San Francisco Bay Strategic Shallow-Water Placement Pilot Project

Appendices

Albany Mudflats with Mount Tamalpais in the distance (Photo by Noah Berger, courtesy of MTC)

Corte Madera Marsh (Photo by Pete Kauhanen, SFEI)

US Army
Corps of Engineers
San Francisco District

Water Boards

Coastal
Conservancy

23 September 2022

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Appendix A – ENVIRONMENTAL COMPLIANCE

1. SUMMARY OF COMPLIANCE WITH APPLICABLE LAWS AND REGULATIONS

1 FEDERAL LAWS

CLEAN AIR ACT

Clean Air Act, 42 U.S.C. § 1857h-7, *et seq*. No general conformity analysis is needed because the action alternatives are below de minimus thresholds. The proposed action would not exceed national ambient air quality standards based on modeled estimates of emission rates during project implementation. Modeled estimates of emission rates during project implementation demonstrate that the proposed action would not exceed applicability rates (Appendix A(4)).

CLEAN WATER ACT

Clean Water Act, 33 U.S.C. § 1251, *et seq*. The proposed action would involve discharge of fill material into Waters of the U.S. in the lower South Bay. Although USACE does not issue permits for their own projects, USACE does comply with the guidelines and substantive requirements of Section 404, including Sections 404(b)(1) and 401. A Section 404(b)(1) analysis was conducted on the recommended plan (Appendix A(3)). The analysis concluded that the placement of approximately 100,000 CY would not result in impacts to waters of the U.S. or wetlands. Initial coordination with the RWQCB was conducted and the RWQCB has indicated its support for the project and acknowledges the future requirement to obtain a Section 401 water quality certification prior to initiation of the work. The dredging contractor would be required to implement the measures listed in the BMPs and to avoid and minimize adverse effects on water quality. The project would be in full compliance with the CWA when a Section 401 water quality certification is obtained prior to implementation.

COASTAL ZONE MANAGEMENT ACT

Coastal Zone Management Act, 16 U.S.C. § 1456, *et seq.* Under Section 307 of the CZMA, the San Francisco Bay Conservation and Development Commission (BCDC) (I.e., not the California Coastal Commission (CCC)), has jurisdiction over federal activities in San Francisco Bay to ensure they are “consistent to the maximum extent practicable” with the “enforceable policies” of BCDC’s NOAA-approved San Francisco Bay segment (I.e., the San Francisco Bay Plan) of the California coastal management program (CCMP; 15 CFR § 923, Subpart K; https://bcdc.ca.gov/bcdc-jurisdiction-authority.html). Consistency Determination has been prepared and will be submitted BCDC (Appendix A(5); see *California Coastal Act*, below). The project would be in full compliance with the CZMA after obtaining a Consistency Notification from BCDC prior to implementation.

ENDANGERED SPECIES ACT

Endangered Species Act of 1973, ; 16 U.S.C. § 1531, et seq. Based on the locations of the proposed work, the listed species that could be affected by the proposed action include the California Least Tern, Ridgway's rail, Western snowy plover, and Southern salt marsh harvest mouse under the jurisdiction of USFWS; and the southern DPS of North American green sturgeon Southern DPS, Central California Coast DPS of steelhead, and the critical habitats of these two species ,under the jurisdiction of NMFS. The USACE has determined that the project will not affect FESA-listed species under the jurisdiction of the USFWS, and determined that the project may affect, but is not likely to adversely affect the FESA-listed species and critical habitats under the jurisdiction of NMFS. The USACE will submit a request for concurrence with the not likely to adversely affect determination to NMFS (Appendix A(2)). The project would be in full compliance with FESA once USACE receives written confirmation of concurrence from NMFS prior to implementation.

FISH AND WILDLIFE COORDINATION ACT

Fish and Wildlife Coordination Act of 1958; 16 U.S.C. § 661, *et seq* The USFWS is the Federal agency responsible for administering this act, which requires Federal agencies to coordinate with USFWS and State wildlife agencies during the planning of projects that would result in the control or modification of a natural stream or body of water. The FWCA intends that wildlife conservation be given equal consideration with other features of these projects. USACE initiated coordination with USFWS early in the planning process, and USFWS will provide a Planning Aid Letter (Appendix A(6)) for full compliance in the final report.

MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

Magnuson-Stevens Fishery Conservation and Management Act of 1996; 16 U.S.C. § 1801, *et seq*. The Magnuson-Stevens Act establishes a management system for national marine and estuarine fishery resources. This legislation requires that all Federal agencies consult with NMFS regarding all actions or proposed actions permitted, funded, or undertaken that may adversely affect Essential Fish Habitat (EFH). Under the Magnuson-Stevens Act, effects on habitat managed under the Pacific Salmon Fishery Management Plan must also be considered. The USACE incorporated an EFH effects analysis into the NMFS FESA concurrence request and requested consultation under the Magnuson-Stevens Act, in parallel with the Section 7 ESA informal consultation (Appendix A(2)). The project would be in full compliance with the Magnuson-Stevens Act once NMFS provides EFH conservation recommendations and USACE responds with a description of proposed measures for avoiding, minimizing, mitigating, or otherwise offsetting the impact of the activity on EFH. Full compliance would be achieved prior to implementation.

MIGRATORY BIRD TREATY ACT

Migratory Bird Treaty Act of 1928, 16 U.S.C. § 715, et seq. USFWS is the Federal agency responsible for administering this act, which implements a treaty between the U.S. and Great Britain (for Canada), Mexico, Japan, and the Soviet Union (now Russia) for the protection of migratory birds. Unless permitted by regulations, this law prohibits anyone to "pursue, hunt, take, capture, kill, attempt to take, capture or kill … any migratory bird …or any part, nest, or egg of any such bird" (16 U.S.C. § 703). Areas in the study area have foraging, resting, nesting, and breeding habitat for numerous migratory birds. The project is not expected to affect any migratory bird species or habitats because dredge placement activities will occur 2 miles offshore and abundant alternative foraging habitat in San Francisco Bay is available, and project sedimentation rates in wetland resting, nesting, and breeding habitats will be so low they will be difficult to measure.

MARINE MAMMAL PROTECTION ACT

The Marine Mammal Protection Act (16 U.S.C. §§ 1361-1421h), adopted in 1972. The MMPA makes it unlawful to take or import any marine mammals and/or their products. Under Section 101(a)(5)(D) of this act, an incidental harassment permit may be issued for activities other than commercial fishing that may impact small numbers of marine mammals. An incidental harassment permit covers activities that extend for periods of not more than 1 year, and that will have a negligible impact on the impacted species. Amendments to this act in 1994 statutorily defined two levels of harassment. Level A harassment is defined as any act of pursuit, torment, or annoyance that has the potential to injure a marine mammal in the wild. Level B harassment is defined as harassment having potential to disturb marine mammals by causing disruption of behavioral patterns including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering. The project alternatives are not expected to result in impacts to marine mammals that would require an incidental harassment permit.

NATIONAL ENVIRONMENTAL POLICY ACT

National Environmental Policy Act of 1969; 42 U.S.C. § 4321, *et seq*. The Council on Environmental Quality (CEQ) is responsible for ensuring that Federal agencies operate in accordance with NEPA, which requires full disclosure of the environmental effects, alternatives, potential mitigation, and environmental compliance procedures of most Federal management, regulation, or funding activities that affect the environment. NEPA requires the preparation of an environmental document to ensure that Federal agencies accomplish the law's purposes. Although, final public review is not required under NEPA for an EA, the Final EA would undergo a state and agency review in compliance with USACE policy for the review of feasibility studies. The Finding of No Significant Impact (FONSI) would not be signed until after state and agency review. Full compliance with NEPA would be achieved when the FONSI is signed and the Final EA made available to commenting agencies and the public.

NATIONAL HISTORIC PRESERVATION ACT

National Historic Preservation Act of 1966; 54 U.S.C. § 300101, *et seq*. The SHPO in each state is responsible for ensuring that Federal agencies comply with Section 106 of this act, which requires that they consider the effects of a proposed undertaking on properties that have been determined to be eligible for, or included in, the National Register of Historic Places. The Section 106 review process consists of four steps: (1) identification and evaluation of historic properties; (2) assessments of the effects of the undertaking on historic properties; (3) consultation with the SHPO and appropriate agencies to develop a plan to address the treatment of historic properties; and (4) concurrence from the SHPO regarding the agreement or results of consultation. A description of ongoing SHPO (and tribal) consultation activities to date is included in Appendix A(7)). The project would be in full compliance with the NHPA after obtaining concurrence from SHPO on the Section 106 analysis prior to implementation.

SUBMERGED LANDS ACT

The Submerged Lands Act of 1953 (43 U.S.C. § 1301 *et seq*.) grants states title to all submerged navigable lands within their boundaries. This includes navigable waterways, such as rivers, as well as marine waters within the state's boundaries, generally three geographical miles from the coastline. Section 1311(d) of the Submerged Lands Act provides that nothing in the act shall affect the use, development, improvement, or control by or under the constitutional authority of the United States for the purposes of navigation or be construed as the release or relinquishment of any rights of the United States arising under the constitutional authority of Congress to regulate or improve navigation. In compliance with this act, the California State Land Commission will receive a copy of this Environmental Assessment/Environmental Impact Report and will have the opportunity to comment on its potential impacts to submerged lands.

ABANDONED SHIPWRECK ACT

The Abandoned Shipwreck Act, 43 U.S.C. §§ 2101–2106, is a federal legislative act, but does protect shipwrecks found in state waters. The Abandoned Shipwreck Act also states that the laws of salvage and finds do not apply to abandoned shipwrecks protected by the act. Under the Abandoned Shipwreck Act, the United States asserts title to abandoned shipwrecks in state waters that are either:

- Embedded in state-submerged lands;
- Embedded in the coralline formations protected by a state on submerged lands; or
- Resting on state-submerged lands and are either included in or determined eligible for the NRHP.

The Abandoned Shipwreck Act also has a provision for the simultaneous transfer, by the federal government, of title for those abandoned shipwrecks to the state(s) in whose waters the wrecks are located. As detailed further in this section, because there are no known shipwrecks within the federal navigation channels or existing placement sites, no impacts are expected to result from the project alternatives.

2 EXECUTIVE ORDERS

EXECUTIVE ORDER 11990: PROTECTION OF WETLANDS

This order (42 Federal Register [FR] 26961, May 25, 1977) requires federal agencies to minimize destruction of wetlands when managing lands, when administering federal programs, or when undertaking construction. Agencies are also required to consider the effects of federal actions on the health and quality of wetlands. The project alternatives are not expected to result in adverse impacts but rather have beneficial impacts on wetlands.

EXECUTIVE ORDER 13112: INVASIVE SPECIES

The purpose of this order is to prevent the introduction of invasive species, and to provide control for the spread of invasive species that have already been introduced. This order states that the federal government “shall, to the extent practicable and permitted by law, not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere unless, pursuant to guidelines that it has prescribed, the agency has determined and made public its determination that the benefits of such actions clearly outweigh the potential harm caused by invasive species; and that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions.” The project alternatives are not expected to cause the introduction or substantial spread of invasive nonnative plants or wildlife.

3 STATE LAWS

CALIFORNIA ENVIRONMENTAL QUALITY ACT

The California Environmental Quality Act (CEQA) (California Public Resources Code §21000-21178) and the CEQA Guidelines (14 California Code of Regulations 15000-15387) are the primary policies that require projects to analyze potential impacts to land use, as well as to analyze the project’s consistency with land use planning policies applicable to the project. This document is intended to fulfill the requirements of CEQA and the CEQA Guidelines.

PUBLIC TRUST DOCTRINE (CALIFORNIA STATE LANDS COMMISSION)

The California State Lands Commission (CSLC) manages lands in California according to the Public Trust Doctrine. Several of the guiding principles of the Public Trust are:

I. Lands under the ocean and under navigable streams are owned by the public and held in trust for the people by government. These are referred to as public trust lands and include filled lands formerly under water. Public trust lands cannot be bought and sold like other state-owned lands. Only in rare cases may the public trust be terminated, and only where consistent with the purposes and needs of the trust.

II. Uses of trust lands, whether granted to a local agency or administered by the state directly, are generally limited to those that are water dependent or related, and include commerce, fisheries, and navigation, environmental preservation and recreation. Public trust uses include, among others, ports, marinas, docks and wharves, buoys, hunting, commercial and sport fishing, bathing, swimming, and boating. Public trust lands may also be kept in their natural state for habitat, wildlife refuges, scientific study, or open space. Ancillary or incidental uses are also permitted—that is, uses that directly promote trust uses; are directly supportive and necessary for trust uses; or that accommodate the public's enjoyment of trust lands. Although trust lands cannot generally be alienated from public ownership, uses of trust lands can be carried out by public or private entities by lease from the CSLC or a local agency grantee.

III. Because public trust lands are held in trust for all citizens of California, they must be used to serve statewide, as opposed to purely local, public purposes (CSLC, 2010).

CALIFORNIA COASTAL ACT

The California Coastal Act includes specific policies (Division 20 of the California Public Resources Code) for planning and regulatory decisions made by the CCC and local governments. The CCC developed the CCMP, pursuant to the requirements of the CZMA, described above. The BCDC, further described below, is the state's coastal zone management agency responsible for reviewing consistency determinations under the CZMA in San Francisco Bay and developed the San Francisco Bay segment of the CCMP, the San Francisco Bay Plan. For activities outside of the Golden Gate, consistency determinations are reviewed by the CCC.

Article 4 of the California Coastal Act requires that marine resources be maintained, enhanced, and where feasible, restored. The act also requires that special protection be given to areas and species of special biological or economic significance. It further requires that uses of marine environments be such that habitat function, biological productivity, healthy species populations, and fishing and recreational interests of coastal waters are maintained for long-term commercial, recreational, scientific, and educational purposes; and that marine resources are protected against the spillage of crude oil, gas, petroleum products, and hazardous substances.

MCATEER-PETRIS ACT

The McAteer-Petris Act (California Government Code Section 66000, *et seq*.), first enacted in 1965, created the BCDC to prepare a plan to protect the San Francisco Bay and shoreline, and provide for appropriate development and public access. This act directs BCDC to exercise its authority to issue or deny permit applications for placing fill; dredging; or changing the use of any land, water, or structure in the area of its jurisdiction. The BCDC also reviews determinations of consistency with the CZMA for federally sponsored projects. The San Francisco Bay Plan (Bay Plan) is BCDC's policy document specifying goals, objectives, and policies for BCDC jurisdictional areas. Pursuant to the federal CZMA, USACE is required to be consistent to the maximum extent practicable with the enforceable policies of the Bay Plan.

SAN FRANCISCO BAY CONSERVATION AND DEVELOPMENT COMMISSION SAN FRANCISCO BAY PLAN

BCDC has permit authority over development of San Francisco Bay and the shoreline pursuant to the McAteer-Petris Act (California Government Code Section 66000 *et seq*.). The act requires BCDC to prepare a "comprehensive and enforceable plan for the conservation of the water of San Francisco Bay and the development of its shoreline." BCDC's jurisdiction includes all tidal areas of San Francisco Bay up to the line of mean high tide; all areas formerly subject to tidal action that have been filled since September 17, 1965; and the "shoreline band," which extends 100 feet inland from and parallel to the San Francisco Bay shoreline.

The Bay Plan, first adopted in 1969, and last updated in 2011, is BCDC's policy document specifying goals, objectives, and policies for BCDC jurisdictional areas (BCDC, 2007). Policies in the Bay Plan applicable to the proposed project include those in the following categories: Dredging; Fish, Other Aquatic Organisms, and Wildlife; Water Quality; Tidal Marshes and Tidal Flats; Subtidal Areas; and Navigational Safety and Oil Spill Prevention.

DREDGING POLICIES IN THE BAY PLAN RELEVANT TO THE PROPOSED PROJECT ARE SUMMARIZED BELOW:

Dredging Policy 1. Dredging and dredged material disposal should be conducted in an environmentally and economically sound manner. Dredgers should reduce disposal in San Francisco Bay and certain waterways over time to achieve the Long-Term Management Strategy (LTMS) goal of limiting in-Bay disposal volumes to a maximum of one million CY per year. The LTMS agencies should implement a system of disposal allotments to individual dredgers to achieve this goal only if voluntary efforts are not effective in reaching the LTMS goal. In making its decision regarding disposal allocations, the BCDC should confer with the LTMS agencies and consider the need for the dredging and the dredging projects, environmental impacts, regional economic impacts, efforts by the dredging community to implement and fund alternatives to in-Bay disposal, and other relevant factors.

Dredging Policy 2. Dredging should be authorized when the BCDC can find: (a) the applicant has demonstrated that the dredging is needed to serve a water-oriented use or other important public purpose, such as navigational safety; (b) the materials to be dredged meet the water quality requirements of the Regional Water Board; (c) important fisheries and Bay natural resources would be protected through seasonal restrictions established by the California Department of Fish and Wildlife (CDFW), the United States Fish and Wildlife Service (USFWS), and/or the National Marine Fisheries Service (NMFS), or through other appropriate measures; (d) the siting and design of the project will result in the minimum dredging volume necessary for the project; and (e) the materials would be disposed of in accordance with Policy 3.

Dredging Policy 3. Dredged materials should, if feasible, be reused or disposed outside San Francisco Bay and certain waterways. Except when reused in an approved fill project, dredged material should not be disposed in San Francisco Bay and certain waterways unless disposal outside these areas is infeasible and the BCDC finds: (a) the volume to be disposed is consistent with applicable dredger disposal allocations and disposal site limits adopted by the BCDC by regulation; (b) disposal would be at a site designated by the BCDC; (c) the quality of the material disposed of is consistent with the advice of the Regional Water Board and the Dredged Material Management Office; and (d) the period of disposal is consistent with the advice of the CDFW, the USFWS, and the NMFS.

Dredging Policy 4. If an applicant proposes to dispose dredged material in tidal areas of San Francisco Bay and certain waterways that exceeds either disposal site limits or any disposal allocation that the BCDC has adopted by regulation, the applicant must demonstrate that the potential for adverse environmental impact is insignificant, and that nontidal and ocean disposal is infeasible because there are no alternative sites available or likely to be available in a reasonable period, or because the cost of disposal at alternate sites is prohibitive. In making its decision whether to authorize such in-Bay disposal, the BCDC should confer with the LTMS agencies and consider the factors listed in Policy 1.

Dredging Policy 5. To ensure adequate capacity for necessary Bay dredging projects and to protect Bay natural resources, acceptable nontidal disposal sites should be secured, and the San Francisco Deep Ocean Disposal Site should be maintained. Furthermore, dredging projects should maximize use of dredged material as a resource consistent with protecting and enhancing Bay natural resources, such as creating, enhancing, or restoring tidal and managed wetlands, creating and maintaining levees and dikes, providing cover and sealing material for sanitary landfills, and filling at approved construction sites.

Dredging Policy 6. Dredged materials disposed in San Francisco Bay and certain waterways should be carefully managed to ensure that the specific location, volumes, physical nature of the material, and timing of disposal do not create navigational hazards;

adversely affect Bay sedimentation, currents, or natural resources; or foreclose the use of the site for projects critical to the economy of the San Francisco Bay Area.

POLICIES IN THE BAY PLAN PERTAINING TO FISH, OTHER AQUATIC ORGANISMS, AND WILDLIFE THAT ARE RELEVANT TO THE PROPOSED PROJECT ARE SUMMARIZED BELOW:

Fish, Other Aquatic Organisms, and Wildlife Policy 1. To assure the benefits of fish, other aquatic organisms, and wildlife for future generations, to the greatest extent feasible, San Francisco Bay's tidal marshes, tidal flats, and subtidal habitat should be conserved, restored, and increased.

Fish, Other Aquatic Organisms, and Wildlife Policy 2. Specific habitats that are needed to conserve, increase, or prevent the extinction of any native species, species threatened or endangered, species that the CDFW has determined are candidates for listing as endangered or threatened under the California Endangered Species Act, or any species that provides substantial public benefits, should be protected, whether in San Francisco Bay or behind dikes.

Fish, Other Aquatic Organisms, and Wildlife Policy 4. The BCDC should not authorize projects that would result in the "taking" of any plant, fish, other aquatic organism or wildlife species listed as endangered or threatened pursuant to the state or federal endangered species acts, or the federal Marine Mammal Protection Act, or species that are candidates for listing under the California Endangered Species Act, unless the project applicant has obtained the appropriate "take" authorization from the USFWS, NMFS, or CDFW. The BCDC should give appropriate consideration to the recommendations of the CDFW, NMFS, or USFWS to avoid possible adverse effects of a proposed project on fish, other aquatic organisms, and wildlife habitat.

WATER QUALITY POLICIES IN THE BAY PLAN RELEVANT TO THE PROPOSED PROJECT ARE SUMMARIZED BELOW:

Water Quality Policy 1. Bay water pollution should be prevented to the greatest extent feasible. The Bay's tidal marshes, tidal flats, and water surface area and volume should be conserved, and whenever possible, restored and increased to protect and improve water quality.

Water Quality Policy 2. Water quality in San Francisco Bay should be maintained at a level that will support and promote the beneficial uses of San Francisco Bay as identified in the Regional Water Board's Water Quality Control Plan for the San Francisco Bay Basin and should be protected from all harmful or potentially harmful pollutants. The policies, recommendations, decisions, advice, and authority of the State Water Resources Control Board and the Regional Water Board should be the basis for carrying out the BCDC's water quality responsibilities.

POLICIES IN THE BAY PLAN PERTAINING TO TIDAL MARSHES AND TIDAL FLATS RELEVANT TO THE PROPOSED PROJECT ARE SUMMARIZED BELOW:

Tidal Marshes and Tidal Flats Policy 1. Tidal marshes and tidal flats should be conserved to the fullest possible extent. Filling, diking, and dredging projects that would substantially harm tidal marshes or tidal flats should be allowed only for purposes that provide substantial public benefits, and only if there is no feasible alternative.

Tidal Marshes and Tidal Flats Policy 2. Any proposed fill, diking, or dredging project should be thoroughly evaluated to determine the effect of the project on tidal marshes and tidal flats and designed to minimize—and if feasible—avoid any harmful effects (Federal Navigation Channels EA/EIR 3.0 Affected Environment and Environmental Consequences).

POLICIES FOR SUBTIDAL AREAS IN THE BAY PLAN THAT ARE RELEVANT TO THE PROPOSED PROJECT ARE SUMMARIZED BELOW:

Subtidal Areas Policy 1. Any proposed filling or dredging project in a subtidal area should be thoroughly evaluated to determine the local and Bay-wide effects of the project on: (a) the possible introduction or spread of invasive species; (b) tidal hydrology and sediment movement; (c) fish, other aquatic organisms, and wildlife; (d) aquatic plants; and (e) San Francisco Bay’s bathymetry. Projects in subtidal areas should be designed to minimize—and if feasible—avoid any harmful effects.

Subtidal Areas Policy 2. Subtidal areas that are scarce in San Francisco Bay or have an abundance and diversity of fish, other aquatic organisms, and wildlife (e.g., eelgrass beds, sandy deep water, underwater pinnacles) should be conserved. Filling, changes in use; and dredging projects in these areas should therefore be allowed only if: (a) there is no feasible alternative; and (b) the project provides substantial public benefits.

NAVIGATIONAL SAFETY AND OIL SPILL PREVENTION POLICIES IN THE BAY PLAN RELEVANT TO THE PROPOSED PROJECT ARE SUMMARIZED BELOW:

Navigational Safety and Oil Spill Prevention Policy 1. Physical obstructions to safe navigation, as identified by the U.S. Coast Guard and the Harbor Safety Committee of the San Francisco Bay Region, should be removed to the maximum extent feasible when their removal would contribute to navigational safety, and would not create significant adverse environmental impacts. Removal of obstructions should ensure that any detriments arising from a significant alteration of Bay habitats are clearly outweighed by the public and environmental benefits of reducing the risk to human safety; or the risk of spills of hazardous materials, such as oil.

Navigational Safety and Oil Spill Prevention Policy 3. To ensure navigational safety and help prevent accidents that could spill hazardous materials, such as oil, the BCDC should encourage major marine facility owners and operators, USACE and the National Oceanic and Atmospheric Administration to conduct frequent, up-to-date surveys of major shipping channels, turning basins, and berths used by deep-draft vessels and oil barges. Additionally, the frequent, up to-date surveys should be quickly provided to the U.S. Coast Guard Vessel Traffic Service San Francisco, masters, and pilots.

2. ENDANGERED SPECIES ACT (ESA) AND MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

DEPARTMENT OF THE ARMY
SAN FRANCISCO DISTRICT, U.S. ARMY CORPS OF ENGINEERS
450 GOLDEN GATE AVENUE
SAN FRANCISCO, CALIFORNIA 94102-3661

September 7, 2022

Subject: 2023 San Francisco Bay Strategic Shallow-Water Placement Pilot Project – Request for Concurrence with Endangered Species Act Determination and for Essential Fish Habitat Consultation under the Magnuson-Stevens Fishery Conservation and Management Act

Lisa Van Atta
Assistant Regional Administrator
California Coastal Office
National Marine Fisheries Service
777 Sonoma Avenue, Room 325
Santa Rosa, California 95404-4731

Dear Ms. Van Atta:

Pursuant to Section 7(a)(2) of the Endangered Species Act of 1973, as amended (ESA; 50 C.F.R. Part 402), the U.S. Army Corps of Engineers, San Francisco District (USACE) is requesting concurrence from the National Marine Fisheries Service (NMFS) with our determination that the proposed 2023 Dredge Sediment Strategic Placement Pilot project is not likely to adversely affect the Central California Coast (CCC) distinct population segment (DPS) of steelhead (*Oncorhynchus mykiss*; threatened) and southern DPS of North American green sturgeon (*Acipenser medirostris*; threatened), or the designated critical habitat of the southern DPS of North American green sturgeon.

