoring program should be designed to support Olympia oyster reef restoration in Mission Bay as part of the Program's broader effort to improve water quality, enhance native biodiversity, and increase habitat complexity. Because the restoration is not compensatory mitigation for environmental impacts, there are no formal success criteria. Instead, the monitoring effort would focus on tracking restoration progress, informing adaptive management if needed, and contributing to the growing knowledge base for Olympia oyster restoration in Southern California.

**Monitoring Timeline**

Monitoring would occur over a five-year period, with more frequent observations during the first year when the reefs are most susceptible to early-stage stressors such as sedimentation or displacement. Baseline data would be collected prior to reef construction to characterize existing site conditions, including reef area, elevation, and environmental parameters such as salinity and temperature. In the first year following restoration, monitoring would be conducted at one, three, six, and twelve months to assess initial performance and survivorship. Annual monitoring would then continue from years two through five.

**Physical Reef Characteristics**

Physical reef characteristics would be measured to evaluate the persistence and spatial extent of the restored structures. The total footprint of each reef and the extent of oyster-colonized areas would be recorded using GPS or drone-based surveys. Reef height would be measured manually at fixed locations to track vertical structure over time and detect potential flattening or burial.

**Biological Performance**

Biological performance would be assessed by measuring live oyster density within representative plots. These surveys would also capture oyster size distributions, which would provide insight into recruitment patterns and population age structure. During these sampling efforts, other filter-feeding species would also be identified and counted to assess community composition and overall habitat biodiversity.

**Environmental Conditions**

Water quality parameters, including salinity, temperature, and dissolved oxygen, would be continuously monitored using deployed sensors. This would help capture both seasonal variation and short-term events that may influence oyster performance. Sediment accumulation would also be measured, both adjacent to and directly on the reefs, to detect potential burial and track site-level sediment dynamics.

**Additional Observations**

Visual surveys during site visits would document any sediment accumulation on reef surfaces. Sediment probes or other simple tools may be used to track buildup that could inhibit oyster settlement. Practitioners would also look for evidence of predation, such as the presence of oyster drills or bored shells, and signs of disease, although these threats are currently considered low for Olympia oysters in San Diego.

**Adaptive Management Triggers**

Although no regulatory thresholds apply, several indicators may prompt management intervention. These include extensive burial or loss of reef structure, a noticeable decline in oyster density, or a lack of new recruitment over multiple years. If needed, adaptive measures may include adding shell to increase reef elevation, modifying reef placement to reduce sedimentation, or adjusting site strategies to improve habitat performance.

## REFERENCES

Conte, F. S. 1996. California oyster culture. University of California, Davis, Department of Animal Science.

Dayton, P. K. 1972. Toward an Understanding of Community Resilience and the Potential Effects of Enrichments to the Benthos at McMurdo Sound, Antarctica. Scripps Institution of Oceanography, La Jolla California.

Dudek. 2022. Mission Bay Supplemental Environmental Project Oyster Establishment Feasibility Study.

Emery, M. 2021. In-person communication between M. Emery (M.S. student, California State University, Fullerton) and V. Goodwin (Dudek).

Everett, R., G. Ruiz, and J. Carlton. 1995. Effect of oyster mariculture on submerged aquatic vegetation: an experimental test in a Pacific Northwest estuary. Marine Ecology Progress Series 125:205–217.

Kellogg, M., J. Cornwell, M. Owens, and K. Paynter. 2013. Denitrification and nutrient assimilation on a restored oyster reef. Marine Ecology Progress Series 480:1–19.

Meyer, D. L., E. C. Townsend, and G. W. Thayer. 1997. Stabilization and Erosion Control Value of Oyster Cultch for Intertidal Marsh. Restoration Ecology 5:93–99.

Newell, R. I. E., and E. W. Koch. 2004. Modeling seagrass density and distribution in response to changes in turbidity stemming from bivalve filtration and seagrass sediment stabilization. Estuaries 27:793–806.

Piehler, M. F., and A. R. Smyth. 2011. Habitat-specific distinctions in estuarine denitrification affect both ecosystem function and services. Ecosphere 2:art12.

Shatkin, G., S. Shumway, and R. Hawes. 1997. Considerations regarding the possible introduction of the Pacific oyster, Crassostrea gigas, to the Gulf of Maine: a review of global experience. Journal of Shellfish Research 16:463–478.