The USACE also is requesting consultation under the Magnuson-Stevens Fisheries Conservation and Management Act (Magnuson-Stevens Act; 50 C.F.R 600.920(e)). We have determined that the proposed action may affect essential fish habitat (EFH) managed as part of the Pacific Groundfish Fishery Management Plan (FMP), Pacific Salmon FMP, and Pacific Coastal Pelagic Species FMP.

Project Description

The proposed project would involve placing dredged material in shallow water about 2 miles offshore from a sediment-starved tidal wetland and using natural hydrodynamic processes to transport the sediment onto the mudflat and marsh (i.e., strategic placement). The purpose of this pilot project is to examine the ability of tides and currents in San Francisco Bay to move dredged sediment placed in shallow water on the periphery of the bay onto existing mudflats and marshes to increase resilience to rising sea levels. The project will compare the costs of successfully moving a noteworthy and significant volume of dredged sediment to the target placement area to the costs of traditional placement options (i.e., ocean, in-water, or confined upland disposal).

Dredged material for the proposed project would be obtained from the operations and maintenance (O&M) dredging of Redwood City Harbor (RCH), with dredging of Oakland Harbor as a contingency plan. The O&M dredging activities of RCH and Oakland Harbor are conducted under separate authorizations and are separate projects. The RCH (or potentially Oakland Harbor) would provide the source material for the 2023 strategic placement of dredged sediment pilot project; however, RCH maintenance dredging occurs every two years independent of the proposed project. The federal Base Plan for maintenance dredging of RCH, as practiced for the past several decades, is completed using clamshell or hopper dredges with placement at the designated in-bay site, SF-11. Oakland Harbor is completed using a clamshell dredge, and the Base Plan site is SF-DODS. The evaluation of the potential impacts associated with the O&M dredging of RCH and Oakland Harbor is presented in the Final Environmental Assessment/Environmental Impact Report for Maintenance Dredging of the Federal Navigation Channels in San Francisco Bay Fiscal Years 2015-2024. The NMFS has completed ESA consultation on the O&M dredging activities at RCH and Oakland Harbor as part of assessing the effects of the Long Term Management Strategy for the Placement of Dredge Material in San Francisco Bay (NMFS consultation number WCR-2014-1599).

For the proposed strategic placement pilot project, a small scow will be light loaded with 900 cubic yards (CY) of dredged material at RCH and transported using a tugboat to the project placement site near Eden Landing (Whale's Tail) in south San Francisco Bay (Figure 1). The placement site would be in approximately 10 feet of absolute water depth. This depth is necessary to accommodate the scow draft and offers the greatest likelihood of sediment transport onto the adjacent wetland based on modeling results. The total area of the placement site would be approximately 138 acres. The dredged material from each scow-load would be released all at once through the bottom release doors. Release time is expected to require 9 minutes (Anchor QEA, LLC 2022). Due to drift in the water column, maximum depth of the sediment layer as the dredged material settles on the bottom substrate is expected to be between 10 cm and 30 cm (Anchor QEA, LLC 2022). After placing the dredged material, the tug and scow will return to RCH to repeat the process. The entire placement volume will be 100,000 CY, requiring approximately 112 scow-loads to complete. At maximum, the placement process will occur 24 hours per day, 7 days per week, for 25 days. Therefore, 4-5 scow-loads will be placed per day on average, although placements could occur as often as every 1.5 hours if the tides allow the site to remain deep enough. Work will occur within the in-water work window for dredging, which is June 1 through November 30. The placement area and adjacent mudflat-marsh complex will be monitored before and after placement.

Both pre- and post-project monitoring will occur in the following areas (please see attachment):

Pre-project monitoring
- Bathymetry and topography
- Oceanographic data collection: suspended sediment concentration, wave conditions
- Benthic communities
- Eelgrass surveys
- Sediment flux across the shallows
- Background marsh accretion rates

Post-project
- Resurveys of placement site
- Benthos, eelgrass recovery

- Oceanographic data collection: suspended sediment concentration, wave conditions
- Sediment flux post placement
- Marsh and mudflat accretion

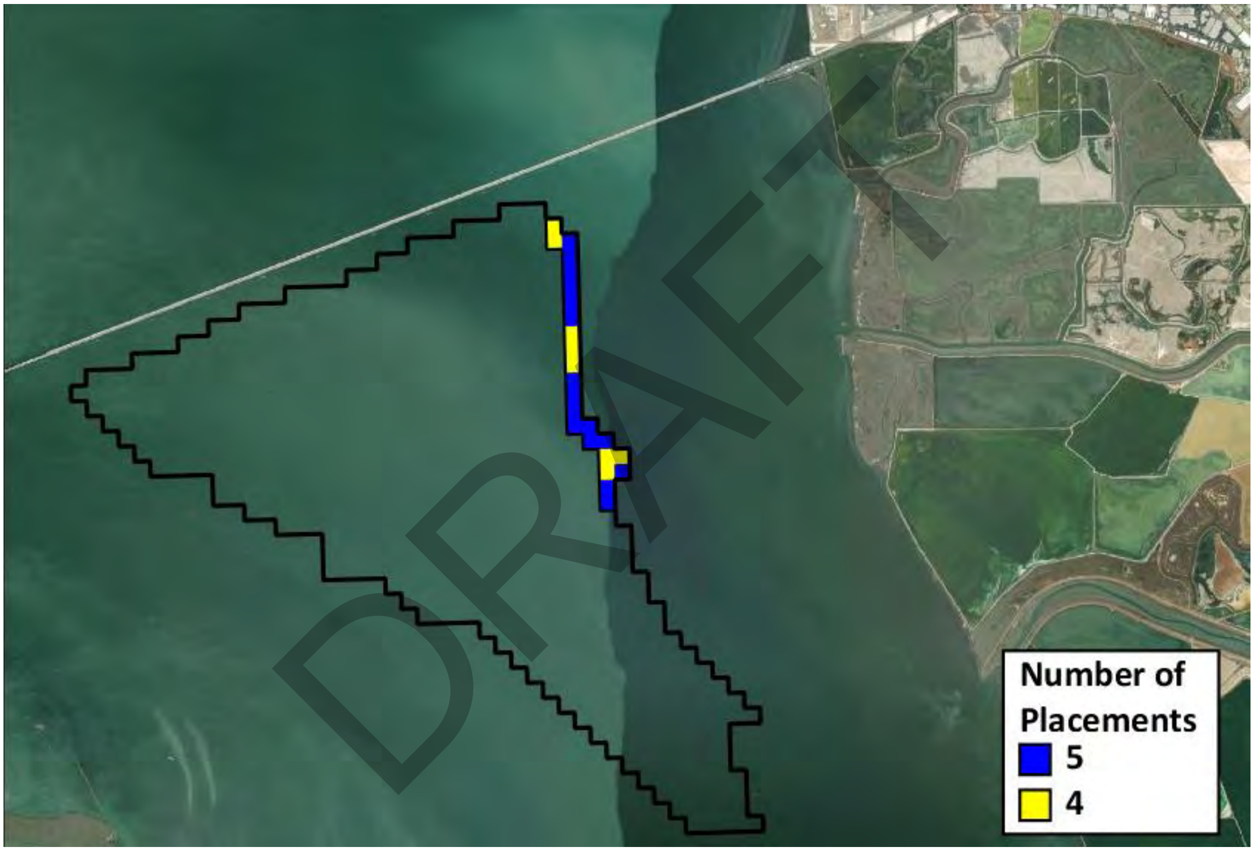

Figure 1. Placement cells in shallow water aproximately two miles off the marsh at Eden Landing (i.e., Whale's Tail) for the Shallow/East placement. The black outline represents the entire placement grid modeled by Anchor QEA, LLC (2022) to identify the best locations for placement, whereas the blue and yellow cells represent the Eden Landing Shallow/East placement footprint cells selected for actual use by the project. Each of the selected cells will receive five or four placements,respectively depending on the water depths and tidal timings. The placement footprint of the blue and yellow cells is approximately 9,700 feet long and 630 feet wide (i.e., 138 acres).

Endangered Species Act Consultation

The proposed project has been reviewed for its potential impacts to threatened or endangered species and designated critical habitats. Primary impacts include the following:

- Benthic invertebrates are expected to be buried by up to 10 cm of sediment and potentially injured or killed when the dredge material is placed. Larger or more motile organisms such as fish also could be injured or killed should they remain under or close to the scow when the bottom release doors are opened and the dredge material is deposited.
- Turbidity and suspended sediment levels in and around the placement site are expected to increase, potentially reducing the ability of fish to feed by sight or increase energy expenditures due to gill-flaring to clear sediment, etc. Elevated turbidity and suspended sediment levels would be highest during the placement process. However, the project is intended to use natural hydrodynamic processes to move the placed sediment. Therefore, project-related contributions to turbidity and suspended sediment are expected to continue over a period of several months.
- Marsh and mudflat habitats may experience increased rates of sediment deposition, which is the intent of the project. This would occur over a period of several months. Marsh and mudflat accretion rates are expected to be up to approximately 0.1 cm per 2 months per simulation modeling (Anchor QEA, LLC 2022).

Central California Coast Steelhead: As CCC steelhead spawning occurs in nearby south San Francisco Bay watersheds such as Alameda Creek, Coyote Creek, and the Guadalupe River, steelhead could occur at or near the project site. However, adult steelhead migrate into their spawning streams from December through April, and juveniles outmigrate to the ocean from January through May (Fukushima and Lesh 1998). Furthermore, summertime water temperature in south San Francisco Bay can be expected to measure approximately 70 ºF or more (e.g., as measured by the USGS at the Dumbarton Bridge). This temperature is above the preferred temperature ranges for steelhead/rainbow trout (*O. mykiss*) juveniles and smolts generally reported in the literature (e.g., Raleigh et al. 1984; Sauter et al. 2001). Overall, juvenile steelhead are not expected to be in the project area during the period from June 1 through November 30 and hence are not expected to encounter the project. Any early migrating adults would be expected to easily avoid the project due to its small size relative to the large migration corridor in the project area. The effects of the proposed project on juvenile CCC steelhead are expected to be discountable, and effects on the few adults that may encounter the project are expected to be minor, temporary, and localized and not impede migration into their south bay spawning streams. The USACE has determined that the proposed project is not likely to adversely affect CCC steelhead.

Southern DPS of North American Green Sturgeon and Critical Habitat: North American green sturgeon may be present year-round in San Francisco Bay. Only juvenile, subadult, and adult rearing or migrating green sturgeon would be present and likely feeding on benthic macroinvertebrates, juvenile crabs, and small benthic fishes. No spawning adults would be present, as green sturgeon spawn in fresh water and the nearest spawning habitat would be in the Sacramento River (Moyle 2002).

A summary provided by the San Francisco Estuary Institute of telemetry studies conducted through 2015 primarily on white sturgeon (*Acipenser transmontanus*) suggests that green sturgeon could occasionally occur in south San Francisco Bay (chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.sfei.org/sites/default/files/biblio_files/2015%20Summary%20of%20Sturgeon%20Telemetry%20Studies%20in%20SF%20Estuary.pdf). The most recent summary of sturgeon report card data provided by the California Department of Fish and Wildlife shows zero to low catch of white sturgeon for the months from June through November, 2007-2019 in San Francisco Bay "south of Highway 80" (presumably the Oakland-San Francisco Bay Bridge, approximately 18 miles north of the proposed project; Dubois et al. 2020). Location data are not provided for the green sturgeon that were caught and released by anglers. Interestingly, a blog post from a fishing guide states that one of his favorite, year-round (white) sturgeon fishing areas is south of the Dumbarton Bridge, due to the brackish water and shallow depths; he describes these white sturgeon as "resident" there (https://coastsidefishingclub.com/grey-beard-articles/an-introduction-to-sturgeon-fishing/). The Dumbarton Bridge is located approximately 8 miles south of the proposed project.

More detailed information concerning green sturgeon timing and distribution in San Francisco Bay is provided by the recent acoustic telemetry study of Miller et al. (2020). This study involved surgically implanting small, acoustic transmitters into 41 green sturgeon and 160 white sturgeon in Suisun and San Pablo bays, and then detecting the fish with automated receivers to determine their seasonal distribution in the Sacramento River and Suisun, San Pablo, and San Francisco bays. Large juveniles, subadults, and adults all were tagged as part of the study. Data for 100 green sturgeon and 92 white sturgeon previously tagged for other studies were included in the data analysis. The receiver array is shown in Figure 2; note that area #3 is described as "south San Francisco Bay" and includes approximately six receivers placed along the Bay Bridge as well as a single receiver located at the Dumbarton Bridge. Miller et al. (2020) report that in summer, juvenile and subadult green sturgeon were detected primarily in central San Francisco Bay, San Pablo Bay, and Suisun Bay. Subadults also were detected a few times in the Pacific Ocean. Adult green sturgeon were much more widespread, and also detected in the Pacific Ocean and Sacramento River. Green sturgeon are described as being "highly marine" compared to white sturgeon; juvenile and subadult green sturgeon were detected more often than similarly-aged white sturgeon near the Golden Gate Bridge, and white sturgeon are described as "resident in the estuary throughout adulthood." Miller et al. (2020) report few detections of juvenile, subadult, or adult green sturgeon in south San Francisco Bay in summer or fall. However, all south San Francisco Bay detections were made by the acoustic receivers located at the Bay Bridge, and none occurred at the Dumbarton Bridge. Consequently, there is no evidence from this study that green sturgeon occurred near the area of the proposed project.

Based on the timing and distribution information described above green sturgeon would have a low likelihood of encountering the proposed project. We know that green sturgeon occur north (i.e., in the vicinity of the Bay Bridge) of the proposed project and that white sturgeon occur both to the north and south (i.e., south of the Dumbarton Bridge). Adult white sturgeon may be resident in the brackish waters south of the Dumbarton Bridge. Little is known about green or white sturgeon occurrence specifically in the vicinity of the project area, but in general sturgeon occurrence in south San Francisco Bay during the period from June through November appears to be low.

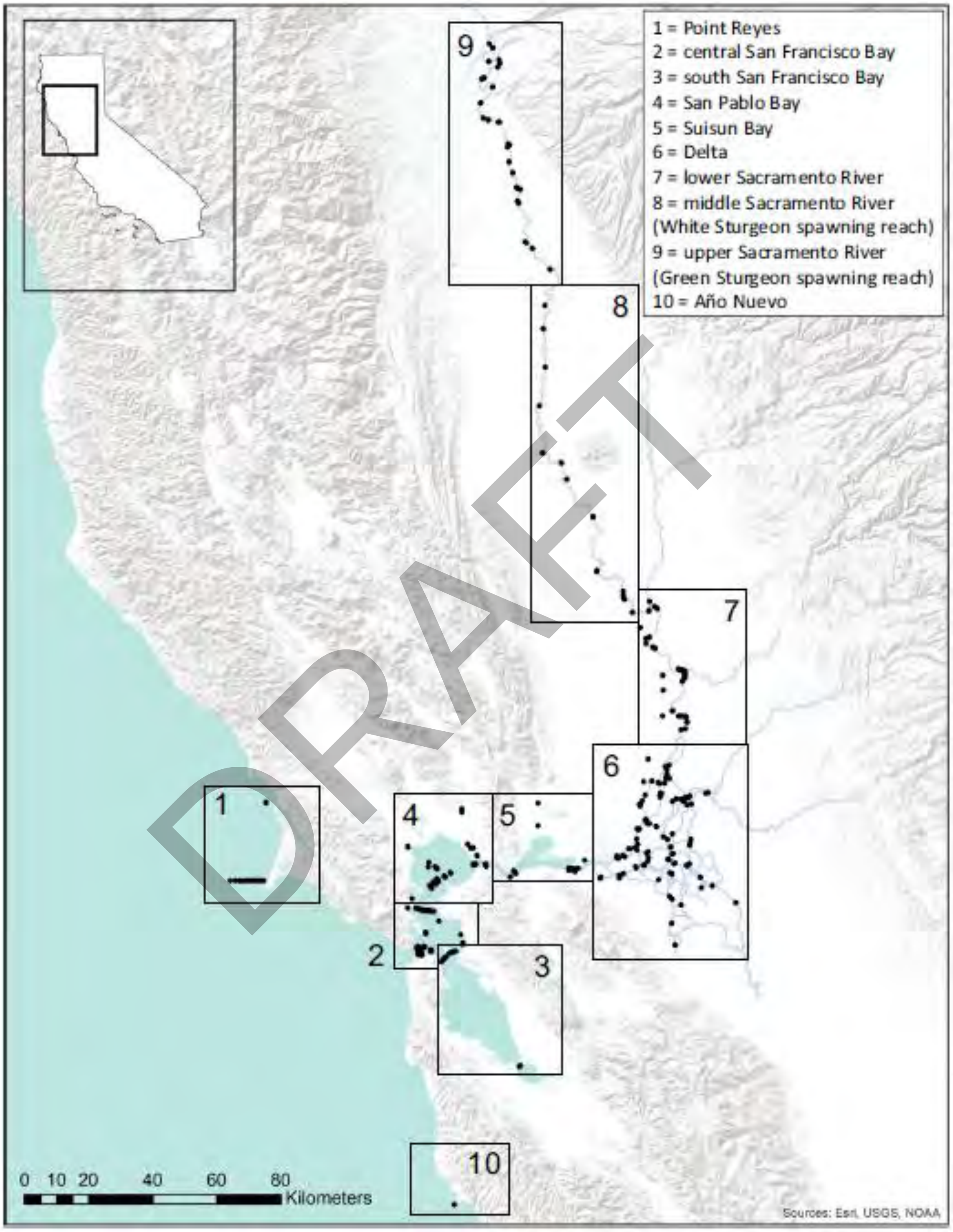

Figure 2. Acoustic receiver array used to assess green and white sturgeon distribution in the Sacramento River and San Francisco Bay. Reproduced from Figure 1 in Miller et al. (2020).

Should a green sturgeon encounter the project, the severity of impacts may depend on the size of the affected individual. Juveniles may have an increased likely of being injured or killed from being buried by sediment, or less capable of avoiding project-related turbidity. Although detections by Miller et al. (2020) of green sturgeon in south San Francisco Bay were low overall, they were greatest for juveniles. Miller et al. (2020) considered the size of juvenile green sturgeon in San Francisco Bay to be up to 90 cm; smaller individuals may be 30 cm (Moyle 2002). Boysen and Hoover (2009) found that juvenile white sturgeon less than 82 mm total length (TL) had "escape speeds" capable of being maintained for 1 minute of less than 40 cm per second, and juveniles measuring 82 - 92 mm TL had escape speeds of 42 - 45 cm per second. In general, larger, motile fish including even juvenile green sturgeon would be expected to move away from the active project area due to the physical disturbance from the draft of the tug and scow as they maneuver in shallow water. It is likely that juvenile sturgeon also could escape burial by project sediment even if they remained directly under the scow when the scow doors opened. Dredge material placement from the proposed project is expected to deposit a sediment layer of up to 10 cm thick below or near the transport scow. This deposition would occur over a period of about 9 minutes (Anchor QEA, LLC 2022). Consequently, juvenile green sturgeon should be able to simply swim away from the sediment deposition activities as well as project-related turbidity.

Although dredge placement activities are known to increase turbidity and suspended sediment levels in the water column, this not considered to be a major concern for sturgeon (Stanford et al. 2009). Background turbidity levels in San Francisco Bay are relatively high. Turbidity measured 4 feet from the bottom at the Dumbarton Bridge (USGS gauge 373015122071000) for the years 2014-2021 typically ranged from 200 – 600 formazin nephelometric units (FNU) during the period from June through November but measured as high as 700 – 800 FNU on some occasions. The summary from a symposium concerning dredging effects on green sturgeon and longfin smelt (*Spirinchus thaleichthys*) in the San Francisco Estuary (Stanford et al. 2009) indicates that in one study, white sturgeon "did not disperse during dredging operations, but became more active. This increased activity could have resulted from either stress or increased foraging activity….white sturgeon remained in a disposal site throughout a several hour sediment disposal operation." An overall conclusion of the symposium was that "sturgeon appear to be undisturbed by high concentrations of naturally-produced suspended sediment. Therefore, adverse effects of sediment resuspension are unlikely."

In summary, green sturgeon are unlikely to be in the project area in June or July and hence are not expected to encounter the project. However, any green sturgeon, even a juvenile, that encounters the project during active dredge material placement should be able to swim strongly enough to avoid physical injury or turbidity plumes. Elevated turbidity levels are not expected to adversely affect sturgeon. The USACE has determined that the proposed project is not likely to adversely affect the southern DPS of North American green sturgeon.

Green sturgeon designated critical habitat in San Francisco Bay, San Pablo Bay, and Suisun Bay includes all tidally influence areas up to the elevation of mean higher high water. In the project area, designated critical habitat includes the area upstream to the head of tide endpoint in Alameda Creek.

The proposed project is expected to deposit dredge sediment in a 138-acre area of south San Francisco Bay. The benthic substrate in the south bay is largely mud flat, but also includes oyster shell "hash" (S. De La Cruz, USGS, personal communication, June 28, 2022) and bryozoan reefs (Zabin et al. 2010). Sturgeon likely can be found over all three substrate types in their search for food. Benthic organisms such as macroinvertebrates, juvenile crabs, and small fish (e.g., staghorn sculpin (*Leptocottus armatus*)) may be buried by the proposed dredge material placement and injured or killed. These organisms represent food items regularly consumed by green sturgeon. Elevated turbidity levels also are expected to occur during active placement activities which would occur over 25 days. However, the dredge material placement site is about 138 acres or 0.22 square miles in size, whereas the area of Suisun, San Pablo, and San Francisco bays combined is estimated to be about 225 square miles (i.e., assuming dimensions of 75 miles long x 3 miles wide on average). Therefore, the dredge material placement area is extremely small relative to the amount of habitat available to green sturgeon, and sturgeon should continue to be able to find foraging habitat and adequate food for the duration of the project. Additionally, benthic organisms are expected to recolonize the dredge material placement site, and the benthos will be monitored for a period of 1 year. Turbidity is expected to subside between scow loads and quickly return to background levels once dredge material placement is complete.

The proposed project is expected to contribute sediment for transport onto nearby wetlands over a period of several months. Consequently, the project may increase turbidity levels in the placement area over the long term. However, due to the elevated background turbidity levels in south San Francisco Bay, project-related turbidity increases are not expected to be measurable following the active period of dredge material placement (Jessie Lacy, USGS, personal communication, June 28, 2022). Transport of sediment through shallow water areas and deposition of small amounts (i.e., up to about 0.1 cm per 2 months) in wetlands near the placement site is considered a beneficial effect of the project but is not expected to meaningfully affect green sturgeon habitat or their benthic food. In any case, sediment transport and deposition will be monitored for a period of 1 year.

Given the analysis provided above, project effects to green sturgeon critical habitat are expected to be minor, temporary, and localized. The USACE has determined that the proposed project is not likely to adversely affect the designated critical habitat of the southern DPS of North American green sturgeon.

Magnuson-Stevens Fisheries Conservation and Management Act (Essential Fish Habitat) Consultation

The proposed project area consists of open water habitat and benthic habitat that may include mudflat, shell hash, or bryozoan reefs. Eelgrass occurs between the dredge material placement site and the wetland targeted for restoration through sediment transport (Figure 3). Marsh habitats also are present. The project area is under tidal influence.

The proposed project is expected to deposit dredge sediment in a 138-acre area of south San Francisco Bay over a period of 25 days and increase turbidity in the water column. Benthic organisms would be buried and potentially injured or killed. These organisms are expected to recolonize over a period of weeks or months, and the benthos will be monitored for up to one year. The project also would contribute sediment for transport onto nearby wetlands over a period of months or years. Deposition of small amounts (i.e., up to about 0.1 cm per 2 months) is expected to occur in wetlands near the placement site. Sediment transport and deposition will be monitored for a period of 1 year. Sediment deposition onto wetlands is considered a beneficial effect and is the purpose of the project.

Figure 3. Eelgrass mapped near Eden Landing. Includes data from surveys conducted in 2003, 2009, 2013, and 2019. The orange border indicates the 250 m turbidity buffer from NMFS (2011). A comparison with Figure 1 indicates no encroachment of the dredge disposal site into the turbidity buffer. Source: San Francisco Bay Eelgrass Impact Assessment Tool | CNRA GIS Open Data (ca.gov)

The eelgrass shown in Figure 3 would be outside of the 250 m buffer zone (i.e., from the dredge placement site) established by NMFS (2011) for protection from indirect effects of dredging activity such as turbidity. Additionally, the substrate and conditions offshore of Eden landing are not especially conducive to eelgrass colonization and growth, and Figure 3 primarily shows individual clones from one spot survey (Kathy Boyer and Keith Merkel, pers. comm., July 2022). However, pre- and post-project eelgrass monitoring would occur to document effects on eelgrass.