Tronske, N.B., T.A. Parker, H.D. Henderson, J.L. Burnaford, and D.C. Zacherl 2018. "Densities and Zonation Patterns of Native and Non-Indigenous Oysters in Southern California Bays." *Wetlands* 38:1313–1326. https://doi.org/10.1007/s13157-018-1055-0

Wasson, K., Zabin, C., Bible, J., Ceballos, E., Chang, A., Cheng, B., Deck, A., Grosholz, T., Latta, M., & Ferner, M. 2014. *A guide to Olympia oyster restoration and conservation: Environmental conditions and sites that support sustainable populations in central California.* San Francisco Bay National Estuarine Research Reserve. http://www.oyster-restoration.org/wp-content/uploads/2014/10/Olympia-Oyster-Full-Report-10_7_2014.pdf


SOURCE: SANGIS 2023

DUDEK

0 900 1,800 Feet

**FIGURE A**

Oyster Restoration Overview

Mission Bay Park Water Quality Improvements Eelgrass Mitigation and Monitoring and Oyster Habitat Restoration Plan

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SOURCE: SANGIS 2023

DUDEK

0 75 150 Feet

**FIGURE** B1

Oyster Restoration Detail Series

Mission Bay Park Water Quality Improvements Eelgrass Mitigation and Monitoring and Oyster Habitat Restoration Plan

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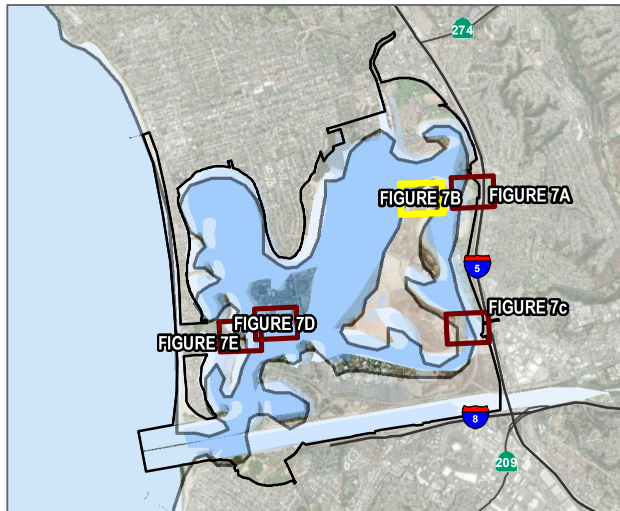



Mission Bay Park Improvement Zone
Shell Bags (2,434 Linear Ft.)

**Restoration Areas**

- Berm
- High Marsh
- Indirect 15-Foot Buffer
- Least Tern Preserve
- Low Marsh
- Mid Marsh
- Mudflat
- Subtidal
- Transitional
- Upland

SOURCE: SANGIS 2023

DUDEK

0 125 250 Feet

**FIGURE B2**

Oyster Restoration Detail Series

Mission Bay Park Water Quality Improvements Eelgrass Mitigation and Monitoring and Oyster Habitat Restoration Plan

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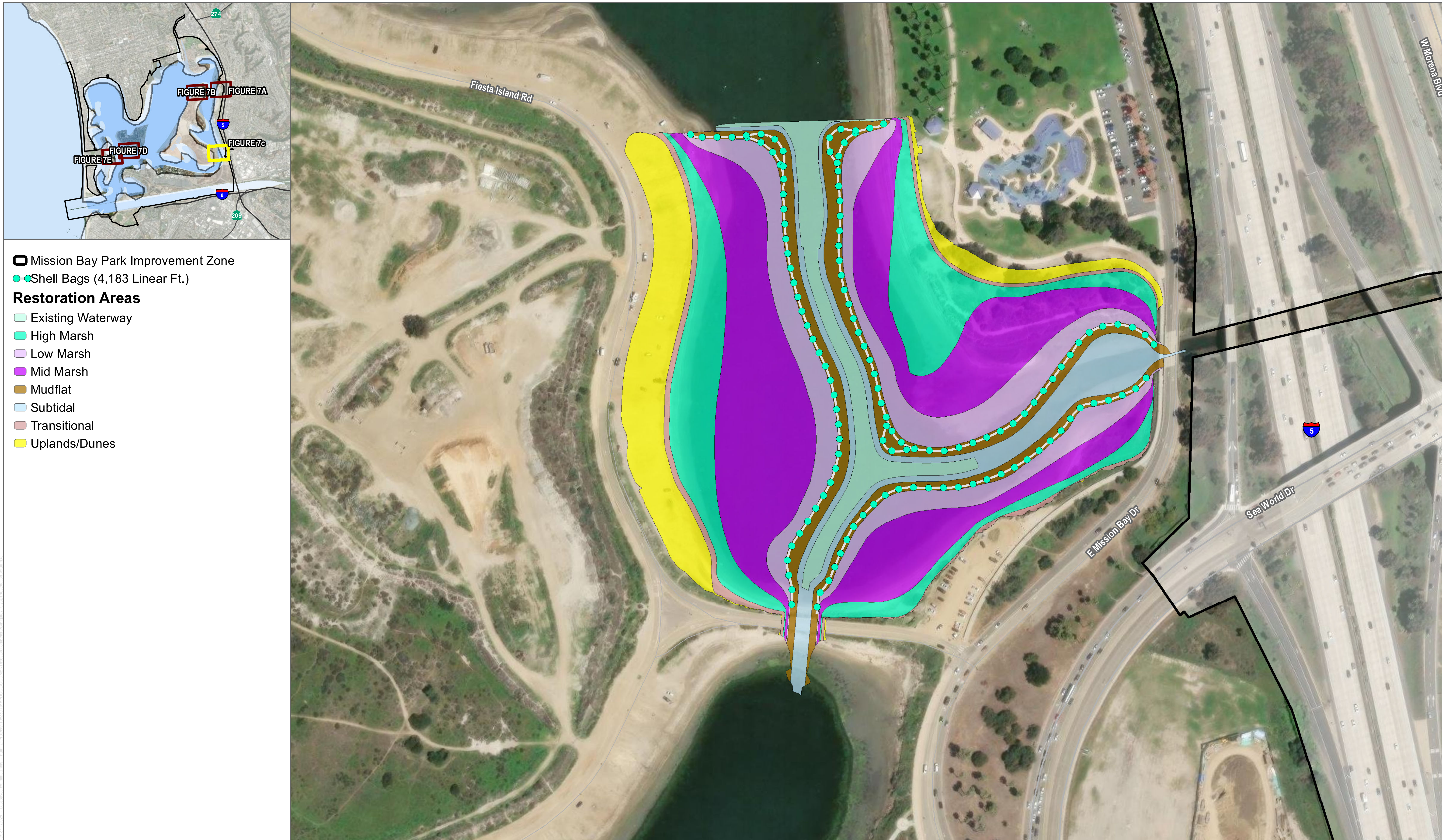