The proposed project is expected to have minor, temporary, and localized effects to EFH as described above. The USACE has determined that the project may affect EFH managed as part of the Pacific Groundfish, Pacific Salmon, and Pacific Coastal Pelagic Species fishery management plans.

We are requesting your written concurrence with our determination that the proposed project may affect, but is not likely to adversely affect the CCC DPS of steelhead, southern DPS of North American green sturgeon, or the designated critical habitat of the southern DPS of North American green sturgeon. We also request a response regarding EFH. If you would like to further discuss our determination or require additional information, please contact Dr. Beth Campbell of my staff at elizabeth.a.campbell@usace.army.mil, or at (415) 503-6845 regarding this consultation request.

Sincerely,

Dr. Tessa Beach
Environmental Branch Chief

References:

Anchor QEA, LLC. 2022. Hydrodynamic and sediment transport modeling of the San Francisco Bay to evaluate pilot sites for shallow water placement of dredge material. Draft report prepared for USACE. June 2022. 153 pages plus appendices.

Boysen K.A., and J. J. Hoover. 2009. Swimming performance of juvenile white sturgeon (*Acipenser transmontanus*): training and the probability of entrainment due to dredging. Journal of Applied Ichthyology 25 (Supplement 2):54–59

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Enclosure

3. CLEAN WATER ACT

CALIFORNIA
Water Boards

GAVIN NEWSOM
GOVERNOR

YANA GARCIA
SECRETARY FOR
ENVIRONMENTAL PROTECTION

San Francisco Bay Regional Water Quality Control Board

September 23, 2022

Tessa Beach
Chief, Environmental Planning and Sciences
U.S. Army Corps of Engineers
San Francisco District (SPN)
450 Golden Gate Avenue, 4th floor
San Francisco, CA 94102
Email: Tessa.E.Bernhardt@usace.army.mil

Subject: San Francisco Regional Water Quality Control Board Acknowledgement of the San Francisco Bay Shallow-Water Strategic Placement Pilot Project

Dear Ms. Beach:

The purpose of this communication is to respond to a request by the San Francisco District of the U.S. Army Corps of Engineers' (USACE). We have been engaged with USACE staff and management regarding the proposed San Francisco Bay Shallow-Water Strategic Placement Pilot Project (Project), including monthly meetings and a joint effort with Water Board staff to create the Environmental Analysis and Mitigated Negative Declaration.

Due to federal requirements for dredging projects, the USACE is required to submit a request for Water Quality Certification (WQC) pursuant to Section 401 of the federal CWA for review and acceptance by the Water Board prior to commencing any work. To issue a WQC the Water Board will need to receive a valid request in accordance with 40 CFR § 121 and comply with the California Environmental Quality Act. It is the intent of the Water Board to fully review this Project once a valid request for a WQC is submitted to the Water Board, which we understand will occur at the pre-construction engineering and design phase.

If you have any further questions, please contact Christina Toms of my staff at 510-622-2506, or by email at Christina.Toms@waterboards.ca.gov.

Sincerely,

for

Digitally signed by Xavier Fernandez
Date: 2022.09.23 14:28:26 -07'00'

Eileen White
Executive Officer

cc w/ attachments (*all via email*):
Arye Janoff, USACE, arye.m.janoff@usace.army.mil
Julie Beagle, USACE, julie.r.beagle@usace.army.mil

DRAFT Section 404(b)(1) Checklist

Summary Evaluation

PROJECT: National Regional Sediment Management Program Section 1122 Beneficial Use Pilot Project San Francisco Bay Strategic Shallow Water Placement

PROJECT MANAGER: Peter Mull

PROJECT DESCRIPTION: The proposed project would place sediment dredged from a federal San Francisco Bay navigation channel in shallow water on the periphery of the Bay to examine the ability of tides and currents to move the placed material to existing mudflats and marshes. This aquatic placement technique – placing dredged sediment in shallow water in the nearshore adjacent to a tidal wetland and utilizing natural hydrodynamic and morphodynamic processes to move the sediment onto the mudflat and marsh – is referred to as strategic shallow water placement. This strategic shallow-water placement pilot project is expected to move a portion of the placed sediment to the mudflats and the marsh plain, mimicking natural sediment supply to wetland ecosystems to improve habitat and increase mudflat and marsh resilience to sea level rise (SLR).

Based on the modeling results, and other site selection criteria, the proposed project evaluates the potential impacts associated with strategically placing approximately 100,000 cubic yards (yd^3) of dredged sediment from the Redwood City Harbor federal navigation channels over approximately 19 – 56 days using a clamshell dredge and a dump scow at a shallow-depth (9 - 12 feet [ft]), at a 138-acre subtidal site two miles offshore of the Eden Landing Ecological Reserve in southern San Francisco Bay. This proposed pilot project addresses tidal mudflat and salt marsh responses to strategic sediment placement at one South-Bay location.

1. Summary of Technical Evaluation Factors (Subparts C-F).

A detailed evaluation is provided in the main body of this report

a. Potential Impacts on Physical and Chemical Characteristics of the Aquatic Ecosystem (Subpart C) (Sec. 230.20-230.25)

	N/A	Not Significant	Significant*
1) Substrate -	☐	☒	☐
2) Suspended particulates/turbidity	☐	☒	☐
3) Water Quality	☐	☒	☐
4) Current patterns and water circulation	☐	☒	☐
5) Normal water fluctuations	☐	☒	☐
6) Salinity gradients	☒	☐	☐

b. Potential Impacts on Biological Characteristics of the Aquatic Ecosystem (Subpart D)(Sec. 230.30-230.32)

1) Threatened and endangered species	☐	☒	☐
2) Fish, crustaceans, mollusks and other aquatic organisms in the food web	☐	☒	☐
3) Other wildlife	☐	☒	☐

c. Potential Impacts on Special Aquatic Sites (Subpart E)(Sec. 230.40-230.45)

1) Sanctuaries and refuges	☐	☒	☐
2) Wetlands	☐	☒	☐
3) Mud flats	☐	☒	☐
4) Vegetated shallows	☐	☒	☐
5) Coral reefs	☒	☐	☐
6) Riffle and pool complexes	☒	☐	☐

d. Potential Effects on Human Use Characteristics (Subpart F)(Sec 230.50-230.55)

1) Municipal and private water supplies	☒	☐	☐
2) Recreational and commercial fisheries	☐	☒	☐
3) Water-related recreation	☐	☒	☐
4) Aesthetics	☐	☒	☐
5) Parks, national and historic monuments, national seashores, wilderness areas, research sites, and similar preserves	☐	☒	☐

2. <u>Evaluation and Testing (Subpart G)</u> (Sec. 230.60-230.61)

a. The following information has been considered in evaluating the biological availability of possible contaminants in dredged or fill material. (Check only those appropriate.)

1) Physical characteristics	☒
2) Hydro-geography in relation to known or anticipated sources of contaminants	☐
3) Results from previous testing of the material or similar material in the vicinity of the project	☒
4) Known, significant sources of persistent pesticides from land runoff or percolation	☐
5) Spill records for petroleum products or designated hazardous substances (Section 311 of CWA)	☐

6) Public records of significant introduction of contaminants from industries, municipalities, or other sources | |

7) **Known existence of substantial material deposits** of substances which could be released in harmful quantities to the aquatic environment by man-induced discharge activities | |

8) Other sources (specify) | |

List appropriate references.

DMMO testing reports & grain size analysis from Fanny

b. An evaluation of the appropriate information in 3a above indicates that there is reason to believe the proposed dredge or fill material is not a carrier of contaminants, or that levels of contaminants are substantively similar at extraction and disposal sites and not likely to require constraints. The material meets the testing exclusion criteria. –

|x| YES |__| NO

3. Disposal Site Delineation (Section 230.11(f)).

a. The following factors, as appropriate, have been considered in evaluating the disposal site.

1) Depth of water at disposal site | x |

2) Current velocity, direction, and variability at the disposal site | x |

3) Degree of turbulence | x |

4) Water column stratification | x |

5) Discharge vessel speed and direction | x |

6) Rate of discharge | x |

7) Dredged material characteristics **(Constituents, amount, and type** of material, settling velocities) | x |

8) Number of discharges per unit of time | x |

9) Other factors affecting rates and patterns of mixing (specify) | x |

List appropriate references:

LTMS (Long-Term Management Strategy Agencies), 1998. Long-Term Management Strategy for the Placement of Dredged Material in the San Francisco Bay Region, Final Policy Environmental Impact Statement/Environmental Impact Report. Volume I.

USACE (United States Army Corps of Engineers), 2015. Final Environmental Assessment/Environmental Impact Report Maintenance Dredging of the Federal Navigation Channels in San Francisco Bay Fiscal Years 2015 – 2024 (State Clearinghouse No. 2013022056).

b. An evaluation of the appropriate factors in 4a above indicates that the disposal site and/or size of mixing zone are acceptable

| x | YES | | NO

4. Actions To Minimize Adverse Effects (Subpart H)(Sec. 230.70-230.77).

All appropriate and practicable steps have been taken, through application of recommendation of Section 230.70-230.77 to ensure minimal adverse effects of the proposed discharge.

| x | YES | | NO

List actions taken:

a. Tidal stage

b. Work windows

c. Amount of fill per scow: 900 CY per scow

5. Factual Determination (Section 230.11).

A review of appropriate information as identified in items 2 - 5 above indicates that there is minimal potential for short or long term environmental effects of the proposed discharge as related to:

a. Physical substrate (review sections 2a, 3, 4, and 5 above). YES | x | NO | |

b. Water circulation, fluctuation and salinity (review sections 2a, 3, 4, and 5) YES | x | NO | |

c. Suspended particulates/turbidity (review sections 2a, 3, 4, and 5). YES | x | NO | |

d. Contaminant availability (review sections 2a, 3, and 4) YES | x | NO | |

e. Aquatic ecosystem structure, function and organisms(review sections 2b and c, 3, and 5) YES | x | NO | |

f. Proposed disposal site (review sections 2, 4, and 5) YES | x | NO | |

g. Cumulative effects on the aquatic ecosystem (beneficial!) YES | x | NO | |

h. Secondary effects on the aquatic ecosystem (beneficial) YES | x | NO | |

6. <u>Review of Compliance (Section 230.10(a)-(d))</u>.

a. The discharge represents the least environmentally damaging practicable alternative and if in a special aquatic site, the activity associated with the discharge must have direct access or proximity to, or be located in the aquatic ecosystem to fulfill its basic purpose.

|_x_| |___|
YES NO

b. The activity does not appear to:
1) violate applicable state water quality standards or effluent standards prohibited under Section 307 of the CWA; 2) jeopardize the existence of Federally listed threatened and endangered species or their critical habitat; and 3) violate requirements of any Federally designated marine sanctuary

|_x_| |___|
YES NO

c. The activity will not cause or contribute to significant degradation of waters of the U.S. including adverse effects on human health, life stages of organisms dependent on the aquatic ecosystem, ecosystem diversity, productivity and stability, and recreational, aesthetic, and economic values ☒ YES ☐ NO

d. Appropriate and practicable steps have been taken to minimize potential adverse impacts of the discharge on the aquatic ecosystem ☒ YES ☐ NO

7. <u>Findings of Compliance or non-compliance</u>. (Sec. 230.12)

The proposed disposal site for discharge of dredged or fill material complies with the Section 404(b)(1) guidelines YES ☒ NO ☐

DATE

District Commander

4. CLEAN AIR ACT AND CLIMATE CHANGE (GREEN HOUSE GASES)

Proposed Alternative A

Redwood City Harbor Sediments Taken to Eden Landing Placement Site

	ROG	CO	NOx	SOx	PM_{10}	$PM_{2.5}$
Peak Daily Emissions Total (lbs/day)	1.24	3.87	28.45	5.09	0.61	0.55
Yearly Project Emissions Totals (tons/year)	0.04	0.13	0.94	0.17	0.02	0.02
BAAQMD Average Daily Threshold (lbs/day)	54.00	N/A	54.00	N/A	82.00	54.00
Project Emissions Exceed BAAQMD Daily Thresholds?	**NO**	N/A	**NO**	N/A	**NO**	**NO**
BAAQMD Yearly Threshold (tons/year)	10	N/A	10	N/A	15	10
Project Emissions Exceed BAAQMD Yearly Thresholds?	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
EPA Yearly Significance Thresholds (tons/year)	100.00	100.00	100.00	100.00	100.00	100.00
Project Emissions Exceed Federal Yearly Threshold?	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**

Alternative B

Oakland Dredging Taken to Emeryville Crescent Placement Site

	ROG	CO	NOx	SOx	PM_{10}	$PM_{2.5}$
Peak Daily Emissions Total (lbs/day)	1.27	3.98	29.26	5.24	0.63	0.57
Yearly Project Emissions Totals (tons/year)	0.04	0.13	0.97	0.17	0.02	0.02
BAAQMD Average Daily Threshold (lbs/day)	54.00	N/A	54.00	N/A	82.00	54.00
Project Emissions Exceed BAAQMD Daily Thresholds?	**NO**	N/A	**NO**	N/A	**NO**	**NO**
BAAQMD Yearly Threshold (tons/year)	10	N/A	10	N/A	15	10
Project Emissions Exceed BAAQMD Yearly Thresholds?	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
EPA Yearly Significance Thresholds (tons/year)	100.00	100.00	100.00	100.00	100.00	100.00
Project Emissions Exceed Federal Yearly Threshold?	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**

Proposed Alternative A	Redwood Dredging Taken to Eden Landing Placement Site	
	Total CO2eq (lbs/day)	1382.78
	Total Project CO2eq (Tons)	45.63
	Council on Environmental Quality Yearly GHG Threshold (CO2eq) (Tons)	None
	Project Exceeds Council on Environmental Quality Yearly GHG Threshold?	**N/A**
	Project is Significant with Respect to Regional Output?	**No**

Alternative B	Oakland Dredging Taken to Emeryville Crescent Placement Site	
	Total CO2eq (lbs/day)	1422.22
	Total Project CO2eq (Tons)	46.93
	Council on Environmental Quality Yearly GHG Threshold (CO2eq) (Tons)	None
	Project Exceeds Council on Environmental Quality Yearly GHG Threshold?	**N/A**
	Project is Significant with Respect to Regional Output?	**No**

Emissions Inventory and Air Quality Analysis: Redwood Dredging to Eden Landing Placement Site (Alternative A)

Emissions Inventory

Emission Source Data							Pollutant Emission Factors for Specific Construction Equipment (lbs/1,000 Gal)[1]						Daily Equipment Emissions from Construction Activities (lbs/day)					
Construction Activity/Equipment Type	**Power Rating (Hp)**	**Power Rating (kW)**	**Load Factor**	**# Active**	**Hrs per Day**	**Fuel Use**	**ROG**	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**	**ROG**	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**
Tug Boat - Redwood to Eden Landing (Towing Barge-Loaded)	800	596.56	0.2	1	2.12	42.40	18.20	57.00	419.00	75.00	9.00	8.10	0.772	2.417	17.766	3.180	0.382	0.343
Tug Boat - Redwood to Eden Landing (Towing Barge-Un-Loaded)	800	596.56	0.2	1	1.59	25.50	18.20	57.00	419.00	75.00	9.00	8.10	0.464	1.454	10.686	1.913	0.230	0.207

Air Quality Analysis

	ROG	CO	NOx	SOx	PM10	PM2.5
Peak Daily Emissions Totals (Redwood to Eden)(lbs/day)	1.24	3.87	28.45	5.09	0.61	0.55
Yearly Project Emissions Totals (Redwood to Eden)(tons/	0.04	0.13	0.94	0.17	0.02	0.02
BAAQMD Average Daily Threshold (lbs/day)	54.00	N/A	54.00	N/A	82.00	54.00
Project Emissions Exceed BAAQMD Daily Thresholds?	**NO**	N/A	**NO**	N/A	**NO**	**NO**
BAAQMD Yearly Threshold (tons/year)	10	N/A	10	N/A	15	10
Project Emissions Exceed BAAQMD Yearly Thresholds?	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
EPA Yearly Significance Thresholds (tons/year)	100	100	100	100	100	100
Project Emissions Exceed Federal Yearly Thresholds?	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**

Tug speed loaded - 6 knots, 1.06 hours delivery time to Eden Landing Placement Site from Dredge Site, twice per day

Tug speed unloaded - 8 knots, 0.797 hours return trip to Dredge Site from Eden Landing Placement Site, twice per day

Tug fuel use - 8 gallons per hour idling, 16 gallons per hour towing unloaded barge, 20 gallons per hour towing loaded barge

Based on a production rate of 1,800 cy per day and 66 days of dredging (112 trips) for a total of 100,000 CY.

Clamshell dredge has 2 hours downtime per day for refueling and shift change

1. Emissions factors for tugboat maintenance dredging taken from the Port of Los Angeles Channel Deepening Project Final Supplemental Environmental Impact Statement/Environmental Impact Report, September 2000.

$\textit{Tug Emissions} = A * EF * T * F$

Where:

A = # of units Active = the number of machines in use for each type

EF = Emission Factor = lbs per 1000 gallons of fuel combusted contributing emissions for each pollutant

T = Time = daily operating time (hours)

F = Fuel = Fuel used per day in gallons

Note: must divide emission factor by 1000 to convert to lbs/gal

Greenhouse Gas Inventory: Redwood Dredging to Eden Landing Placement Site (Alternative A)

Greenhouse Gas Emissions Inventory

Emission Source Data							GHG Emission Factors for Specific Construction Equipment (lbs/Hp-hr)(lbs/1,000 Gal)[1]				Daily Equipment Emissions from Construction Activities (lbs/day)				
Construction Activity/Equipment Type	**Power Rating (Hp)**	**Power Rating (kW)**	**Load Factor**	**# Active**	**Hrs per Day)**	**Fuel Use**	**CO**	**CO_2**	**CH_4**	**NOx**	**CO**	**CO_2**	**CH_4**	**NOx**	**CO2eq**
Tug Boat - Redwood to Eden Landing (Towing Barge-Loaded)	800	596.56	0.2	1	2.12	42.40	57.00	1.12	0.000004	419.00	2.417	380.635	0.002	17.766	827.640
Tug Boat - Redwood to Eden Landing (Towing Barge-Un-Loaded)	800	596.56	0.2	1	1.59	25.50	57.00	1.12	0.000004	419.00	1.454	286.194	0.001	10.686	555.140

Greenhouse Gas Inventory Results

Total CO2eq (lbs/day)	1382.78
Total Project CO2eq (Tons)	45.63
Council on Environmental Quality Yearly GHG Threshold (CO2eq) (Tons)	None
Project Exceeds Council on Environmental Quality Yearly GHG Threshold?	**No**

Tug speed loaded - 6 knots, 1.06 hours delivery time to Eden Landing Placement Site from Dredge Site, twice per day

Tug speed unloaded - 8 knots, 0.797 hours return trip to Dredge Site from Eden Landing Placement Site, twice per day

Tug fuel use - 8 gallons per hour idling, 16 gallons per hour towing unloaded barge, 20 gallons per hour towing loaded barge

Based on a production rate of 1,800 cy per day and 66 days of dredging (112 trips) for a total of 100,000 CY.

Clamshell dredge has 2 hours downtime per day for refueling and shift change

1. Emissions factors for tugboat maintenance dredging taken from the Port of Los Angeles Channel Deepening Project Final Supplemental Environmental Impact Statement/Environmental Impact Report, September 2000.

Tug Emissions= $A * EF * T * F$

Where:
A = # of units Active = the number of machines in use for each type
EF = Emission Factor = lbs per 1000 gallons of fuel combusted contributing emissions for each pollutant
T = Time = daily operating time (hours)

Note: must divide emission factor by 1000 to convert to lbs/gal

CO2eq = CO2 + X*CO + Y*NOx + Z*CH4

Where X = 100 Year Global Warming Potential for Carbon Monoxide = 1
Where Y = 100 Year Global Warming Potential for Oxides of Nitrogen = 298
Where Z = 100 Year Global Warming Potential for Methane = 25

CFR Title 40 Chapter I Subchapter C Part 98: Table A-1 Global Warming Potentials

For Emissions Comparison to Alternatives A and B: No Action - Redwood City Harbor to SF-11

Emissions Inventory

Emission Source Data								Emission Factors (g/hp-hr)				Calculated Emissions (lbs/CY)			
Construction Activity/Equipment Type	**Load Size (CY)**	**Engine Type**	**Engine Size (Hp)**	**Number of Engines**	**Time For 1-way Trip**	**Load Factor**	**Calculated Power Rate (Hp-hr/CY)**	**ROG**	**CO**	**NOx**	**PM10**	**ROG**	**CO**	**NOx**	**PM10**
Tug Boat - Redwood City to SF-11 (Towing Barge-Loaded)	4,500	Tug - Main Engine	1800	1	3.84	0.8	1.2288	0.0300	0.8829	0.9694	0.0224	0.000081	0.002392	0.002626	0.000061
Tug Boat - SF-11 to Redwood City (Towing Barge-UnLoaded)	4,500	Tug - Main Engine	1800	1	2.88	0.8	0.9216	0.0300	0.8829	0.9694	0.0224	0.000061	0.001794	0.001970	0.000045
											Daily Emisions (lbs/day)	0.64	18.84	20.68	0.48

Tug speed loaded - 6 knots, 3.84 hours from Redwood City Dredge Site to SF-11, once per day

Tug speed unloaded - 8 knots, 2.88 hours return trip to Redwood City from SF-11, once per day

Distance from dredge to 3 Mile Limit - 17.5 miles (one-way)

Load Size for Disposal - 4,500 CY

Fill to level (% of capacity) - 90%

Material/round trip - 4500 CY

Transport Rate - 5,000 CY/hr

Emission factors for mechanical dredge engines taken from the USACE Environmental Assessment for Maintenance Dredging of the Federal Navigation Channels in San Francisco Bay Fiscal Years 2015-2024, Appendix B: Air Quality

$Emissions = A * PR * EF$

Where:
A = # of units Active = the number of machines in use for each type
PR = Power Rate = power used per cubic yard of material dredged calculated from the horse power, load factor, and time to dredge each cubic yard.
EF = Emission Factor = fraction of emissions for each pollutant in lbs per hour

Emissions Inventory and Air Quality Analysis: Oakland Dredging to Emeryville Crescent Placement Site Alternative (Alternative B)

Emissions Inventory

Emission Source Data							Pollutant Emission Factors for Specific Construction Equipment (lbs/1,000 Gal)[1]						Daily Equipment Emissions from Construction Activities (lbs/day)					
Construction Activity/Equipment Type	**Power Rating (Hp)**	**Power Rating (kW)**	**Load Factor**	**# Active**	**Hrs per Day**	**Fuel Use**	**ROG**	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**	**ROG**	**CO**	**NOx**	**SOx**	**PM10**	**PM2.5**
Tug Boat - Oakland to Emeryville Crescent (Towing Barge-Loaded)	800	596.56	0.2	1	2.18	43.6	18.20	57.00	419.00	75.00	9.00	8.10	0.794	2.485	18.268	3.270	0.392	0.353
Tug Boat - Oakland to Emeryville Crescent (Towing Barge-Un-Loaded)	800	596.56	0.2	1	1.64	26.24	18.20	57.00	419.00	75.00	9.00	8.10	0.478	1.496	10.995	1.968	0.236	0.213

Tug speed loaded - 6 knots, 1.09 hours delivery time to Emeryville Placement Site from Dredge Site, twice per day
Tug speed unloaded - 8 knots, 0.82 hours return trip to Dredge Site from Emeryville Placement Site, twice per day
Tug fuel use - 8 gallons per hour idling, 16 gallons per hour towing unloaded barge, 20 gallons per hour towing loaded barge
Based on a production rate of 1,800 cy per day and 66 days of dredging (112 trips) for a total of 100,000 CY.
Clamshell dredge has 2 hours downtime per day for refueling and shift change

[1] Emissions factors for tugboat maintenance dredging taken from the Port of Los Angeles Channel Deepening Project Final Supplemental Environmental Impact Statement/Environmental Impact Report, September 2000.

Air Quality Analysis

Peak Daily Emissions Totals (lbs/day)	1.27	3.98	29.26	5.24	0.63	0.57
Yearly Project Emissions Totals (tons/year)	0.04	0.13	0.97	0.17	0.02	0.02
BAAQMD Average Daily Threshold (lbs/day)	54.00	N/A	54.00	N/A	82.00	54.00
Project Emissions Exceed BAAQMD Daily Thresholds?	**NO**	N/A	**NO**	N/A	**NO**	**NO**
BAAQMD Yearly Threshold (tons/year)	10	N/A	10	N/A	15	10
Project Emissions Exceed BAAQMD Yearly Thresholds?	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
EPA Yearly Significance Thresholds (tons/year)	100	100	100	100	100	100
Project Emissions Exceed Federal Yearly Thresholds?	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**

`

$\mathit{Tug\ Emissions} = A * EF * T * \mathrm{F}$

Where:
A = # of units Active = the number of machines in use for each type
EF = Emission Factor = lbs per 1000 gallons of fuel combusted contributing emissions for each pollutant
T = Time = daily operating time (hours)
F = Fuel = Fuel used per day in gallons

Note: must divide emission factor by 1000 to convert to lbs/gal

Greenhouse Gas Inventory: Oakland Dredging to Emeryville Crescent Placement Site (Alternative B)

Greenhouse Gas Emissions Inventory

Emission Source Data							GHG Emission Factors for Specific Construction Equipment (lbs/Hp-hr)(lbs/1,000 Gal)[1]				Daily Equipment Emissions from Construction Activities (lbs/day)				
Construction Activity/Equipment Type	**Power Rating (Hp)**	**Power Rating (kW)**	**Load Factor**	**# Active**	**Hrs per Day**	**Fuel Use**	**CO**	**CO_2**	**CH_4**	**NOx**	**CO**	**CO_2**	**CH_4**	**NOx**	**CO2eq**
Tug Boat - Oakland to Emeryville Crescent (Towing Barge-Loaded)	800	596.56	0.2	1	2.18	43.6	57.00	1.12	0.000004	419.00	2.485	391.407	0.002	18.268	851.064
Tug Boat - Oakland to Emeryville Crescent (Towing Barge-Un-Loaded)	800	596.56	0.2	1	1.64	26.24	57.00	1.12	0.000004	419.00	1.496	294.453	0.001	10.995	571.160

Greenhouse Gas Inventory Results

Total CO2eq (lbs/day)	1422.22
Total Project CO2eq (Tons)	46.93
Council on Environmental Quality Yearly GHG Threshold (CO2eq) (Tons)	None
Project Exceeds Council on Environmental Quality Yearly GHG Threshold?	**No**

Tug speed loaded - 6 knots, 1.09 hours delivery time to Emeryville Placement Site from Dredge Site, twice per day

Tug speed unloaded - 8 knots, 0.82 hours return trip to Dredge Site from Emeryville Placement Site, twice per day

Tug fuel use - 8 gallons per hour idling, 16 gallons per hour towing unloaded barge, 20 gallons per hour towing loaded barge

Based on a production rate of 1,800 cy per day and 66 days of dredging (112 trips) for a total of 100,000 CY.

1. Emissions factors for tugboat maintenance dredging taken from the Port of Los Angeles Channel Deepening Project Final Supplemental Environmental Impact Statement/Environmental Impact Report, September 2000.

Tug Emissions = $A * EF * T * F$

Where:

A = # of units Active = the number of machines in use for each type

EF = Emission Factor = lbs per 1000 gallons of fuel combusted contributing emissions for each pollutant

T = Time = daily operating time (hours)

Note: must divide emission factor by 1000 to convert to lbs/gal

CO2eq = CO2 + X*CO + Y*NOx + Z*CH4

Where X = 100 Year Global Warming Potential for Carbon Monoxide = 1

Where Y = 100 Year Global Warming Potential for Oxides of Nitrogen = 298

Where Z = 100 Year Global Warming Potential for Methane = 25

CFR Title 40 Chapter I Subchapter C Part 98: Table A-1 Global Warming Potentials

For Emissions Comparison to Alternatives A and B: No Action - Oakland Harbor to SF-DODS

Emissions Inventory

Emission Source Data								Emission Factors (g/hp-hr)					Calculated Emissions (lbs/CY)			
Construction Activity/Equipment Type	**Load Size (CY)**	**Engine Type**	**Engine Size (Hp)**	**Number of Engines**	**Time For 1-way Trip**	**Load Factor**	**Calculated Power Rate (Hp-hr/CY)**	**ROG**	**CO**	**NOx**	**PM10**	**CO_2**	**ROG**	**CO**	**NOx**	**PM10**
Tug Boat - Oakland to 3 Mile Limit (Towing Barge-Loaded)	4,500	Tug - Main Engine	1800	1	8	0.8	2.56	0.0300	0.8829	0.9694	0.0224	568.0000	0.000169	0.004983	0.005471	0.000126
Tug Boat - 3 Mile Limit to Oakland (Towing Barge-UnLoaded)	4,500	Tug - Main Engine	1800	1	10.6	0.8	3.392	0.0300	0.8829	0.9694	0.0224	568.0000	0.000224	0.006602	0.007249	0.000167
												Daily Emisions (lbs/day)	1.77	52.13	57.24	1.32

Tug speed loaded - 6 knots, 10.6 hours from Oakland Dredge Site to 3 Mile Limit, once per day

Tug speed unloaded - 8 knots, 8 hours return trip to Oakland Dredge Site from 3 Mile Limit once per day

Distance from dredge to 3 Mile Limit - 17.5 miles (one-way)

Load Size for Disposal - 4,500 CY

Fill to level (% of capacity) - 90%

Material/round trip - 4500 CY

Transport Rate - 5,000 CY/hr

Emission factors for mechanical dredge engines taken from the USACE Environmental Assessment for Maintenance Dredging of the Federal Navigation Channels in San Francisco Bay Fiscal Years 2015-2024, Appendix B: Air Quality

Emissions = $A * PR * EF$

Where:
A = # of units Active = the number of machines in use for each type
PR = Power Rate = power used per cubic yard of material dredged calculated from the horse power, load factor, and time to dredge each cubic yard.

5. COASTAL ZONE MANAGEMENT ACT: CONSISTENCY DETERMINATION

CONSISTENCY DETERMINATION

2023 San Francisco Bay Strategic Shallow-Water Placement Pilot Project

By

U.S. Army Corps of Engineers
San Francisco District

August 2022

The Strategic Shallow Water Placement Pilot Project in San Francisco Bay, offshore of Union City, Alameda County, California, evaluates the potential impacts associated with a new method of placing dredged material in San Francisco Bay that uses natural, in-bay hydrodynamic processes to move dredged sediment placed in shallow water to existing mudflats and marshes, making them more resilient to rising waters. This project focuses on mudflats and salt marshes at a selected location offshore of the Eden Landing Ecological Reserve. The US Army Corps of Engineers, San Francisco District (USACE) is the lead of the project, and the California State Coastal Conservancy (SCC) is the non-cost sharing non-federal sponsor. The San Francisco Regional Water Quality Control Board (Waterboard) is the California Environmental Quality Act (CEQA) lead. The general project area is shown in Figures 1 and 2.

1 AUTHORITY

This Consistency Determination (CD) describes USACE's proposed Strategic Shallow-Water Placement Pilot Project. This CD is being submitted in accordance with the Coastal Zone Management Act of 1972, as amended (CZMA), 16 U.S.C. §1451 and the implementing regulations entitled Federal Consistency with Approved Coastal Management Programs, 15 C.F.R. Part 930. Under these regulations, USACE is responsible for managing its projects within the coastal zone jurisdiction in a manner that is consistent, to the maximum extent practicable, with the coastal zone management programs approved for California by the National Oceanic and Atmospheric Administration (NOAA). The program applicable to USACE projects in San Francisco Bay is the San Francisco Bay Plan (Bay Plan), which is administered by the San Francisco Bay Conservation and Development Commission (BCDC).

The beneficial use of material dredged from a San Francisco Bay federal navigation channel and placed in shallow bay water is authorized by Section 1122 of WRDA 2016. Section 1122 requires USACE to establish ten pilot projects, nationwide, that beneficially use dredged material. The intent is to:

- maximize the beneficial placement of dredged material from federal and non-federal navigation channels;
- incorporate, to the maximum extent practicable, two or more federal navigation, flood control, storm-damage reduction, or environmental restoration projects;
- coordinate the mobilization of dredges and related equipment, including using such efficiencies in contracting and environmental permitting as can be implemented under existing laws and regulations;
- foster federal, state, and local collaboration;
- implement best practices to maximize the beneficial use of dredged sand and other sediments;

- ensure that the use of dredged material is consistent with all applicable environmental laws.

Of the several stated purposes in the pilot program’s implementation guidance, this Strategic Placement Pilot Project falls under “Other innovative uses and placement alternatives that produce public, economic, or environmental benefits”.

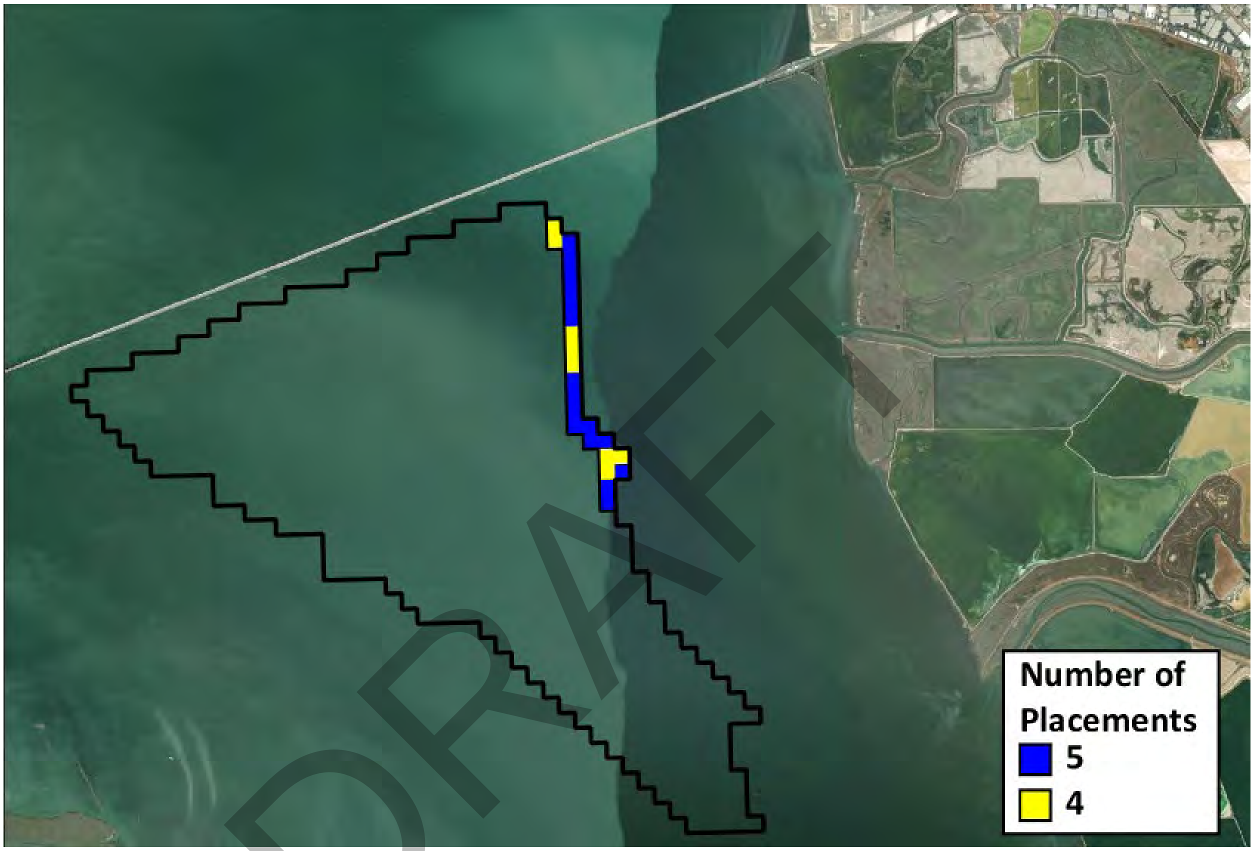

Figure 1. Placement cells in shallow water aproximately two miles off the marsh at Eden Landing (i.e., Whale’s Tail) for the Shallow/East placement.The black outline represents the entire placement grid, while the blue and yellow cells represent the Eden Landing Shallow/East placement footprint cells with five and four placements respectively depending on the water depths and tidal timings. The placement footprint is approximately 9,700 feet long and 630 feet wide and covers approximately 138 acres (i.e., the area comprised by the blue and yellow grid cells).

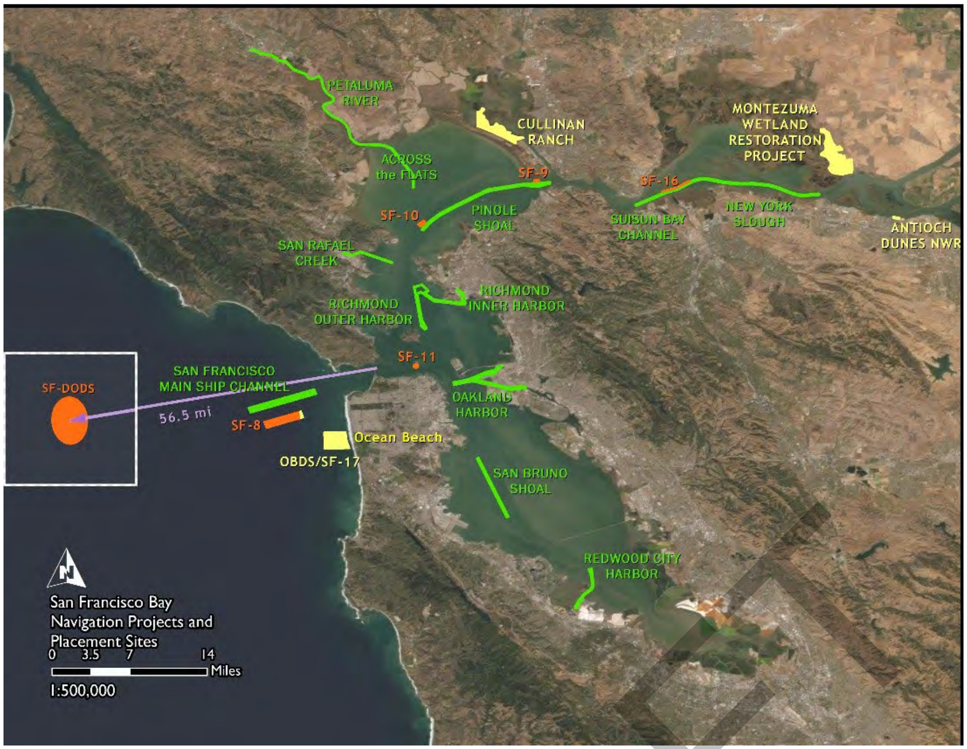

Figure 2. San Francisco District (SPN) Federal Navigation Projects

2 DETERMINATION

The proposed Strategic Placement Pilot Project entails the diversion of 100,000 cubic yards of suitable Redwood City O&M dredged material from the usual disposal location at SF-11[1], or suitable Oakland Harbor O&M dredged material to the subtidal area just off the Eden Landing Ecological Reserve. The material will be monitored to determine how much is transported on to the adjacent mudflats and tidal marsh to determine if nearshore placement is a possible tool to help maintain sediment surface elevations with respect to sea level rise and protect these habitats in the future.

The proposed Strategic Placement Pilot Project is entirely within the jurisdiction of BCDC under the CZMA and Bay Plan.

The USACE has evaluated the proposed project and has determined that it is consistent, to the maximum extent practicable, with the San Francisco Bay Plan Policies. A detailed project description and an assessment of this project's consistency with those policies are provided below.

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[1] Using funds from Assembly-person Mullin, funds were used during the 2019 dredging season which placed ~41k CY of dredged material from the Port of Redwood City at Montezuma Wetlands, using ~$562k. In 2021, Mullin funds were used to place ~199k CY using ~$2.5 million. The balance of the funds is currently ~$2.6 million.

3 PROJECT LOCATION AND EXISTING CONDITIONS

Redwood City Harbor and the Eden Landing Ecological Reserve are located on opposite sides of South San Francisco Bay just south of the San Mateo Bridge. The bay bottom in this region is comprised of muddy and sandy shallow water habitat with some areas of oyster shell and bryozoan reefs.

4 PROJECT DESCRIPTION

The proposed Strategic Placement Pilot Project would place approximately 100,000 CY of sediment from operation and maintenance (O&M) dredging in a shallow-water placement area adjacent to the mudflat and marsh at Eden Landing (Figure 1) to evaluate the ability of tides and currents to move dredged sediment placed in the nearshore environment to the adjacent mudflat and marsh (Figure 3, Figure 4). Throughout one dredging episode of either the Redwood City Harbor or the Oakland Harbor Operations and Maintenance (O&M) Project (or a combination of the two), scows with dredged material will be diverted from the federal standard placement site SF-11 or SF Deep Ocean Disposal Site (SF-DODS) respectively (Figure 2) and placed at the in-bay, strategic placement site. Based on wave and current modeling, the scows will unload in water depths of approximately 10 ft in absolute depth (i.e., the placement location will vary somewhat depending on the stage of the tide) to maximize inland transport of sediment by waves and currents. Placements will take place during flood tides within a 138-acre placement footprint that was determined by computer modeling and geospatial analysis to be most suitable for successful transport of sediment into mudflat and marsh areas. Scows light loaded with 900 CY of dredge material will make approximately 112 round trips between Redwood City (or Oakland) and the placement site. All placement activities will occur between June 1 and November 30, which is the work window for O&M dredging activities. The placement area and adjacent mudflat-marsh complex will be monitored before and after placement. Both pre- and post-project monitoring will occur in the following areas:

Pre-project monitoring (see Appendix D for more detail)

- Bathymetry and topography
- Oceanographic data collection: suspended sediment concentration (SSC), wave conditions
- Benthic communities
- Eelgrass surveys
- Sediment flux across the shallows
- Background marsh accretion rates

Post-project monitoring

- Resurveys of placement site
- Benthos, eelgrass recovery
- Oceanographic data collection: SSC, wave conditions
- Sediment flux post placement
- Marsh and mudflat accretion
- Particle tracking study

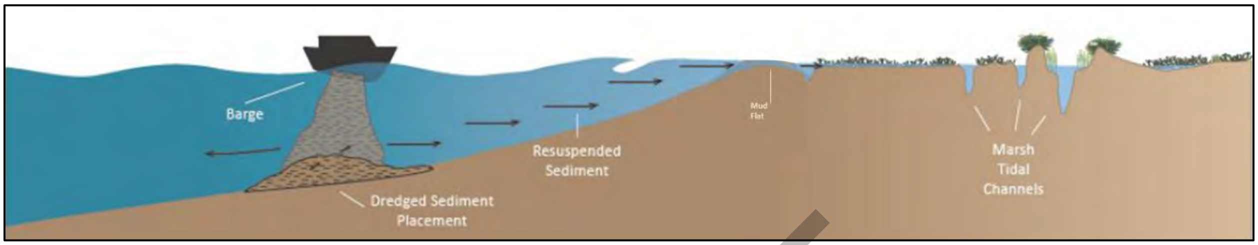

Figure 3. Strategic shallow-water placement cross-sectional conceptual model.

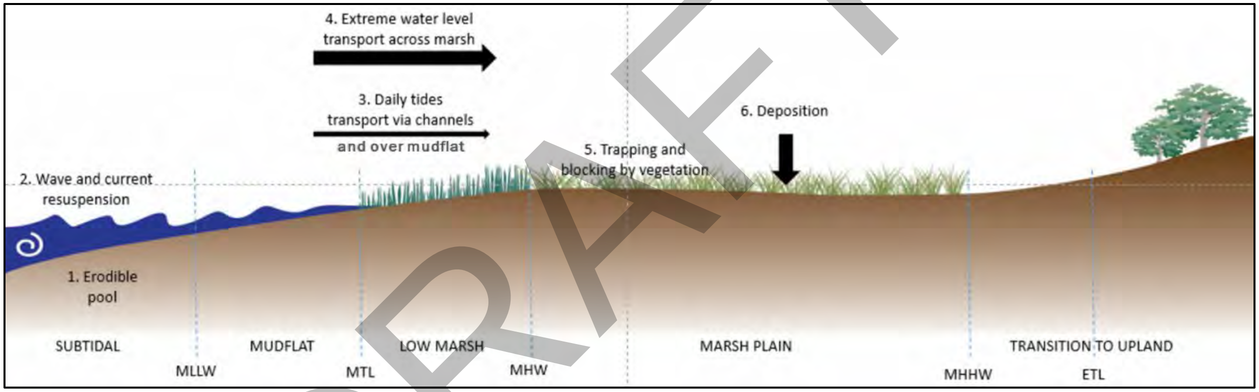

Figure 4. Inorganic sediment supply to mudflats and marshes.

5 CONSISTENCY WITH PROVISIONS OF THE SAN FRANCISCO BAY PLAN

This section presents analyses of the Proposed Action's consistency with applicable Bay Plan policies. The project area does not contain, and the project does not propose and would not result in impacts related to, the following Bay Plan policy topics: freshwater inflow; safety of fills; water related industry; ports; airports; transportation; commercial fishing; salt ponds; managed wetlands; fill for Bay-oriented commercial recreation and Bay-oriented public assembly on privately-owned property; filling for public trust uses on publicly-owned property granted in trust to a public agency by the legislature; and public trust. Consequently, Bay Plan polices related to these topics are not addressed further in this document. Applicable Bay Plan topics and policies are identified and discussed below.

5.1 FISH, OTHER AQUATIC ORGANISMS AND WILDLIFE

To ensure that the shallow water placement of dredge material is conducted in a manner that protects special-status species and their habitats in and around San Francisco Bay, USACE is consulting with the National Marine Fisheries Service (NMFS) on the project, in accordance with Section 7(a)(2) of the Endangered Species Act (ESA) (16 U. S.C. 1536[c]) and Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (Public Law 104297). The USACE will consider any recommendations and ensure compliance with any requirements from NMFS that are applicable to the to avoid potential adverse effects on special-status species and their habitat.

5.2 SPECIAL-STATUS FISH SPECIES AND ESSENTIAL FISH HABITAT

Table 1. Special Status Species, Critical Habitats, and EFH potentially occurring in and adjacent to the proposed action area.

Scientific Name	Common Name	Status	Statutory Protection
Sterna antillarum browni	California least tern	Endangered	FESA; CESA
Rallus obsoletus	Ridgway's rail	Endangered	FESA, CESA
Charadrius alexandrinus nivosus	Western snowy plover	Threatened	FESA
Acipenser medirostris	North American green sturgeon, Southern Distinct Population Segment (DPS)	Threatened with Critical Habitat Present	FESA
Onchorhynchus mykiss	Steelhead, Central California Coast DPS	Threatened with Critical Habitat Present	FESA
Spirinchus thaleichthys	Longfin smelt	Threatened	CESA
Reithrodontomys raviventris	Southern salt marsh harvest mouse	Endangered	FESA; CESA
Enhydra lutris nereis	Southern sea otter	Threatened	FESA

Zalophus californianus	California Sea Lion	Protected	MMPA
Phoca vitulina	Pacific harbor seal	Protected	MMPA
---	Pacific Groundfish Fisheries Management Plan (FMP)	Essential Fish Habitat; Seagrass (I.e., Eelgrass) and Estuary HAPCs	MSFCMA
---	Coastal Pelagic FMP	Essential Fish Habitat	MSFCMA
---	Pacific Salmon FMP	Essential Fish Habitat; Marine and Estuarine Submerged Aquatic Vegetation (I.e., Eelgrass) and Estuary HAPCs	MSFCMA
---	Bryozoan Reefs	---	NA
---	Olympia oyster beds	---	NA

Notes: **State Status:** FP = Fully Protected ST = State Listed Threatened

5.2.1 California Least Tern

The breeding population of the California least tern (*Sternula antillarum browni*) is distributed in five clusters along the coast: Bay area, San Luis Obispo/Santa Barbara County, Ventura County, Los Angeles/Orange County, and San Diego (HT Harvey 2012). The California least tern was listed as a federal endangered species in 1970 under the FESA, and as a State endangered species in 1980 under the CESA. Least terns typically arrive at California breeding areas in middle or late April and begin courting immediately (Goals Project 1999). Nesting happens in two waves, one from early May through early June, and the second from mid-June through early July (Goals Project 1999). Least terns prefer to build their nests on open sand or fine gravel substrate with sparse vegetation. They are opportunistic nesters and will sometimes use newly filled or graded lands and airports. Nests are usually found near open water, usually along coastal beaches and estuaries, with adequate food sources (Goals Project 1999). California least terns forage in both shallow and deep water by hovering and diving into the water to catch prey. Nesting sites for least terns exist along the runway apron at the former Naval Air Station Alameda in the city and county of Alameda. Least terns have been observed to forage primarily along the breakwaters and shallows of the southern shoreline of Naval Air Station Alameda and in Ballena Bay during May through August. Least terns are known to use a restoration site (i.e., the Middle Harbor Enhancement Area [MHEA]) in the middle harbor area of Oakland Harbor for foraging and roosting. Foraging from this colony probably also extends into the Emeryville Crescent. Surveys conducted by the San Francisco Bay Bird Observatory have documented least tern nesting in the Eden Landing Ecological Reserve. Between May 27 and July 22, 2019, at least 48 pairs established at least 101 nests at pond E14 that were confirmed and monitored (San Francisco Bay Bird Observatory 2019). These birds would be expected to forage in the waters nearby including the proposed placement area and areas where the material would settle.

Potential Impacts to California Least Tern

Eelgrass beds are important spawning habitat for San Francisco topsmelt and jacksmelt, both species on which least terns prey. However, all eelgrass in the project area would be outside of the 250 m buffer zone (i.e., from the dredge placement site) established by NMFS (2011) for protection from indirect effects of dredging activity such as turbidity. Dredge material from Redwood City Harbor normally is placed at the designated in-bay site, SF-11. Consequently, impacts such as increased turbidity and its effects on prey resources and potential release of contaminants from project dredge material placement have been accounted for as part of the USFWS biological opinion on the LTMS (USFWS 1998). As placement activities for this project will occur approximately 2 miles offshore, disruption of least tern nesting and/or breeding activities is not anticipated.