SOURCE: SANGIS 2023

DUDEK

0 100 200 Feet

**FIGURE B3**

Oyster Restoration Detail Series

Mission Bay Park Water Quality Improvements Eelgrass Mitigation and Monitoring and Oyster Habitat Restoration Plan

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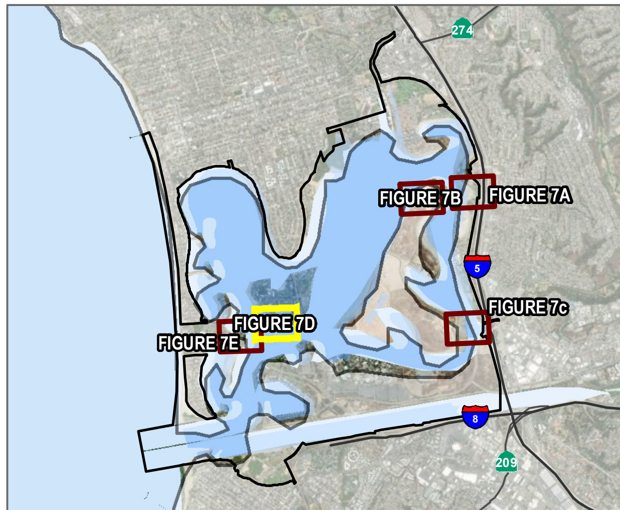


Mission Bay Park Improvement Zone
Riprap Extension (1,636 Line Ft.)

**Restoration Areas**

Buried Revetment Crest
Revetment Repaired/Raised to Accomodate Sea Level Rise
Oyster Habitat

SOURCE: SANGIS 2023

DUDEK

0 75 150 Feet

**FIGURE** B4

Oyster Restoration Detail Series

Mission Bay Park Water Quality Improvements Eelgrass Mitigation and Monitoring and Oyster Habitat Restoration Plan

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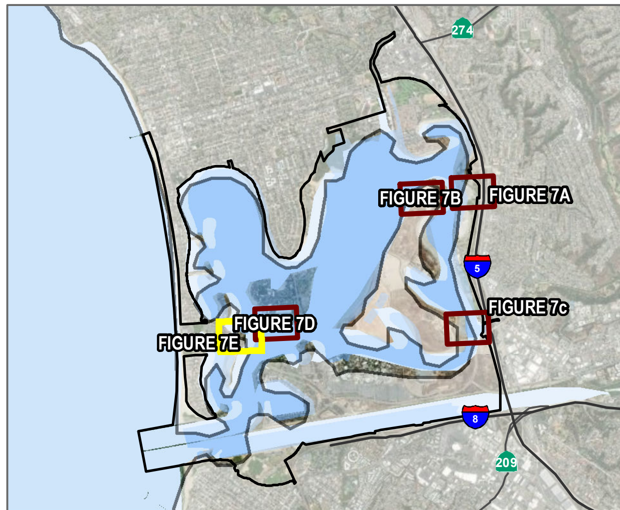


Mission Bay Park Improvement Zone
Riprap Extension (509 Line Ft.)

**Restoration Areas**

Revetment Repaired/Raised to Accomodate Sea Level Rise
Oyster Habitat


SOURCE: SANGIS 2023

DUDEK

0 75 150 Feet

**FIGURE** B5

Oyster Restoration Detail Series

Mission Bay Park Water Quality Improvements Eelgrass Mitigation and Monitoring and Oyster Habitat Restoration Plan

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