5.2.2 Ridgway's rail

Ridgway's rail (previously known as the California Clapper rail) was listed as endangered under the ESA by the USFWS on October 13, 1970 (35 Fed. Reg. 16047). Ridgway's rail is also listed as endangered under CESA by CDFW and is considered a fully protected species. The species formerly occurred in salt marshes along the California coast from Humboldt Bay to San Luis Obispo County, but at present it is only found in salt marshes around San Francisco, San Pablo, and Suisun bays. Ridgway's rails favor habitats that are dominated by pickleweed (*Salicornia pacifica*) with extensive stands of Pacific cordgrass (*Spartina foliosa*) and are subject to direct tidal circulation. These habitats provide an intricate network of tidal sloughs and abundant numbers of benthic invertebrates for foraging (Harvey 1988) and serve as escape routes from predators (Zembal and Massey 1983; Foerster et al. 1990).

Ridgway's rail is a permanent resident of salt and brackish marshes around San Francisco Bay. The only remaining populations occur in San Francisco Bay. Since the mid-1800s, about 80 percent of San Francisco Bay's marshlands have been eliminated through filling, diking, or conversion to salt evaporation ponds. As a result, Ridgway's rail lost most of its former habitat, and the population declined severely. These birds also require shallow areas or mudflats for foraging, particularly channels with overhanging banks and vegetation (Goals Project 2000). Ridgway's rails forage on crabs, mussels, clams, snails, insects, spiders, worms, and occasionally mice and dead fish. As a refuge from extreme high tides and as a supplementary foraging area, rails move to the upper marsh vegetation where it intergrades with upland vegetation. These birds have no requirement for fresh water. Ridgway's rails nest from early March through August in the tallest vegetation along tidal sloughs, particularly in California cordgrass and marsh gumplant. They are nonmigratory, although juveniles disperse during late summer and autumn. The USFWS considers all potential habitat to be occupied by this species unless surveys that year document its absence.

Surveys conducted by the San Francisco Estuary Invasive Spartina Project in 2020 detected Ridgway's rails in the project area at Whale's Tail Marsh, The Eden Landing Ecological Reserve, along Mt Eden Creek, and along Alameda Creek. Densities were highest in the south units of Whale's Tail Marsh and Eden Landing Ecological Reserve. The surveys also detected rails in the Emeryville Crescent, although in lower densities. (San Francisco Estuary Invasive Spartina Project 2020).

Potential Impacts to Ridgway's Rail

The potential impact to Ridgway's rails would be the alteration or degradation of their foraging and nesting habitat on the mudflats due to increased sedimentation as the placed material migrates on to the flats and into the marsh. Modeling predicts that less than 0.1 mm would be deposited in areas of the tidal marsh. This is not expected to affect the availability of rail prey species. In addition, this low level of inundation is not expected to affect Spartina health and vigor and therefore would not have a deleterious effect on Ridgway's rail nesting habitat. As placement activities for this project will occur approximately 2 miles offshore, disruption of Ridgway's rail nesting and/or breeding activities is not anticipated.

5.2.3 Western Snowy Plover

The western snowy plover (*Charadrius alexandrinus nivosus*) is listed as threatened under the ESA. Western snowy plovers are one of two recognized subspecies of snowy plovers in North America. The coastal population, about 2,000 birds, breeds along the Pacific coast from southern Washington to southern Baja California, Mexico. Breeding occurs from March through September. Plovers forage for invertebrates on wet sand areas of intertidal zones, in dry, sandy areas above high tide lines, on salt pans and along the edges of salt marshes and salt ponds. They nest on coastal sand spits, dune-packed beaches, gravel bars, beach strands with little or no vegetation, open areas around estuaries, and on beaches at river mouths and gravel bars from early March to the third week in July. Both eggs and nests are extremely difficult to see even at close range. Chicks leave the nest within hours of hatching but cannot fly for about a month. Western snowy plovers are site-faithful nesters, returning to successful nesting sites year after year.

Surveys conducted by the San Francisco Bay Bird Observatory monitored 79 nests in the Eden Landing Ecological Reserve with the highest densities in ponds E14, E6B, and E8. Weekly counts were higher at the preserve than at any other South Bay site monitored with a weekly average of 122.7 birds per week (San Francisco Bay Bird Observatory 2021). Snowy plovers also forage along the marsh edge at Whale's Tail Marsh. Plover foraging also occurs along the marsh edge and in pannes at Emeryville Crescent.

Potential Impacts to Western Snowy Plover

The potential impact to snowy plovers would result from the alteration or degradation of their foraging habitat on the mudflats due to increased sedimentation as the placed material migrates on to the flats and into the marsh. Modeling predicts that less than 1 mm would be deposited on areas of the mudflat. This is not expected to affect plover prey species or plover's ability to forage. As placement activities for this project will occur approximately 2 miles offshore, disruption of snowy plover nesting and/or breeding activities is not anticipated.

5.2.4 North American Green Sturgeon Southern DPS

On April 7, 2006, the Southern DPS of the North American green sturgeon was listed as threatened under the ESA by NOAA Fisheries (71 Fed. Reg. 17,757). Green sturgeon is also considered a species of special concern by CDFW. Green sturgeon are not abundant along the Pacific Coast but are known to exist in the Estuary (Pycha 1956; Skinner 1962; Moyle 2002). Green sturgeon are anadromous fish that spend most of their lives in estuarine or marine waters and return to natal rivers to spawn. Adult southern DPS green sturgeon spawn in the reaches of the Sacramento River watershed with swift currents and large cobble. Adult green sturgeon enter San Francisco Bay between late February and early May, as they migrate to spawning grounds in the Sacramento River (Heublein et al. 2009). Post-spawning adults may be present in San Francisco Bay Estuary during the spring and early summer for months prior to migrating to the ocean. Green sturgeon larvae begin feeding approximately 10 to 15 days after hatching, and approximately 35 days later metamorphose into juveniles. After hatching, young-of-the-year (i.e., first-year juvenile) green sturgeon move into the Delta and Estuary where they may remain for 2 to 3 years before migrating to the ocean (Allen and Cech, Jr. 2007; Kelly et al. 2007). Sub-adult and nonspawning adult green sturgeon use both ocean and estuarine environments for rearing, foraging, and feeding on benthic invertebrates, crustaceans, and fish (Moyle 2002).

Potential Impacts to Green Sturgeon

Eggs or larval life stages of green sturgeon are not expected to be present at either of the shallow water placement alternative sites or at the no action alternative placement locations because they spawn upstream in the Sacramento River as stated above. Large adult and juvenile fish would be motile enough to avoid the physical effects in areas of high turbidity plumes caused by dredged material disposal. Green sturgeon are fairly tolerant of turbidity and may even be attracted to the invertebrates contained within the placed material as a food source. There is the remote possibility that an individual may be smothered by the placed material if the barge were to discharge directly overhead. Sturgeon sometimes will remain immobile on the bottom rather than flee. The likelihood of a barge depositing directly on a green sturgeon is extremely remote.

Brief plumes caused by in-water placement have the potential to reduce food availability and foraging success for green sturgeon that might be in the vicinity of the placement sites. Species that might be affected can forage in the unaffected areas surrounding the placement site, so any temporary reduction in food supply and foraging success would be minor. No significant long-term effects to pelagic-based food resources are expected, because of the fairly rapid recovery expected in these communities and the small area affected.

5.2.5 Central California Coast Steelhead DPS

Central California Coast steelhead was federally listed as threatened on August 18, 1997 and is a CDFW species of concern. The Central Valley steelhead was initially listed as threatened under the ESA by National Oceanic and Atmospheric Administration (NOAA) Fisheries on March 19, 1998 (63 Fed. Reg. 13,347); this listing was reaffirmed on January 5, 2006 (71 Fed. Reg. 834).

Steelhead historically ranged throughout the northern Pacific Ocean, from Baja California to Kamchatka Peninsula. Currently, their range extends from Malibu Creek in southern California to Kamchatka Peninsula (Busby et al. 1996). San Francisco Bay and its tributary streams support migrating steelhead populations. *O. mykiss* can be either anadromous or can complete their entire life cycle in fresh water. Those fish that remain in fresh water are referred to as rainbow trout. Steelhead, the anadromous form of *O. mykiss*, can spend several years in fresh water prior to smoltification, and can spawn more than once before dying, unlike most other salmonids (Busby et al. 1996). Adult steelhead typically migrate from the ocean to fresh water between December and April, peaking in January and February (Fukushima and Lesh 1998). Juvenile steelhead migrate as smolts to the ocean from January through May, with peak migration occurring in April and May (Fukushima and Lesh 1998). Central California Coast Steelhead DPS spawns in tributaries of San Francisco Bay, including the watersheds of the Petaluma and Napa rivers, and several tributaries of the South Bay. Central Valley steelhead DPS spawn in the Sacramento and San Joaquin watersheds.

Potential Impacts to Steelhead

Eggs or larval life stages of steelhead are not expected to be present at either of the shallow water placement alternative sites or at the no action alternative placement locations due to the use of the June 1 – November 30 work window for the dredge placement. Similarly, few adult or juvenile fish are expected to be present in South San Francisco Bay during the work window, and any that are present would be motile enough to avoid areas of high turbidity plumes caused by dredging.

Brief plumes caused by in-water placement have the potential to reduce food availability and foraging success for fish and marine mammals that might be in the vicinity of the placement sites. It is expected that steelhead will avoid the plumes, which are ephemeral in nature (LTMS 1998). Species that might be affected can forage in the unaffected areas surrounding the placement site, so any temporary reduction in food supply and foraging success would be minor. No significant long-term effects to pelagic-based food resources are expected due to the rapid recovery expected in these communities and the small area affected.

5.2.6 Longfin Smelt

Longfin Smelt was listed as threatened under CESA in 2009 (CDFG 2009). The species generally has a 2-year life cycle and die after spawning. However, some individuals delay spawning until age 3, and repeat spawning may be possible (Baxter 2018).

Adult longfin smelt inhabit bays, estuaries, and near shore coastal habitats; including Suisun, San Pablo, Central, and South San Francisco bays (CDFW 2009). During the late fall, adults migrate from these areas to the low salinity zone of eastern Suisun Bay and the western Delta. Spawning may start as early as November and extend through July (Baxter 1999).

Embryos hatch primarily between January through March and are buoyant (CDFG 2009). They move into the upper part of the water column and are transported to Suisun, San Pablo, Central, and South San Francisco bays with high spring and winter flows to waters with salinities ranging from 15 to 30 psu.

Longfin smelt larvae begin feeding on copepods and cladocerans, and as they grow, they also feed on mysids and amphipods (CDFG 2009). Juveniles predominately feed on mysids, amphipods, copepods, and daphnia, with fish making up a smaller portion. Adult longfin smelt feed primarily on opossum shrimp, Acanthomysis spp. and Neomysis mercedis, when available. Longfin smelt feed throughout the day and into the night, which suggests that turbidity may not hamper feeding success. They have well developed olfactory organs that aid in finding prey (CDFG 2009).

Potential Impacts to Longfin Smelt

All life stages of longfin smelt are rare in South San Francisco Bay in the summer and fall (Robinson and Greenfield 2011). Often zero individuals have been detected near the project area in over 25 years of sampling (Robinson and Greenfield 2011). Their presence even in winter months tends to occur during years of high freshwater outflow. Consequently, longfin smelt are unlikely to encounter project activities including dredge material placement.

5.2.7 Salt Marsh Harvest Mouse

The salt marsh harvest mouse (*Reithrodontomys raviventris*) was listed as Federally Endangered in 1970 under the FESA, and as a State endangered species under the CESA in 1971. It occurs in native salt and brackish habitats of tidal or diked marshes throughout the San Francisco Estuary. The northern subspecies (*R.r. halicoetes*) is found on the upper portion of the Marin Peninsula, and in the Suisun, Petaluma, and Napa marshes and San Pablo Bay. A few, small disjunct populations are found on the northern coast of Contra Costa County. The southern subspecies (*R.r. raviventris*) occurs primarily in the South Bay with a few, small disjunct populations on the Marin Peninsula and along the Richmond shoreline (Goals Project 2000). The highest number of consistent populations occurs in marshes on the eastern side of San Pablo Bay and in the dredged material disposal ponds on the Mare Island Shipyard property (Bias and Morrison 1993; Duke et al. 2004).

Salt marsh harvest mice depend on dense vegetative cover for protection from predators (Goals Project 2000). The mice prefer the deepest (60-75 cm tall), most dense pickleweed, mixed with fat hen and alkali heath.

Salt marsh harvest mice breed from March to November, and during this time, they build ball like nests of dry grasses and other vegetation on the ground or up in the pickleweed (Goals Project 2000). Salt marsh harvest mice are known to occur in the tidal marshes around Eden Landing and Emeryville Crescent. This project will assume presence of the mice in any pickleweed habitat.

Potential impacts to Salt Marsh Harvest Mouse

Increased sedimentation has the potential to affect the health and vigor of the salt marsh vegetation that they depend upon for cover from predation, feeding, and nesting. Modeling predicts that less than two millimeters would be deposited in areas of the tidal marsh. This is not expected to affect the health of marsh vegetation or have any effect on the salt marsh harvest mouse. As placement activities for this project will occur approximately 2 miles offshore, disruption of salt marsh harvest mouse nesting and/or breeding activities is not anticipated.

5.2.8 Marine Mammals

The most common marine mammals in the Estuary are the Pacific harbor seal, harbor porpoise (*Phocoena phocoena*), and the California sea lion (*Zalophus californianus*). Other marine mammal species that have been seen occasionally in San Francisco Bay include the gray whale (*Eschrichtius robustus*), northern elephant seal (*Mirounga angustirostris*), Steller sea lion (*Eumetopias jubatus*), northern fur seal (*Callorhinus ursinus*), and, less frequently, the southern sea otter (*Enhydra lutris*). These rare visitors to the Bay are generally sited in the deeper Central-Bay waters. On very rare occasions, individual humpback whales (*Megaptera novaeangliae*) have entered San Francisco Bay. The only marine mammals expected to be in the project area are harbor seals, California sea lion and possibly harbor porpoise on occasion.

Pacific harbor seals are nonmigratory and use the Estuary year-round, where they engage in limited seasonal movements associated with foraging and breeding activities (Kopec and Harvey 1995). Harbor seals haul out (come ashore) in groups ranging in size from a few individuals to several hundred. Habitats used as haul-out sites include tidal rocks, bayflats, sandbars, and sandy beaches (Zeiner et al. 1990). No haul-out sites are in either of the shallow water placement sites, however it is possible that an individual may haul out on the mud flats from time to time.

Harbor porpoise have been regularly sighted in San Francisco Bay in recent years, indicating that the species has likely recolonized the area after a long absence. Studies are currently underway to determine the size and status of this population. Most of the sightings have occurred near the Golden Gate, with some sightings occurring in the vicinity of Angel Island and Alcatraz (Keener 2011). Harbor porpoises feed on fishes such as herring, sardines, and whiting, and on squid.

California sea lions breed in Southern California and along the Channel Islands. After the breeding season, males migrate up the Pacific Coast and enter the Estuary. In San Francisco Bay, sea lions are known to haul out at Pier 39 in the Fisherman’s Wharf area. During anchovy and herring runs, approximately 400 to 500 sea lions (mostly immature males) feed almost exclusively in the North and Central bays (USFWS 1992).

Potential impacts to Marine Mammals

Increased turbidity and activity during dredge material placement may disturb marine mammal foraging activities by temporarily decreasing visibility or causing the relocation of mobile prey from the area affected by the sediment plume. Marine mammals would not be substantially affected by placement operations because they forage over large areas of San

Francisco Bay and the ocean and can avoid areas of temporarily increased turbidity and placement disturbance.

5.2.9 Habitats of Special Significance

The MSFCMA was enacted to maintain healthy populations of commercially important fish species. Under the MSFCMA, eight regional Fishery Management Councils are responsible for developing FMPs to manage these species. The 1996 amendments to the MSFCMA included protecting the habitats of species for which there is an FMP; these habitats are designated as EFH.

EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 USC 1802.10). EFH can consist of both the water column and the underlying surface (e.g., seafloor) of a particular area, and it includes those habitats that support the different life stages of each managed species. A single species may use many different habitats throughout its life to support breeding, spawning, nursery, feeding, and protection functions. The Central San Francisco Bay (Central Bay), including the Action Area, is designated EFH for assorted fish species managed under the following FMPs:

- Pacific Coast Groundfish
- Coastal Pelagic Species, and
- Pacific Salmon.

In the San Francisco Bay-Delta region, NMFS has designated two HAPCs that may be affected by the proposed action. HAPCs are a subset of EFH; these areas are rare, particularly susceptible to human-induced degradation, especially ecologically important, and/or located in an environmentally stressed area. They include:

- Eelgrass (*Zostera marina*) beds, and
- Estuary.

Two additional rare habitat types occur in South San Francisco Bay and may be present in the proposed project areas:

- Olympia oyster (*Ostrea lurida*) beds, and
- Bryozoan reefs.

Potential impacts to Habitats of special Significance

Surveys at both the Eden Landing and Emeryville Crescent have shown the presence of small ephemeral patches of eelgrass that change from year to year. Conditions at both sites are not particularly conducive to healthy eelgrass growth. One exception is a slowly expanding colony along the north side of the Bay Bridge abutment. A shoal is developing there that appears to be more conducive to eelgrass growth (4.3.1).

Any eelgrass in the direct footprint of the placement would likely be buried by the either of the action alternatives. However, the most recent available maps show that all eelgrass in the project area would be outside of the 250 m buffer zone (i.e., from the dredge placement site) established by NMFS (2011) for protection from indirect effects of dredging activity such as turbidity. In any case, surveys to map any potential eelgrass patches in the area will be conducted as part of the proposed project before and after the material is placed. This will allow the project to minimize potential effects to eelgrass by avoiding areas where it is detected if possible. Material would migrate by natural physical processes after the initial plume settles and thereafter is not expected to raise turbidity beyond the ambient range. Areas immediately adjacent to the mound could receive up to 2 cm of sediment from the placed berm. This is at the lower range of where sensitivity to burial can occur. Eelgrass further up on the subtidal flats would receive much less sedimentation and would not be affected. Monitoring of turbidity, suspended sediment concentration, and sedimentation will be conducted during placement and for two months after to verify modeling assumptions.

The proposed project is located in estuary habitat, which in South San Francisco Bay has relatively high background levels of turbidity and suspended sediment. The project is very small compared to the large amount of estuary habitat available. Specifically, the dredge material placement site is about 138 acres or 0.22 square miles in size, whereas the area of Suisun, San Pablo, and San Francisco bays combined is estimated to be about 225 square miles (i.e., assuming dimensions of 75 miles long x 3 miles wide on average). In general, project effects to the existing estuary habitat are expected to be minor, temporary, and localized.

Olympiae oysters are considered a historical keystone species for San Francisco Bay and contribute to EFH where oyster beds occur. A century ago, native oysters were a highly visible component of San Francisco Bay ecosystems, supporting industries from cement-making to gourmet dining. Oysters require hard substrate for larval settlement, preferably other oyster shells, and this settling habit led to the formation of oyster reefs, the nooks and crannies of which support communities of fish, crab, and other invertebrates. By the early 1900s, however, overfishing, habitat degradation, and the introduction of nonnative shellfish led to the decline of native oysters. Although "shell hash" occurs near Eden Landing and differs from the typical mud or sand benthic substrate, oyster beds are not known to occur at either of the alternative placement sites.

Bryozoan reefs occur in South San Francisco Bay and may be present in the project area (Zabin et al. 2010). As with shell hash, bryozoan reefs constitute a unique benthic substrate compared to the typical sand or mud. They are relatively widespread in South San

Francisco Bay and are not expected to be greatly impacted by the proposed project due to its small size and the likelihood of bryozoan recolonization.

5.3 WATER QUALITY

The Strategic Placement Pilot Project would not result in adverse effects to tidal marshes or tidal flats, nor would it affect the surface area, flow of water into the Bay, and volume of the Bay. The project does not involve new construction, sewage systems, bayside parking lots, or commercial fishing docks. This project will not cause harm to the public, Bay resources or long-term beneficial uses of the Bay.

Water quality impacts assessed from the proposed project include those associated with transport and placement of 100,000 CY of sediment to the proposed placement site. Potential impacts to dissolved oxygen levels may occur during placement of material. Direct, localized, minor, and temporary reductions in dissolved oxygen may occur. The impact to dissolved oxygen would be short-term and less than significant. No impacts to salinity, temperature, and pH are anticipated.

Temporary and minor impacts to water quality parameters may occur during placement. These impacts would be short-term and less than significant.

Turbidity and TSS impacts assessed from the proposed project include those associated with shallow water placement of 100,000 CY of sediment over approximately 19 - 56 days (occurring between June 1 and November 30), corresponding to approximately 112 trips (Figure 3). Placement of material will create a temporary (approximately 15 minutes) sediment plume and mound per scow trip. A temporary increase in suspended sediments from the placement plume may reduce light penetration and cause siltation on bottom flora and fauna. Wind waves in this area are sufficient to mobilize the bed most afternoons in the summer, so the difference between existing conditions and placement conditions are unlikely to be significant.

The basic purpose of the proposed project is to ascertain the feasibility of using strategic, in-water sediment placement to maintain mudflats and tidal marshes. This is considered a beneficial impact to mudflats and tidal marshes adjacent to Eden Landing.

A Section 404(b)(1) analysis was conducted on the recommended plan and is included in the Environmental Appendix A §b. Pursuant to the Clean Water Act of 1972, as amended, the discharge of dredged or fill material associated with the recommended plan has been found to be compliant with section 404(b)(1) Guidelines (40 CFR 230).

Sediments are tested prior to dredging, and the results are reviewed by the DMMO prior to dredging, transport, and placement, including evaluation of the potential for impact to aquatic organisms. Sediment testing results for previous USACE maintenance dredging episodes at Oakland Harbor and Redwood City Harbor indicate that, in general, dredged materials from the subject federal navigation channels have been suitable for unconfined aquatic disposal. Some isolated areas in Reach 5 of the Redwood City channel have been identified as containing sediment that is not suitable for unconfined aquatic disposal (NUAD); USACE would avoid importing material from these areas. Therefore, dredging and placement activities would not be expected to increase contaminant concentrations in the environment above baseline conditions.

Significant impacts to water quality are not anticipated. This project is consistent to the maximum extent practicable with all Water Quality Bay policies.

5.4 WATER SURFACE AREA AND VOLUME

Based on initial modeling results, the proposed Strategic Placement Project would add 1-2 mm of sediment on the mudflats between the placement site and Whale's Tail Marsh. This placement of sediment would slightly increase fill in the bay; the modeling predicts that tides and currents will move the placed material to the existing mudflats and marshes near Eden Landing.

Placement of dredged material in Bay waters by Eden Landing will not reduce water surface area and would cause an imperceptible decrease in the volume of the Bay. The project does not propose new dikes or piers that would impact water circulation. This project is consistent to the maximum extent practicable with the Bay Plan's water surface area and volume policies.

5.5 TIDAL MARSHES AND TIDAL FLATS

The proposed project would place approximately100,000 CY of dredge material at depths of approximately 10 feet MLLW to enhance existing marsh and mudflat habitat. Placement of dredged material would beneficially contribute to the restoration of tidal marsh and tidal flat habitat. The project proposes to include a monitoring component to understand the scale of sediment deposition post-placement at the placement site, on the intertidal mudflat, and on the adjacent tidal marsh; and the wind, wave, and sediment flux conditions pre- and post-placement across the interconnected subtidal-mudflat-marsh complex measure the success and effects of the placement. This project is consistent to the maximum extent practicable with the Bay Plan's tidal marshes and tidal flats policies.

5.6 SMOG AND WEATHER

The air quality analysis found that the proposed project emissions produced from the proposed project alternatives would not exceed federal or BAAQMD thresholds. Material would be transported from a clamshell dredge via a scow to the project placement site rather than to SFDODS or SF-11, so emissions are not expected to greatly differ from those already permitted. The amount of material placed, 100,000 CY or 1-2 mm, would not increase the thickness of for or smog in the Bay Area. The project would not reduce water surface area in the Bay and is not expected to affect the Bay's function as an environmental regulator of particulate and smog in the atmosphere of the Bay Area. This project is consistent to the maximum extent practicable with the Bay Plan's smog and weather policies.

5.7 SHELL DEPOSITS

Lind Tug and Barge Inc. commercially mines historic oyster shell deposits in San Francisco Bay, just north of the San Mateo–Hayward Bridge. Lind uses a hydraulic suction dredge (shell dredge) to mine the oyster shell deposits, wash the shells, and then place the shells in a barge. Once processed, the shells are used as a mineral and nutrient supplement in poultry diets and as a soil amendment. The proposed project will occur south of the San Mateo-Hayward Bridge and modeling results show material placed will not settle on oyster shell deposits utilized by Lind Tug and Barge. The project does not propose new dikes or fill that would impact shell deposits. This project is consistent to the maximum extent practicable with the Bay Plan's shell deposits policies.

5.8 SUBTIDAL AREAS

Dredge equipment would comply with United States Coast Guard regulations regarding ballast water treatment and management. The project would not introduce or spread invasive species. The proposed project would beneficially place dredge material from the Bay at a shallow, in-Bay location, Eden's Landing, adjacent to mudflat and tidal marsh. This is a pilot project with provides an opportunity for research and testing concepts and techniques before implementing on a large scale. The project placement would be localized and is not expected to affect tidal hydrology. Dredging could affect sediment movement by dredging the federal channel to the authorized depth and moving it to the placement site. However, this would not result in significant changes to sediment movement or bathymetry. During dredging, some sediment would be resuspended in the water column and settle out in the channel and adjacent areas. Other than dredging sediment and transporting it to beneficial use site for placement, the proposed dredging and placement is not expected to substantially affect sediment transport in subtidal areas.

Dredging may affect fish, other aquatic organisms, and birds. Turbidity and noise generated from clamshell dredging could affect fish and other aquatic organisms at the dredge site. Additionally, fish could be directly injured by a clamshell dredge and associated equipment and vessels. These impacts would be limited to the immediate area around clamshell dredging activities. Potential effects of these activities would be reduced through implementation of the avoidance and minimization measures identified in the

Consistency Determination for San Francisco Bay Federal Navigation Channels Maintenance and Operations Dredging Program 2020 – 2024, such as seasonal work windows. The project would not directly remove or impact any mapped eelgrass areas.

Dredging would occur in existing, authorized navigation channels, and there is no feasible alternative to dredging in these areas. The navigation channels provide a substantial public benefit to commerce, not only to the region but to California and the nation. The project is consistent to the maximum extent practicable with the Bay Plan's subtidal areas policies.

5.9 ENVIRONMENTAL JUSTICE AND SOCIAL EQUITY

The proposed Strategic Placement Project would take place in the subtidal area just off the Eden Landing Ecological Reserve near Redwood City Harbor (Figure 5). The project area is located about 2 miles offshore of the Eden Landing Ecological Reserve and therefore is not near community infrastructure. According to the BCDC contamination vulnerability mapper, there are census block groups with mapped high and moderate contamination vulnerability within 2 miles east of the project extent. According to the BCDC community vulnerability mapper, census block groups within 2 miles of the project extent are considered to have low social vulnerability. Adjacent to Eden Landing Ecological Reserve, just past 4 miles of the project extent, there are census block groups with low, moderate, high, and highest social vulnerability. On the southwestern side of the project extent, just past 4 miles outside the project extent, there are census block groups with the highest contamination vulnerability and moderate social vulnerability. The project, however, is not expected to affect these areas. The project plan avoids impacts to vulnerable populations as the affected area is predicted to be Eden Landing Ecological Reserve which may act as a buffer between marshland and vulnerable communities. This would not add contamination to surrounding areas but instead would attempt to enhance coastal marshland and counteract coastal erosion.

Figure 5. Location map. Circle has a four-mile radius.

This project is consistent to the maximum extent practicable with all Environmental Justice and Social Equity Bay policies. There have been several presentations and coordination meetings regarding outreach throughout 2021 and 2022 with relevant partners, stakeholders, and environmental groups. A public meeting was held on 15 July 2022 for CEQA Notice of Scoping. See Section 7 of the Environmental Assessment/Mitigated Negative Declaration for a complete list of agency, stakeholder, and public outreach.

Figure 6 shows the project extent of the proposed plan as well as the different levels of community vulnerability in the surrounding areas. A 1-mile (shown in red) and 4-mile (shown in yellow) buffer radius around the project extent is also shown. There are census block groups with moderate, high, and highest social vulnerability 4 miles outside the project area and no vulnerable communities 1 mile outside the project area.

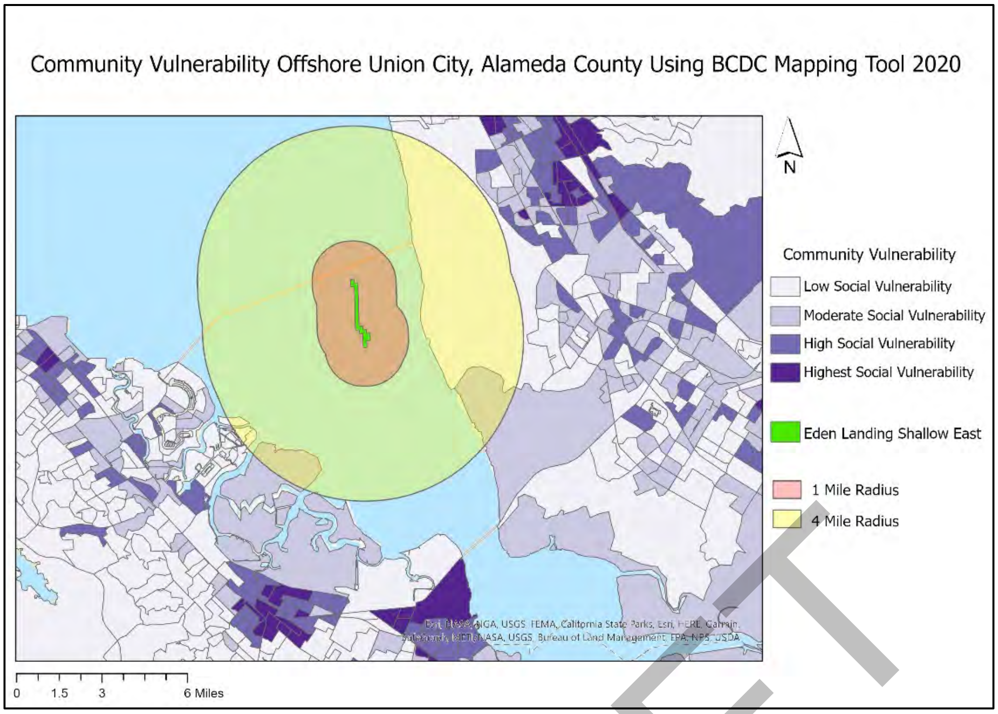

Figure 6. Community vulnerability offshore of Union City, Alameda County (BCDC Mapping Tool, 2020).

5.10 CLIMATE CHANGE

The proposed project will not negatively impact the Bay and will potentially decrease risks to public safety by buffering the adjacent shoreline from sea level rise. The area where material will be deposited is not located in the 100-foot shoreline band, but the targeted area for the sediment accretion, Eden Landing, is located in the 100-foot shoreline band and is adjacent to former salt ponds. This project will increase the sediment accretion rate in the adjacent marshes and mudflats and protect ecosystem services in Eden Landing. This project will enhance the Bay ecosystem by adding sediment to the adjacent tidal wetlands. Strategic placement of sediment is an innovative way to buffer against SLR. The project is consistent to the maximum extent practicable with the Bay Plan's climate change policies.

5.11 SHORELINE PROTECTION

The proposed project would place approximately 100,000 CY of material at a nearshore shallow water site adjacent to existing tidal marsh and shoreline. Placement would have beneficial impacts on storm, wave, and erosion buffers. No hardened structural shoreline protection measures are proposed. Community engagement has occurred, and the proposed project avoids impacts to vulnerable populations and would not contain contaminated material. The proposed pilot project incorporated nature-based techniques which will be monitored for benefits to adjacent tidal flats, tidal marsh, and shoreline. The proposed plan is consistent to the maximum extent practicable with the Bay Plan’s shoreline protection policies.

5.12 DREDGING

The proposed project is dependent upon dredged material from a federal navigation channel. However, the project is not causing dredging, as maintenance dredging would occur regardless of this project’s implementation in accordance with the Consistency Determination for San Francisco Bay Federal Navigation Channels Maintenance and Operations Dredging Program 2020 – 2024. The project is beneficially using dredged material and is consistent to the maximum extent practicable with the Bay Plan’s dredging in the Bay policies.

5.13 RECREATION

This project will not adversely impact recreational resources. The proposed dredged material placement activities would not involve the construction of recreation facilities, would not create demand for new recreational facilities, and would not result in increased use and deterioration of existing recreational facilities.

The project alternatives may occasionally delay or temporarily impede recreational watercraft during dredging and placement activities. In most locations, however, there would be sufficient room for recreational vessels to maneuver around dredging equipment, and therefore, impacts are expected to be negligible. During dredging and placement activities, notes to mariners and navigational warning markers would be used as needed to prevent navigational hazards. In addition, dredging would create a long-term positive effect for small craft by allowing for safe navigation. The project is consistent to the maximum extent practicable with the Bay Plan’s recreation policies.

5.14 PUBLIC ACCESS (AND APPEARANCE, DESIGN, AND SCENIC VIEWS)

The proposed project is not a fill project that would warrant new public access, would not involve the creation of new public access and infrastructure, and would not result in changes to any public access. Although the presence of scows with sediment will necessitate that publicly accessible areas of the channel be closed off from public access, recreation boaters would be able to navigate around the scows while the sediment is being deposited. This project would help protect public access to coastal ecosystems and the Bay adjacent to Eden Landing by protecting against SLR. This project will not create a visual change to the Bay. The project is consistent to the maximum extent practicable with the Bay Plan’s public access policies.

5.15 FILLS IN ACCORD WITH THE BAY PLAN

The fill involved with this project would be minor and would improve shoreline appearance. The proposed project would provide, to the maximum extent feasible, enhancement of natural resources for fish and wildlife. The project is consistent to the maximum extent practicable with the Bay Plan's fill policies.

5.16 MITIGATION

To the maximum extent practicable, the proposed project has been designed to avoid or minimize adverse environmental impacts to San Francisco Bay, in accordance with Bay Plan policies. All practicable and appropriate means to avoid or minimize adverse environmental effects were analyzed and incorporated into the recommended plan. Best management practices (BMPs) as detailed in the EA will be implemented, if appropriate, to minimize impacts. The project would beneficially use the dredged material, which would contribute to restoration projects around the Bay. For these reasons, no compensatory mitigation is required, and the project is consistent to the maximum extent practicable with the Bay Plan's mitigation policies.

5.17 NAVIGATIONAL SAFETY AND OIL SPILL PREVENTION

To ensure navigational safety and help prevent accidents that could spill hazardous material, a Spill Prevention Control and Countermeasure (SPCC) plan would be prepared to address the emergency cleanup of any hazardous material and would be available on site. This project is consistent to the maximum extent practicable with the Bay Plan's navigational safety and oil spill prevention policies.

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6. FISH AND WILDLIFE COORDINATION ACT (FWCA) PLANNING AID LETTER

FWCA Planning Aid Letter will be included in final document release.

7. NATIONAL HISTORIC PRESERVATION ACT

This appendix details the ongoing consultation required under Section 106 of the National Historic Preservation Act of 1966. The section 106 process seeks to accommodate historic preservation concerns with the needs of Federal undertakings through consultation among the agency official and other parties with an interest in the effects of the undertaking on historic properties, commencing at the early stages of project planning. The goal of consultation is to identify historic properties potentially affected by the undertaking, assess its effects, and seek ways to avoid, minimize or mitigate any adverse effects on historic properties.

Summary of Ongoing Tribal Consultation

The NHPA requires tribal consultation in all steps of the process when a federal agency project or effort may affect historic properties that are either located on tribal lands, or when any Native American tribe or Native Hawaiian organization attaches religious or cultural significance to the historic property, regardless of the property's location. The USACE and the California Water Quality Control Board contacted the Native American Heritage Commission (NAHC) requesting an updated Native American tribal consultation list for the Project. The Sacred Lands File search was negative. USACE obtained a tribal consultation list from the Native American Heritage Commission (NAHC) on 14 April 2020. The following Ohlone Tribes were identified as tribal consulting parties under Section 106 of NHPA and the National Environmental Policy Act (NEPA): The Amah Mutsun Tribal Band, Amah Mutsun Tribal Band of Mission San Juan Bautista, Costanoan Ohlone Rumsen-Mutsun Tribe, Indian Canyon Mutsun Band of Costanoan, and the Muwekma Ohlone Indian Tribe of the SF Bay Area.

On June 1, 2022, a virtual Tribal consultation meeting was held with the Confederated Villages of Lisjan (CVL). The CVL is interested in the Pilot Project and wants the opportunity for monitoring any environment impacts. The Tribe would also like access to the data that is collected showing the effectiveness of this study and are especially interested in learning if it is successful. When cultural resources were discussed, Chairperson Gould referred to the marsh itself as a cultural resource and explained the loss of the marshes and mudflats resulted in the loss of sacred sites. Tribal consultation is ongoing, and a site visit with the CVL Tribe will be scheduled in Fall of 2022.

Summary of Ongoing Consultation with the State Historic Preservation Officer

Consultation with the State Historic Preservation Office (SHPO) was initiated on July 25, 2022, for delineation of the Area of Potential Effect (APE) and the Corps' efforts to identify historic properties located within the APE (36 CFR § 800.4) (see Tribal Consultation and SHPO Consultation letters included). Future consultation will be completed to assess the effects of the undertaking on the resources with SHPO and the Tribes. This consultation will establish if the effects on historic resources are adverse, which is based on criteria established in 36 CFR Part 800 of the ACHP regulations.

DEPARTMENT OF THE ARMY
SAN FRANCISCO DISTRICT, CORPS OF ENGINEERS
450 GOLDEN GATE AVENUE, 4TH FLOOR, SUITE 0134
SAN FRANCISCO, CA 94102-3406

CALIFORNIA
Water Boards

April 7, 2022

SUBJECT: Strategic Shallow Water Placement Pilot Project

Ms. Irene Zwierlein
3030 Soda Bay Road
Lakeport, CA, 95453

Honorable Chairperson Zwierlein,

The U.S. Army Corps of Engineers San Francisco District (USACE) and San Francisco Bay Water Quality Control Board (Water Board) are reaching out to Tribes that may have interests in the project area. Our purpose is to inform you of the Strategic Shallow Water Placement Pilot Project (Project) during the early phase of environmental planning. Foremost, we invite you to be a part of the planning process out of respect for your unique experience and knowledge, and to collaborate regarding any tribal interests that may be affected by the Project.

USACE is pursuing the Project in accordance with section 1122 of the Water Resources Development Act of 2016 to explore possibilities for beneficially using material dredged from San Francisco Bay Federal navigation channels. The Project goal is to learn how dredged material can be used to enhance wetland recovery to protect communities from storms and rising seas. As a part of the National Environmental Policy Act process, USACE would welcome your engagement on the Project.

Similarly, the Water Board would appreciate your involvement in advance of preparing a document to satisfy the California Environmental Quality Act. The Water Board requested from the Native American Heritage Commission a list of Tribes in or associated with the project area and identified that no Tribes on the list have requested AB52 Consultation. However, in accordance with the Water Boards' Tribal Consultation Policy[1] and Executive Order B-10-11[2], are seeking consultation with California Native American Tribes with interests in project area. The Water Board values tribal input and aspire to educate both staff and Tribes, thus enhancing our activities, policies, and decision-making process and want to understand the unique tribal interests that may be affected by the proposed project.

USACE and the Water Board recognize the regional need to beneficially use sediment from federal dredging projects to support nature-based solutions to adapt to climate change. This Project will place dredged material in shallow water along the Bay's shoreline and utilize natural transport processes to move dredged material to mudflats and marshes (Figure 1). More specifically, we will use a method known as shallow-water placement. This method uses shallow-draft scows to place dredged sediment where it can be readily resuspended by tidal and

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[1] https://www.waterboards.ca.gov/about_us/public_participation/tribal_affairs/docs/california_water_board_tribal_consultation_policy.pdf
[2] https://www.ca.gov/archive/gov39/2011/09/19/news17223/index.html

wind-wave action and then transported by tidal currents. This will increase the resilience of mudflats and marshes using innovative and cost-effective measures.

For this Project, two in-Bay sites are currently being considered: one is adjacent to the Emeryville Crescent Ecological Reserve and the other is adjacent to Whale's Tail Marsh at Eden Landing (Figure 2). We are working with the U.S. Geological Survey to develop protocols for monitoring environmental impacts before, during, and after placement of the dredged material. If possible, we would like to work with Tribes, local community members, and citizen scientists to help monitor the Project's effectiveness.

Currently, we are seeking your input on site selection, developing monitoring plans, and identifying potential impacts to any historic properties that may be in the project area. Your Tribe's involvement will ensure that recommendations and concerns are addressed in our environmental reviews. By expressing your interest in the project, you will be actively informed of the steps we are taking to identify and preserve important places in the San Francisco Bay Region. Your views and comments will ensure that our undertaking incorporates historic preservation when necessary and fulfills the spirit of public stewardship advocated through section 106 review of the National Historic Preservation Act and its implementing regulations at 36 C.F.R. § 800.4(a)(3).

We hope to engage with you prior to public meetings for the Shallow Placement Project, scheduled to begin in May, and a public comment period for the environmental studies which we expect to be available in June. Once the environmental reports are finalized, the project is proposed to begin in the summer of 2023. The USACE and Water Board are available to consult with you on this project, either individually or jointly, at your convenience (e.g., one-on-one meeting or virtual workshops). If you have any comments or questions, please contact USACE's archaeologist Stephanie Bergman at (415) 503-6844 (Stephanie.M.Bergman@USACE.Army.Mil), or the Water Board's Engineering Geologist Lindsay Whalin at (510) 622-2363 (Lindsay.Whalin@waterboards.ca.gov). Thank you for your time and consideration; we look forward to hearing from you.

Sincerely,

Dr. Tessa E. Beach, Environmental Branch Supervisor, San Francisco District

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Date: 2022.04.14 08:47:45 -07'00'

Thomas Mumley, Interim Executive Officer, Water Board

Enclosures
Figure 1: Figure 1: Diagram of Strategic Shallow Water Placement method.
Figure 2: Potential site locations for the beneficial use of dredging materials in marshes and mudflats.

Additional Contacts

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Samantha Harper, Water Board Tribal Coordinator
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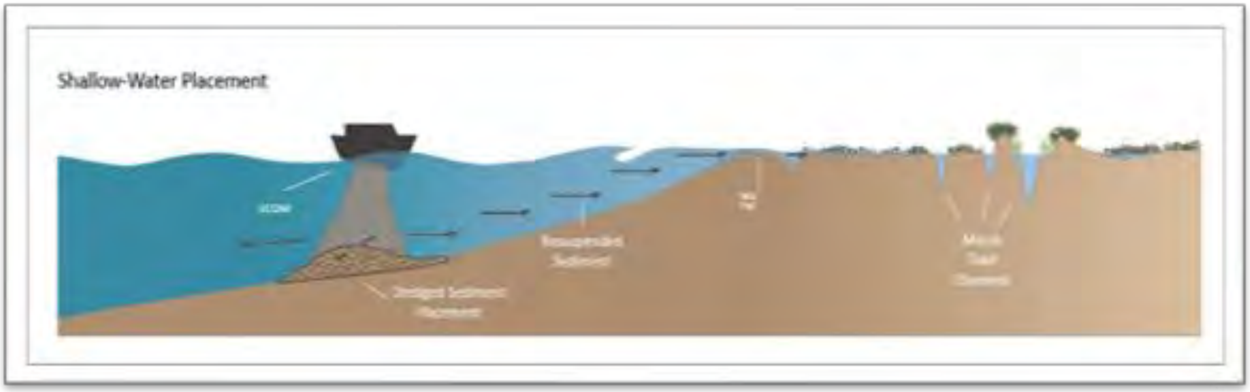

Figure 1. Using natural processes to achieve beneficial use of dredge material, placed in nearshore shallows of SF Bay.

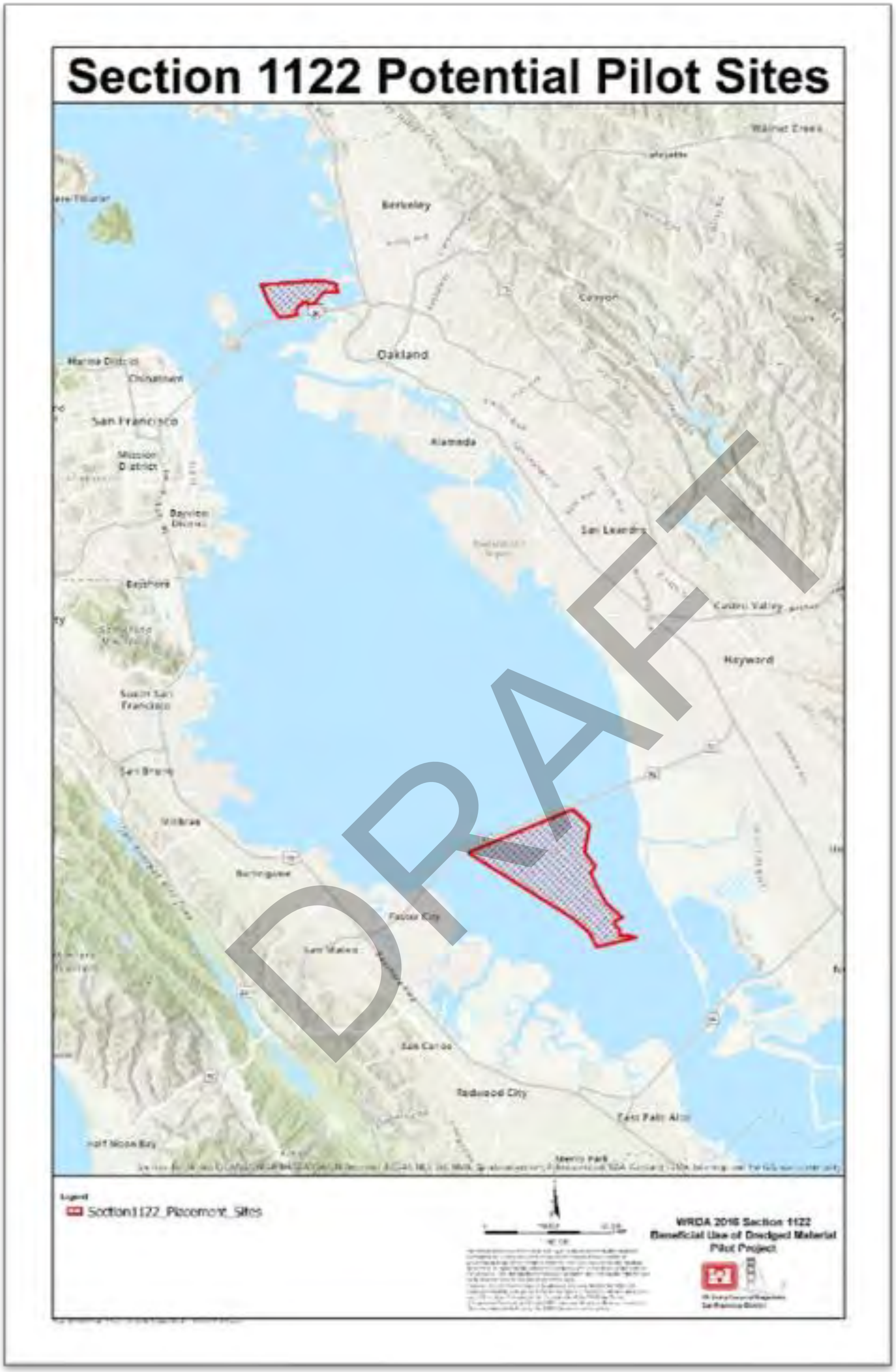

Figure 2: Potential Pilot Site locations in the San Francisco Bay for the study. Note, the proposed pilot project is only for offshore placement, as opposed to direct placement on marshes.

DEPARTMENT OF THE ARMY
SAN FRANCISCO DISTRICT, CORPS OF ENGINEERS
450 GOLDEN GATE AVENUE, 4^{TH} FLOOR, SUITE 0134
SAN FRANCISCO, CA 94102-3406

July 21, 2022

SUBJECT: Strategic Shallow Water Placement Pilot Project

Julianne Polanco
State Historic Preservation Officer
California Office of Historic Preservation
1725 23rd St., Suite 100
Sacramento, CA 95816

Dear Ms. Polanco,

The U.S. Army Corps of Engineers San Francisco District (USACE) is writing to initiate Section 106 review of the National Historic Preservation Act (54 U.S.C. § 306108) with your office for the Strategic Shallow Water Placement Pilot Project (Pilot Project) during the early phase of environmental planning. USACE is pursuing the Pilot Project with our non-federal sponsor, the State Coastal Conservancy (SCC), in accordance with section 1122 of the Water Resources Development Act of 2016 to explore possibilities for beneficially reusing material dredged from San Francisco Bay federal navigation channels. The in-Bay sediment placement site is two-miles offshore from the Eden Landing Ecological Reserve (ELER), near Hayward in Alameda County. The goal of this project is to place dredge material offshore of an eroding or drowning marsh to nourish the adjacent mudflat, marsh, and restoration habitats. The USACE is writing to consult with the SHPO directly under 36 C.F.R. § 800 for this undertaking.

Description of the Undertaking

The USACE recognizes the regional need to beneficially use sediment from federal dredging projects to support nature-based solutions to adapt to climate change. This Pilot Project will place dredged material offshore in shallow water along the Bay’s shoreline and utilize natural transport processes (eg. wind-waves, tides, currents) to move dredged material to mudflats and marshes. More specifically, we will use a method known as shallow-water placement. This method uses shallow-draft scows to place dredged sediment where it can be readily resuspended by tidal and wind-wave action and then transported by tidal currents (Figure 1).

The Section 1122 Pilot Project is planning the sediment placement project near Whale’s Tail Marsh, at the Eden Landing Ecological Reserve (ELER) (Figure 2). The project will strategically place 100,000 cubic yards of dredged sediment from Redwood City Harbor federal navigation channel using a dump scow at a shallow (7 – 9 feet depth) subtidal site two miles offshore ELER. Placement will occur over at least 20 days to reduce impacts, and the scow will be lightly loaded in order to get into shallow enough water where sediment can be resuspended for delivery towards the mudflat and marsh. Modeling results show minimal accretion on the adjacent marsh may be ~0.01cm, and ~0.1cm on the mudflats (Figure 3). This is similar to natural accretion rates observed by the U.S. Geological Survey. Modeling results show that 2 months after placement, the change in bathymetry at the placement site will be less than 10cm (Figure 3). This innovative method of placing dredged material will leverage natural, in-bay, hydrodynamic processes to move the sediment placed in shallow water to existing mudflats and marshes, making them more resilient to rising waters.

We are working with the U.S. Geological Survey to develop protocols for monitoring environmental impacts before, during, and after placement of the dredged material. The monitoring program will be implemented for a minimum of 1.5 years. Before the placement of dredged materials, there will be bathymetry and topography surveys of the placement site, in addition to studies of wave conditions, water quality (eg. suspended sediment concentrations), and benthic communities. There will also be eelgrass surveys, and ongoing documentation of marsh accretion rates. After the placement, there will be re-surveys of the placement site; including benthos, eel grass, recovery; and marsh and mudflat accretion. In addition, we will work with Tribes, local community members, and community scientists to help monitor and communicate the Project's effectiveness.

Defining the APE for the Project

The USACE is defining the Undertaking's preliminary area of potential effects (APE) for direct effects to cover the offshore placement site (~138 acres) and the marsh and mudflats within the western extent of the EDER (~2,500 acres), including all monitoring sites (Figure 4). The vertical APE is a minimum depth of 2' and maximum depth of 10' below the surface of the Bay. The APE for indirect effects includes access routes to monitoring sites located within the ELER, and a large buffer around both the placement and depositional site. The APE overlaps the project boundary of the South Bay Salt Ponds Restoration Project, also occurring at the ELER.

Cultural Resources Identified in the APE

The USACE completed a records search on 16 May 2022 at the Northwest Information Center located in Sonoma State University. Records were also reviewed online for results from underwater surveys at NOAA's Automated Wreck and Obstruction Information System (AWOIS), in addition to T-Charts from the U.S. Coast Survey located at https://historicalcharts.noaa.gov/. Four archaeological survey reports, an MA thesis, and an MOA between the US Fish and Wildlife Service (FWS) and SHPO, were reviewed within a one-mile radius of the APE. The entire study area has gone through extensive reconnaissance as well as archival research. Surveys have been funded by government agencies, including the FWS and CalTrans, since the early 1980s. The results of the records search show there is one eligible historic district--HALS-CA-91, the Eden Landing Salt Works landscape--located within the APE, and ten cultural resources are located within or contributing to the ELER Historic District (Table 1). Additionally, the San Mateo Bridge is an eligible historic property adjacent to the APE.

The offshore placement site was surveyed for cultural resources beginning in 1996, when a seismic retrofit for the San Mateo Bridge was first proposed. Numerous other inventories were completed for ecological restoration work at Eden's Landing as part of the South Bay Salt Pond Restoration Project, which resulted in the identification of the ELER Historic District located in the southern end of San Francisco Bay (Figure 5). The Historic District encompasses 6,612 acres divided into 23 ponds and is being mitigated for ecological restoration, which will focus on restoring the salt ponds to naturally functioning, tidally influenced salt marsh which requires breeching levees and opening ponds to the tides, building levees between the newly restored tidal marsh areas and local communities, and restoring habitat features.

Eden Landing was placed on the Nation Register of Historic Places (NRHP) because it is the birthplace of SF Bay's solar salt industry, which grew to be one of the world's largest salt producers. Beginning in the 1850s, Eden Landing's natural conditions of shallow tidal marsh land, relatively dry summers, and navigable creeks that provided shipping points, were critical features for developing the salt industry. The Eden Landing Salt Works landscape encompasses elements that include archaeological features, salt ponds, and water control structures from three of the original salt company operations that provide an essential link to the earliest period of this important industry.

The initial salt production operations at Eden Landing consisted of small, family-owned parcels of less than 50 acres. There were nearly 30 different salt works located within the Eden Landing area between 1850 and 1910. One of the largest salt operations was the Union Pacific Salt Company which was in continuous production from 1872 to 1927. The Oliver Salt Company was among the few nineteenth century salt producers that continued operation into the 1920s. Between 1910 and 1930 the industry began consolidating as the market demand for salt increased beyond the capacity of the small producers. In 1930 the number of operators dropped from 28 to only five; and by the 1940s Leslie became the only major operator. The small ponds have been altered to meet modern large-scale production needs.

Ten cultural resources have been recorded within the Eden Landing Salt Works Historic Landscape, all of which are related to the historic period of salt manufacturing (Table 2). Four sites have been determined eligible, five sites have been determined ineligible, and one site is unevaluated. And, one architectural resource, the Archimedes Screw Windmills has been determined to be a contributing element of the Eden Landing Salt Works historic landscape.

Section 106 Consulting Parties Identified

The USACE and the California Water Board contacted the Native American Heritage Commission (NAHC) requesting an updated Native American tribal consultation list for the Project. The Sacred Lands File search was negative. USACE obtained a tribal consultation list from the Native American Heritage Commission (NAHC) on 14 April 2020. The following Ohlone Tribes were identified as tribal consulting parties under Section 106 of NHPA and the National Environmental Policy Act (NEPA): The Amah Mutsun Tribal Band, Amah Mutsun Tribal Band of Mission San Juan Bautista, Costanoan Ohlone Rumsen-Mutsun Tribe, Indian Canyon Mutsun Band of Costanoan, and the Muwekma Ohlone Indian Tribe of the SF Bay Area.

On June 1, 2022, a virtual Tribal consultation meeting was held with the Confederated Villages of Lisjan (CVL). The CVL is interested in the Pilot Project and wants the opportunity for monitoring plants and the environment. The Tribe would also like access to the data that is collected showing the effectiveness and impacts to the environment that result from this study and are especially interested in learning if it is successful. When cultural resources are discussed, Chairperson Gould referred to the marsh itself as a cultural resource and explained the loss of the marshes and mudflats resulted in the loss of sacred sites. A site visit with the CVL Tribe is scheduled for August.

National Environmental Policy Act and Early Public Scoping

Outreach meetings held for the public were widely attended by members from the City of Hayward and the East Bay Regional Park District. Enthusiasm for the project and interest in citizen science monitoring was expressed by several attendees. Two Resource Agency Working Group (RAWG) meetings were held on March 26, 2021, and June 23, 2022, and a public CEQA scoping meeting was held on June 15. Representatives from the SHPO attended the June 23rd meeting. We invite the SHPO to continue to participate in the environmental review process as a participating agency, per requirements of 40 C.F.R. Part 1501.8. We ask that you respond in writing to confirm or reject your participation. Consistent with 40 C.F.R. Part 1501.8, we will assume your agency to be a participating agency if no response is received.

Future SHPO Consultation

USACE is consulting with your office to comment on our identification efforts and will next consult on the assessment of effects to historic properties within the APE pursuant to 36 C.F.R. § 800.4 and 36 C.F.R. § 800.5. Currently, USACE is seeking your agreement on our delineation of the APE and your office's response to serve as a NEPA participating agency. Thank you for reviewing this project, and we respectfully request your response within 30 days of receipt of this letter. If you have any comments or questions, please contact San Francisco District archaeologist Stephanie Bergman by email at stephanie.m.bergman@usace.army.mil, or phone, (415) 503-6844.Thank you for your time and consideration.

Sincerely,

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Julie R. Beagle, Environmental Section Lead, San Francisco District

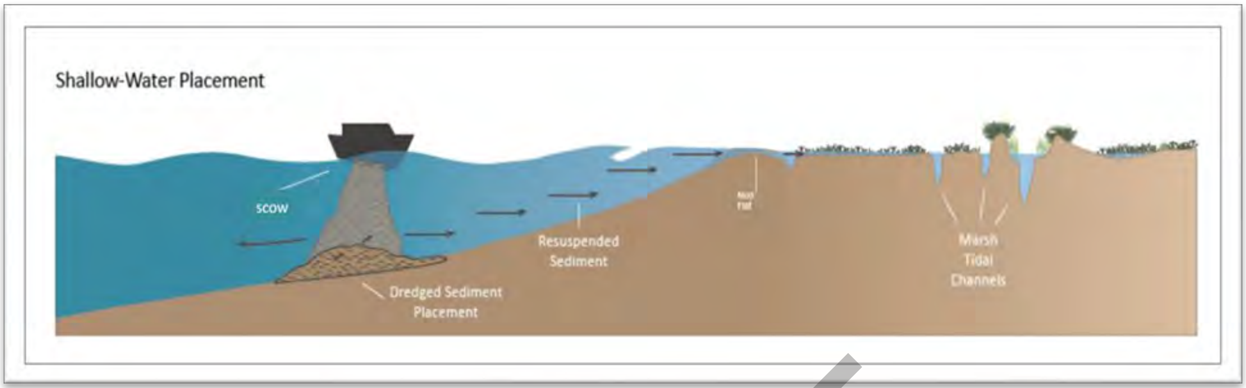


Figure 1: Using natural processes to achieve beneficial use of dredge material, placed in nearshore shallows of SF Bay.

Figure 2: The project location is in the southern portion of the SF Bay, with the proposed placement site in red and the targeted area for deposition in blue/ green hash.

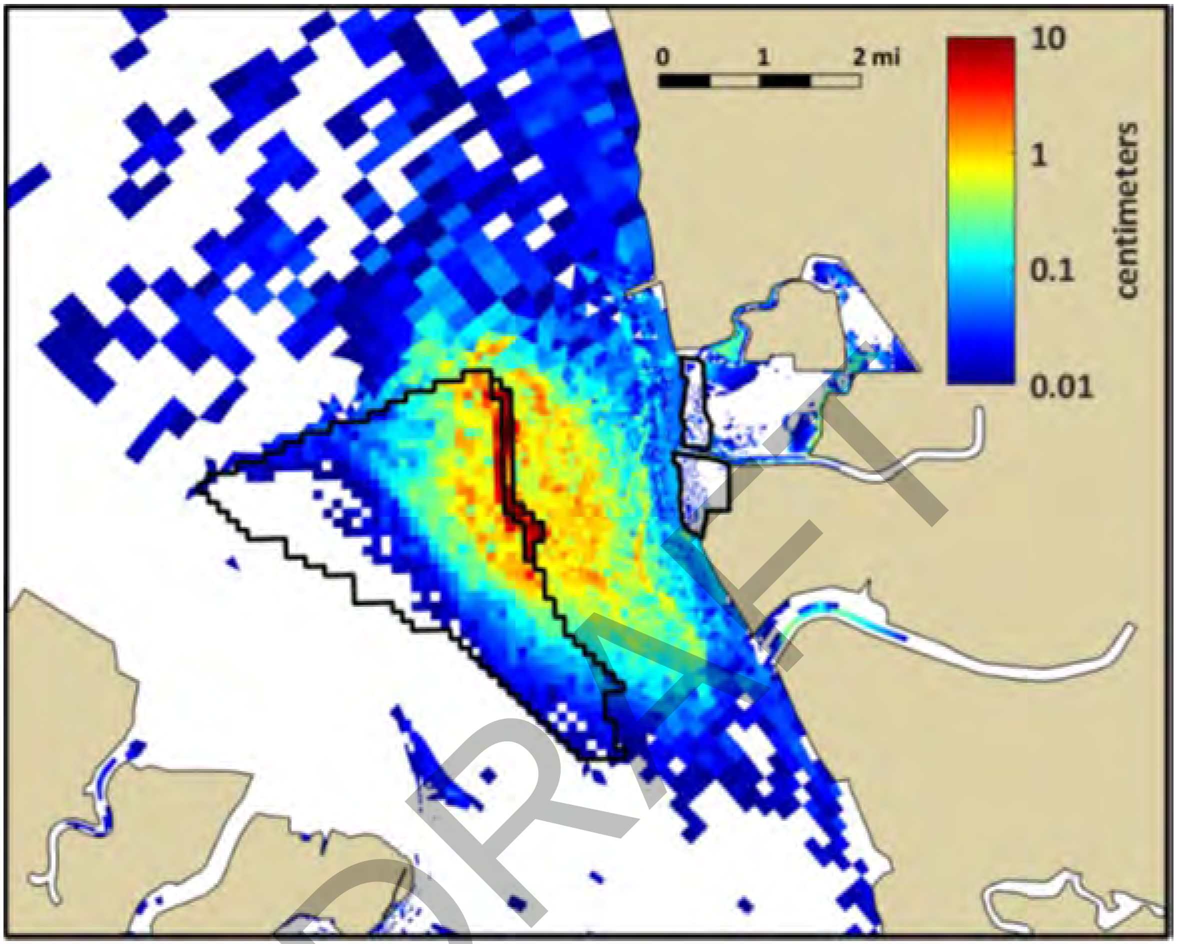
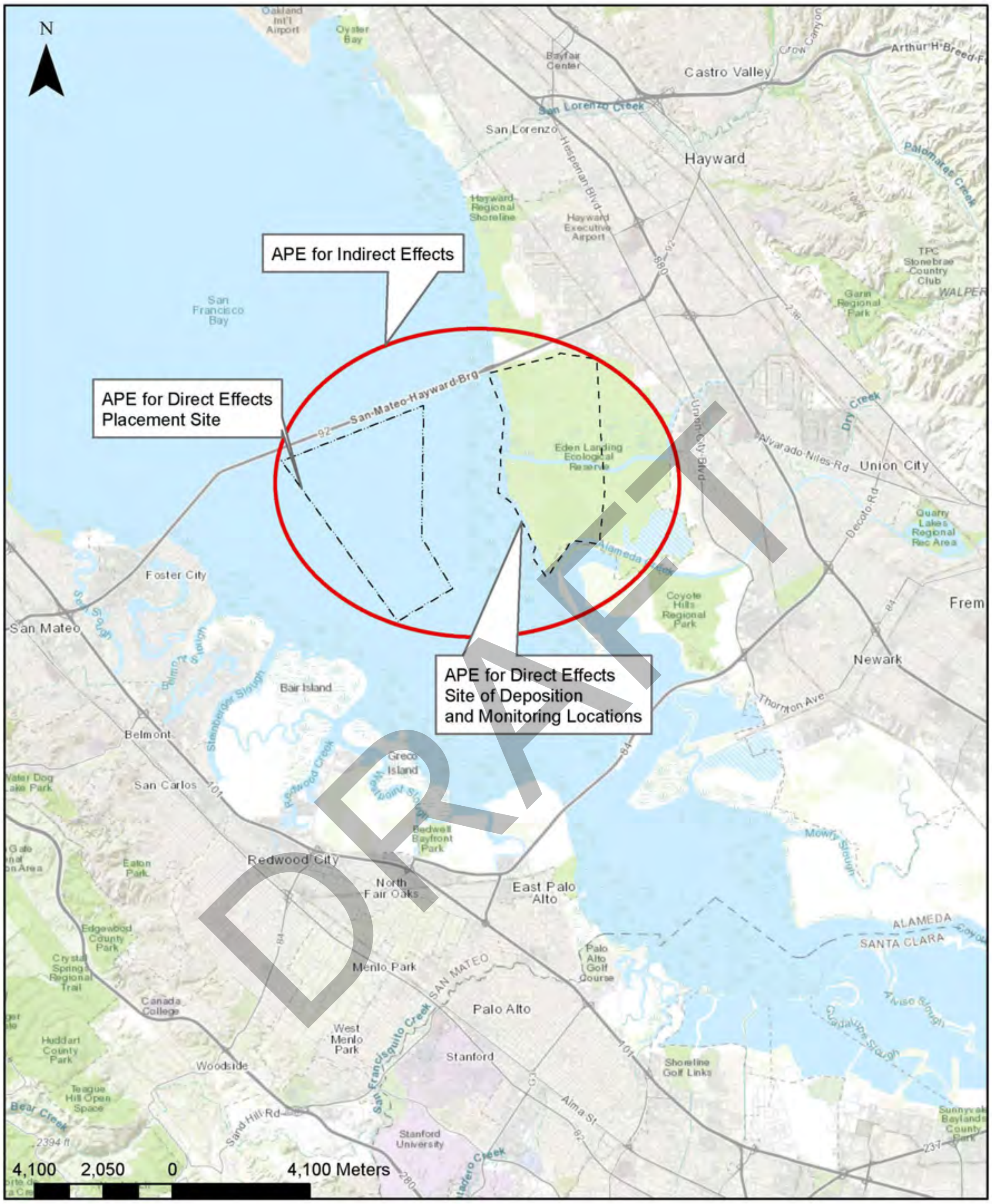


Figure 3: Eden Landing modeling shows shallow/east placement plan view indicating sediment deposition thickness in centimeters after two-month summer model run for 100,000 yd^3.



US Army Corps of Engineers
San Francisco District

Area of Potential Effect
Strategic Placement Pilot Project

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USACE, San Francisco District Date Saved: 7/14/2022

Figure 4: Area of Potential Effects for Direct Effects (placement site, deposition site, and monitoring locations), and buffer to include the APE for Indirect Effects.

Figure 5: One eligible historic district is identified within the APEs, the Eden Landing Salt Work Historic Landscape.

Trinomial Site no.	**Primary Site no.**	**Eligibility**	**Description**
CA-ALA-489H, -501H	P-01-000217	Yes	Eden Landing historic shipping station
CA-ALA-494H	P-01-000210	Yes	Oliver Salt. Co. piling and foundations
	P-01-010740	Yes	Archimedes Screw Windmill
CA-ALA-495H	P-01-00212	No	Former Rocky Point Saltworks—no surface remains
CA-ALA-497H		Yes	Pilings from former Union Pacific Salt
CA-ALA-498H	P-01-214	No	Saltworks, not relocated
CA-ALA-499H	P-01-215	No	Modern refuse scatter
	PF-1	Yes	Whisby Salt Works refuse scatter
	P-01-010834	No	Union City Alvarado Salt Ponds
	FWS-07-12-1	Yes	J. Quigley Alvarado Salt Works, refuse scatter

Table 1: List of identified cultural resources located within the Eden Landing Salt Work Historic Landscape.

Appendix B – PLAN FORMULATION

1 INTRODUCTION

This appendix provides details on the plan-formulation process summarized in Sections 1–3 of the main body of the EA/IS/MND. Most USACE Civil Works projects start with a feasibility study where the plan formulation process is applied. If the feasibility report is approved, the project goes to the design phase and then the construction phase. Because Section 1122 legislation requested proposals that specified the project goals, in essence each 1122 project started at the design phase. Still, it was necessary to use elements of the plan formulation process to select the location and placement parameters.

The PDT utilized the following plan-formulation process from the USACE Institute for Water Resources Planning Primer (1997) to determine its proposed action:

Step 1. *Identifying problems, opportunities, objectives, and constraints:*
Problems are existing, negative conditions.
Opportunities tend to focus on desirable, future conditions.
Objectives are statements that describe the results you want to get by solving the problems and taking advantage of the opportunities you identified.
Constraints are statements about things you want to avoid doing, or things you cannot change, while meeting your objectives.

Step 2. *Inventorying and forecasting conditions:*
Gathering information about historic and existing conditions produces an **inventory**.
Gathering information about potential future conditions requires **forecasts**.
  First, forecast the most likely future **without-project condition** that describes what is expected to happen if no action is taken to solve the problems or realize the opportunities. The without-project condition is the same as the **"no action"** alternative described in the National Environmental Policy Act (NEPA) regulations.
  Later (in Step 4), forecast future **with-project conditions** that describe what is expected to happen if each alternative plan is implemented.

Step 3. *Formulating alternative plans:*
Produce solutions that achieve all or part of one or more of your planning objectives. Solutions are **alternative plans** built from **management measures**.
  A **management measure** is a feature or an activity that can be implemented at a specific geographic site to address one or more planning objectives. It may be a "structural" feature that requires construction or assembly on-site, or it could be a "nonstructural" action that requires no construction. Management measures are the building blocks of **alternative plans**.
  An **alternative plan** is a set of one or more management measures functioning together to address one or more objectives. Sometimes a plan is one measure. More often it's a set of measures.

Step 4. *Evaluating alternative plans:*

The essential purpose of the evaluation step is to determine whether a plan you have formulated is worthy of further consideration. Evaluation consists of four general tasks.

First, forecast the most likely with-project condition expected under each alternative plan.

Second, compare each with-project condition to the without-project condition. Do the comparisons reveal any differences between the two futures? Differences between with- and without-project conditions are a plan's **effects** (i.e., **impacts**).

Third, characterize effects – e.g., magnitude, location, timing, and duration.

Fourth, qualify plans for further consideration. This is a pass/fail test that asks, "Are any effects so significant that they would violate some minimum standards?" If not, the plan should be considered further. If so, the plan should be dropped from further consideration, or reformulated to lessen the effect. Some common qualifying criteria are **Completeness**, **Effectiveness**, **Efficiency**, and **Acceptability**.

Step 5. Comparing alternative plans:

The best plan cannot be selected from among a set of good plans unless you have some way to compare them. It is only by comparison that a plan is no longer good enough, or that a good plan becomes the best plan. The purpose of plan comparison is to identify the most important effects, and to compare the plans against one another across those effects. Ideally, the comparison will conclude with a ranking of plans or some identification of advantages and disadvantages of each plan for use by decision makers.

Step 6. Selecting a plan:

Decision makers must purposefully choose the single best alternative future path from among all those that have been considered. The first choice is always to do nothing. Planners have the burden of demonstrating that any plan that is recommended is better than doing nothing. The second choice is to select the plan that is required by law or policy. For example, cost effectiveness is used in many USACE ecosystem restoration project planning investigations. The third choice is to do something else. Regardless of the choice, those who do the choosing must have good reasons for the final selection. Frequently, a non-Federal sponsor of a Civil Works project will find it in their interest to pursue a plan that sacrifices some benefits for additional contributions to other objectives. A plan that is preferred by a sponsor is commonly called the locally preferred plan.

2 BACKGROUND

Section 1122 requires USACE to establish a pilot program to carry out 10 projects for the beneficial use of dredged material. The pilot program can include projects for the purposes of:

(1) reducing storm damage to property and infrastructure;
(2) promoting public safety;

(3) protecting, restoring, and creating aquatic ecosystem habitats;
(4) stabilizing stream systems and enhancing shorelines;
(5) promoting recreation;
(6) supporting risk management adaptation strategies; and
(7) reducing the costs of dredging and dredged material placement or disposal, such as projects that use dredged material for:
  (A) construction or fill material;
  (B) civic improvement objectives; and,
  (C) other innovative uses and placement alternatives that produce public economic or environmental benefits.

Projects identified under Section 1122 must maximize the beneficial placement of dredged material from federal or non-federal navigation channels and ensure that the use of dredged material is consistent with all applicable environmental laws. The USACE is required to carry out the program in consultation with relevant state agencies and to establish regional teams to assist in evaluating the proposals. Each pilot project is to:

- maximize the beneficial placement of dredged material from federal and non-federal navigation channels;
- incorporate, to the maximum extent practicable, two or more federal navigation, flood control, storm-damage reduction, or environmental restoration projects;
- coordinate the mobilization of dredges and related equipment, including using such efficiencies in contracting and environmental permitting as can be implemented under existing laws and regulations;
- foster federal, state, and local collaboration;
- implement best practices to maximize the beneficial use of dredged sand and other sediments;
- ensure that the use of dredged material is consistent with all applicable environmental laws.

This Strategic Placement Project's primary purpose is to evaluate the ability of tides and currents to transport dredged sediment – that is placed in a San Francisco Bay (i.e., SF Bay or the Bay) shallow-water, shoreline environment – to existing mudflats and marshes to make them more resilient to rising sea level. The intent is to increase the temporal adaptability and resilience to increased water levels and reduced suspended sediment in the Bay. The evaluation includes quantification of sediment transported toward target mudflats and marshes, as well as environmental and other impacts of this innovative beneficial use of dredged sediment.

3 SETTING

Maintenance dredging occurs annually in several federal navigation channels, and the dredged material is placed at designated sites in the Bay, in the ocean, or at beneficial-use sites. The Project Delivery Team (PDT) hypothesizes that strategic placement of dredged sediment in the in-Bay nearshore, subtidal environment can take advantage of natural sediment transport processes and pathways within the Bay system to achieve tidal mudflat and marsh deposition via tidal and wave-flux dynamics (i.e., sediment delivery over a given spatial extent through time). At the same time, it could reduce placement costs because in-Bay sites are closer than ocean and upland sites.

The proposed project would place sediment, dredged from a federal in-Bay navigation channel, in shallow water on the periphery of the Bay to examine the ability of tides and currents to move the placed material to existing mudflats and marshes. This aquatic placement technique – placing dredged sediment in shallow water adjacent to a tidal wetland where natural hydrodynamic and morphodynamic processes can move the sediment onto the adjacent mudflat and marsh – is referred to as strategic shallow-water placement. This strategic shallow-water placement pilot project is expected to move a portion of the placed sediment to the mudflats and the marsh plain, mimicking natural sediment supply to wetland ecosystems supporting habitat construction. Monitoring will be integrated to evaluate the environmental impacts and success of this pilot project.

4 LOCATION

The proposed project is in San Francisco Bay in Northern California, which is a large tidal estuary receiving the outflow of large rivers (e.g., Sacramento and San Joaquin Rivers) and other, smaller rivers and creeks in its watershed. Approximately 40% of California's water draining into San Francisco Bay comes from the Sierra Nevada Mountain Range and the State's Central Valley. Specifically, the project site will be in South San Francisco Bay, which is bounded by the San Mateo Bridge to the north and the southern shoreline of the Bay to the south. Tidal mudflats, salt-water tidal marshes, and subtidal shallow-water environments occur in that part of the Bay.

4.1 SAN FRANCISCO BAY

The San Francisco baylands (e.g., mudflats, marshes, and other intertidal habitats) protect critical infrastructure, improve water quality, and provide habitat for thousands of fish and wildlife species, including several endangered and special-status species. Before 1850, San Francisco Bay and its environs included 350,000 acres of freshwater wetlands and 200,000 acres of salt marshes (Figure 1). Subsequently, the region has lost over eighty-five percent of that acreage through diking, dredging, and development. In addition, sea-level rise (SLR) and sediment deficits further threaten long-term bayland sustainability.

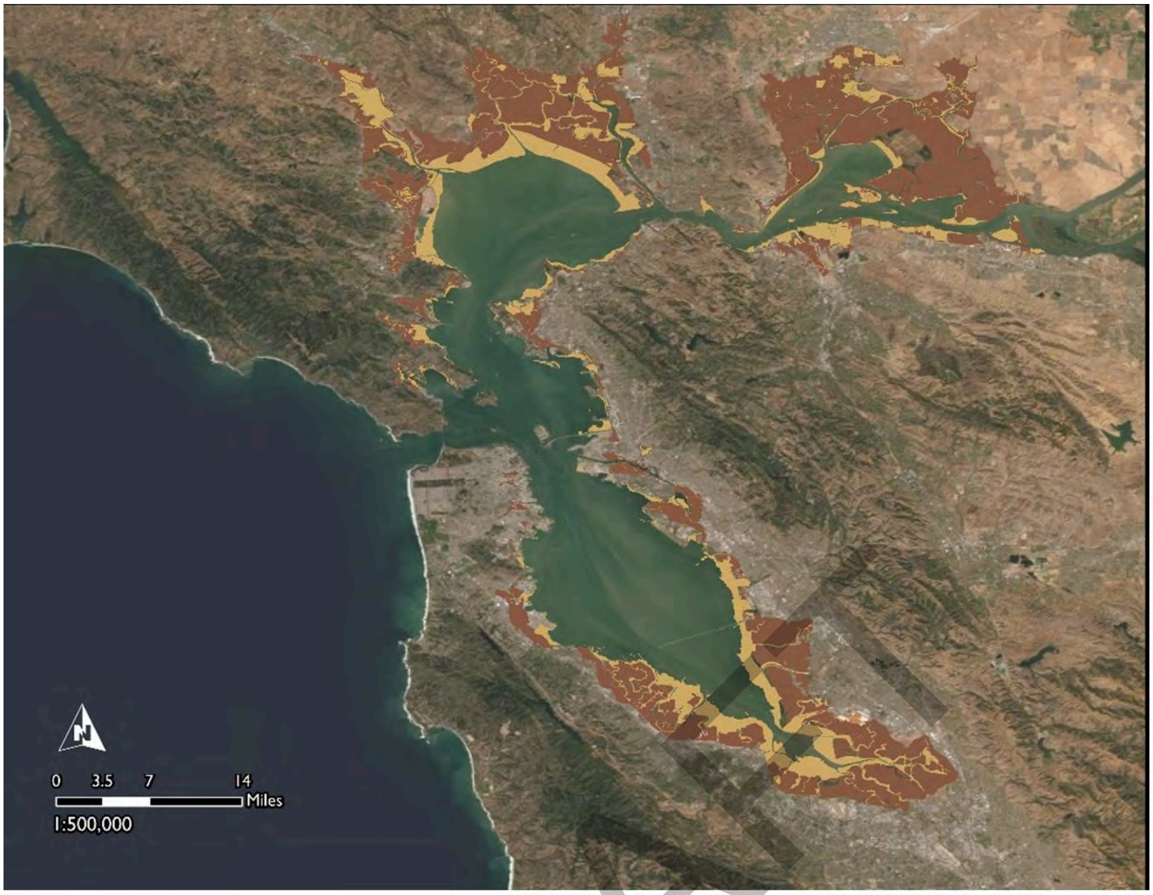


Figure 1. Bay area historical (dark brown) and modern (light brown) baylands.

Efforts are underway to restore these baylands with sediment from other locations. Dusterhoff et al. (2021) of the San Francisco Estuary Institute estimate the Bay's wetlands and mudflats will need approximately 450 million CY of sediment between now and 2100 to maintain existing wetlands and those currently slated for restoration. Sediment dredged from federal navigation channels represents a significant source of supply available for restoration. The practice of beneficially using these sediments to restore marshes already exists and has been successfully implemented (i.e., beneficial use of dredged material, BUDM, or BU). Federal, state, and local agencies and organizations are currently on track to restore 60,000 acres of tidal wetlands to augment 40,000 already-restored acres. The resulting 100,000 acres will help protect the region from tidal flooding and reduce storm damage, especially if sea level rise (SLR) continues as predicted or accelerates.

Through a variety of partnerships, several agencies have acquired land, developed regional plans, conducted environmental reviews, received permits, and are implementing multiple projects to restore critical tidal wetlands for both ecosystem benefits and shoreline protection. Meeting the goal of wetland climate resilience, however, will require optimization on several levels, including finding least-cost methods with streamlined and more-efficient permitting processes to match dredged material volumes with placement site needs and capacities.

In the SF Bay area, the current paradigm of BUDM is to place material directly on subsided baylands to raise site elevations to adjacent marsh plains, thereby supporting rapid development of tidal marsh vegetation and habitat. Subsided restoration sites that are breached without raising site elevations are projected to take 60–75 years to develop into tidal marsh. BUDM can cut development time down to 10–15 years. This is important because restored marshes breached without sediment supply may not accrete fast enough to respond to future rates of SLR. Although direct placement is a critical tool for subsided baylands, it can be a costly restoration strategy. Consequently, given the projected increase in SLR, SF Bay agencies and other organizations are actively evaluating new tools to reduce beneficial-use costs by utilizing natural processes that drive tidal marsh development and resilience under current and future SLR conditions.

The targeted areas for strategic shallow-water placement are locations on the margins of the Bay adjacent to marshes and mudflats in need of sediment (Figure 2, Figure 3). Shallow water ranges from near the bayward edge of the mudflat (around mean lower low water, which is approximately 0 feet North American Vertical Datum [NAVD) to the top of the deep channel (a depth of about 13 feet NAVD).

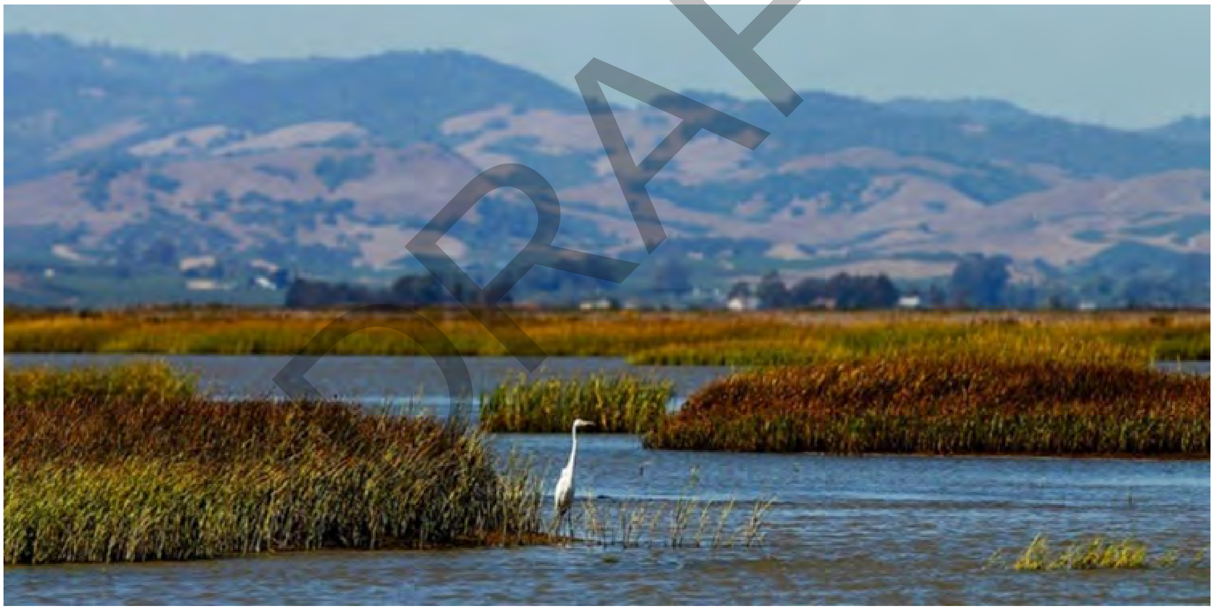


Figure 2. Napa-Sonoma Marshes State Wildlife Unit (Photo: Aric Crabb).

Figure 3. Low tide on a San Francisco Bay mudflat (Photo: Jitze Couperus [Flickr]).

4.2 FEDERAL NAVIGATION PROJECTS

As part of its operation and maintenance (O&M) program for federal channels in the San Francisco Bay area, USACE annually dredges five federal channels (Suisun, Richmond Inner Harbor, Oakland Harbor, Redwood City Harbor, Main Ship Channel), biannually dredges two federal channels (Pinole Shoal and Richmond Outer Harbor), and periodically dredges several other federal channels (Figure 4). This project proposes sourcing dredged sediment from either the Redwood City Harbor or Oakland Harbor federal navigation channel for strategic placement.

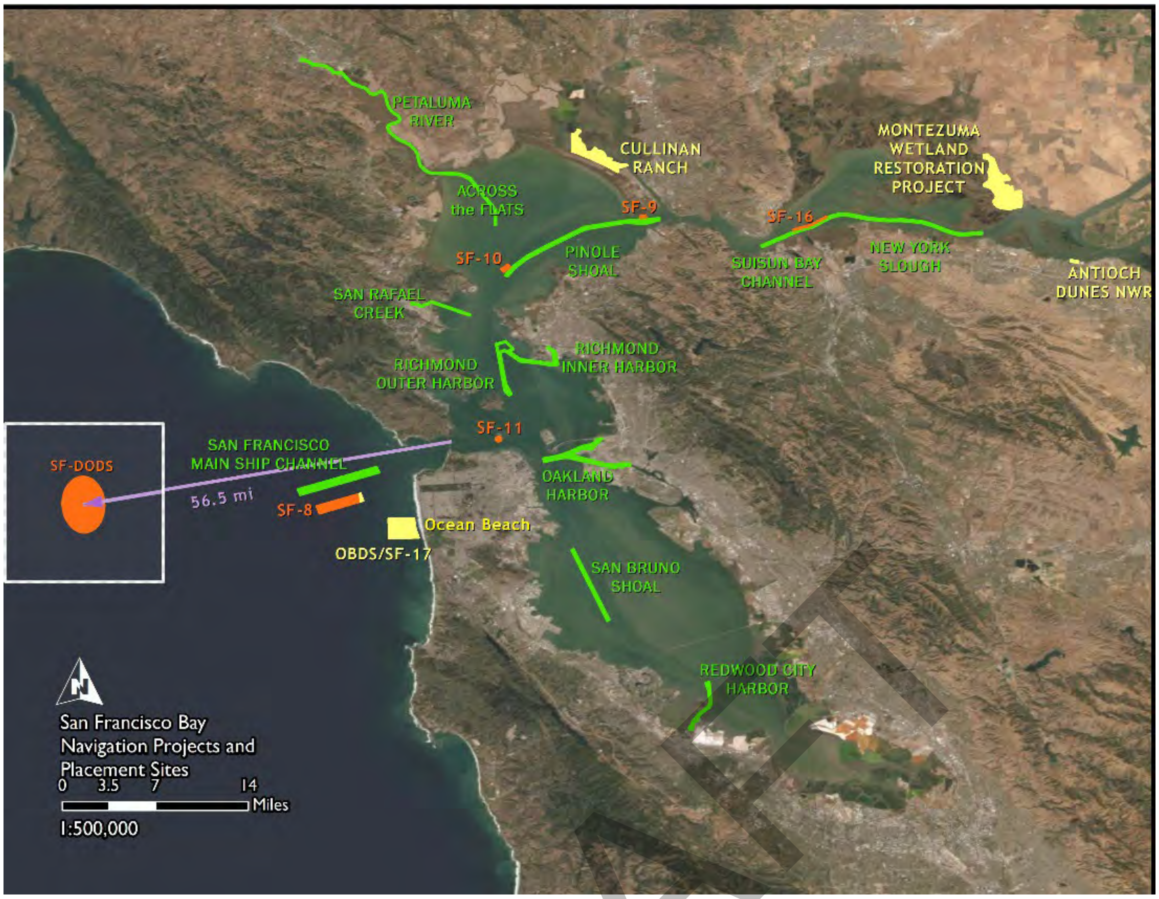


Figure 4. San Francisco District (SPN) federal navigataion projects (green) and traditional placement sites (orange [aqueous] and yellow [beneficial use]).

5 BASIC AND OVERALL Project Purpose

Under Section 404 of the Clean Water Act, USACE is granted permitting authority for any activity that would involve the discharge of dredged or fill materials into waters of the U.S., including wetlands (33 USC 1344). The section 404(b)(1) guidelines prohibit discharge of dredged or fill material if a practicable alternative to the proposed project exists that would have less adverse impacts on the aquatic ecosystem, including wetlands, so long as that alternative does not have other significant adverse environmental consequences. The USACE does not issue itself a permit for its actions involving the discharge of dredged or fill material to waters of the U.S., but instead integrates an equivalent 404(b)(1) analysis in its NEPA documentation. This analysis requires identification of the basic and overall project purposes as defined by the 404(b)(1) guidelines, and an evaluation of alternatives consistent with those purposes to identify the least environmentally damaging practicable alternative.

5.1 BASIC PROJECT PURPOSE

The basic purpose is to ascertain the feasibility of using strategic, in-water sediment placement to maintain mudflats and tidal marshes. This is a water-dependent project under Section 404(b)(1).

5.2 OVERALL PROJECT PURPOSE

The overall purpose of the Strategic Shallow Water Placement Pilot Project is to test a novel approach to increase mudflat and salt-marsh resilience to SLR in SF Bay via strategic placement of sediment – dredged from federal navigation channels – at a shallow, in-Bay location adjacent to the mudflat and tidal marsh. This Engineering with Nature (EWN) approach will augment sediment supply in a sediment-starved system to leverage existing morphodynamic processes to transport sediment toward mudflat-marsh systems for habitat reconstruction. The goal is to determine if this EWN approach can be a successful, lower-cost method to achieve beneficial use relative to the cost of traditional placement options (i.e., ocean, in-Bay, or upland sites). This project aims to understand the scale of sediment deposition post-placement at the placement site, on the intertidal mudflat, and on the adjacent tidal marsh; and the wind, wave, and sediment flux conditions pre- and post-placement across the interconnected subtidal-mudflat-marsh complex.

This project also aims to understand the impacts to benthic (i.e., Bay bottom) habitats, and communities; the spatial extent of the effect zone; the temporal scale of disturbance and recovery time; and whether there will be any detrimental impacts to eelgrass beds, oyster beds, or similar environmental resources. This project will include robust monitoring protocols using appropriate methods and techniques to determine sediment deposition and impacts resulting from strategic placement.

6 ALTERNATIVES CONSIDERED BUT ELIMINATED

The first step in developing alternatives for this project was to reduce the number of suggested sites from several to two sites. Then, various combinations of source channels, placement volumes, and placement areas were used to create several alternatives at each location. Some federal navigation channels are more suited as sources of material for strategic placement than others. For example, Pinole Shoal, Richmond Outer Harbor, and the Main Ship Channel are regularly dredged with a hopper dredge that cannot access shallow water placement sites (i.e., between 13 feet depth NAVD and 0 feet NAVD, or approximately mean lower low water) because these ships have a draft of about 35 feet. Therefore, those channels will not be sources for the material to be placed in shallow water. Because availability of the periodically dredged channels is uncertain, dredged material is expected to be sourced from one or two of the five annually dredged channels. Finally, a sediment-transport model was used to eliminate all but two alternatives (one at each location), which were carried forward for final analysis.

6.1 SITES

Starting with twelve sites (Figure 5), the PDT used eight criteria to reduce the list to two sites (Table 1):

8. Eroding or drowning marsh; lack of natural sediment supply;
9. Sufficient wind-wave action to resuspend placed sediment;
10. Proximity to a federal channel;
11. Open to tidal exchange, existing marsh;
12. Water shallow enough to get scow close to shore;
13. Protection for disadvantaged communities;
14. Lower populations of critical species;
15. Avoiding large eelgrass beds and nearshore reef projects.

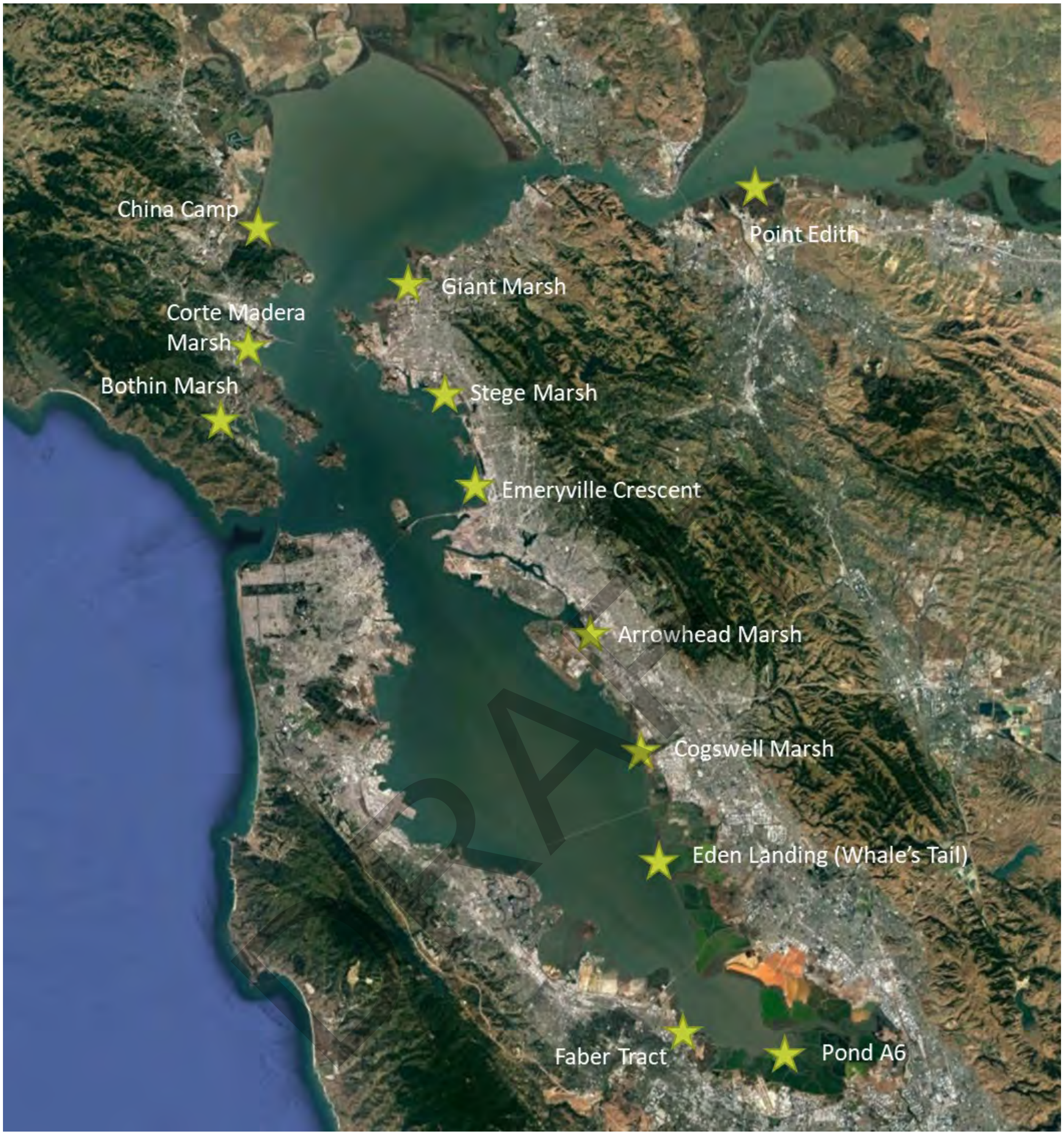


Figure 5. Potential sites for strategic placement across San Francisco Bay.

Table 1. Initial site selection – the checks mark appliable criteria.

Site (south to north)	Criteria								Reject
	1	2	3	4	5	6	7	8	
Pond A6								✓	✓
Faber Tract		✓	✓	✓	✓	✓		✓	✓
Cogswell Marsh	✓	✓	✓	✓	✓	✓			✓
Eden Landing (Whale's Tail)	✓	✓	✓	✓	✓	✓		✓	
Arrowhead Marsh	✓		✓	✓		✓		✓	✓
Emeryville Crescent	✓	✓	✓	✓	✓	✓	✓		
Bothin Marsh	✓			✓				✓	✓
Stege Marsh	✓	✓		✓		✓			✓
Corte Madera Marsh	✓	✓		✓					✓
Giant Marsh		✓	✓	✓	✓	✓		✓	✓
China Camp		✓			✓			✓	✓
Point Edith	✓	✓	✓			✓		✓	✓

6.2 PLACEMENT DEPTHS

Three placement depths were selected based on local bathymetry: (1) shallowest and closest with smallest footprint; (2) intermediate depths with tidal timing; and (3) deepest depths with fully loaded scow. These placement depths were chosen to maximize sediment transport to target mudflats and marshes, while balancing the logistical challenges associated with scow accessibility and maneuverability in shallower depths.

6.3 PLACEMENT VOLUMES

Four placement volumes were evaluated: (1) 50,000 CY; (2) 75,000 CY; 100,000 CY, and 125,000 CY. These placement volumes were chosen to maximize sediment transport to target mudflats and marshes and to minimize the benthic impacts of placement.

6.4 FEDERAL NAVIGATION CHANNELS

Navigation projects were assessed for their proximity to selected project locations, their frequency of interannual dredging, the dredged sediment quality and grainsize characteristics, and the logistical feasibility of utilizing said channels as sediment sources to determine channel material suitability for reuse. Redwood City Harbor is the closest navigation channel to Eden Landing (approximately 1.9 – 3.5 miles), and its grain size distribution sufficiently matches the grain sizes on the marsh and mudflat near Eden Landing. As such, Redwood City Harbor navigation channel is the proposed source of material for this project. Oakland Harbor is similarly not far from Emeryville Crescent marsh (approximately 1 – 3 miles).

6.5 PROPOSED ACTION DETERMINATION – MODELING

Two sites – Eden Landing and Emeryville Crescent Marsh – were analyzed using a quantitative modeling approach (i.e., the UnTRIM Bay-Delta model and the Short-Term Fate [STFATE] of dredged material in open water model) to determine sediment fluxes, shear stresses, transport pathways, and deposition zones for different placement depths and volumes within the placement grid (Figure 6).

Figure 6. Strategic placement sites narrowed down from twelve to two: Emeryville (top) and Eden Landing (bottom). Site map includes both placement footprint (red grid) and target marsh for restoration (aqua hatch).

Placement alternatives incorporated information on flood tides at various stages of the tidal cycle, including Mean Higher High Water (MHHW), Mean Sea Level (MSL), and Mean Lower Low Water (MLLW), during the San Francisco Bay's environmental dredging window (i.e., June 1 – November 30). This determined specific depths for each cell in the placement grid, and ultimately, the design footprints based on depth isolines. The first set of alternatives all utilized the same placement volumes (i.e., 100,000 CY) distributed across the footprint based on scow loading capability as correlated with depths of greater than 9 feet for the shallowest placement; 10 feet for the intermediate placement; and 11 feet for deepest placement. In the first round of modeling, six placement alternatives were analyzed – three for Eden Landing and three for Emeryville Crescent Marsh. The first six scenarios were used to determine whether Emeryville or Eden Landing is most suitable for the pilot project. Different placement strategies at each location were then analyzed to determine the second round of modeling scenarios, and ultimately, to narrow in on the most effective placement strategy (Table 2).

Table 2. First round modeling scenarios testing placement locations, scow volumes, and tidal timings at Emeryville and Eden Landing locations.

Scenario	Placement Grid	Location	Placement Volume (10^3 CY)	Scow Volume (CY)	Minimum Time Between Placements (hrs)	Notes
1	Emeryville	Deep	100	1,400	6	
2	Emeryville	Middle	100	1,150	2	Placements during flood tide
3	Emeryville	Shallow/East	100	900	2	
4	Eden Landing	Deep	100	1,400	5	
5	Eden Landing	Middle	100	1,150	1.5	Placements during flood tide
6	Eden Landing	Shallow/East	100	900	1.5	

The second round of modeling consisted of six scenarios to evaluate the effect of different placement volumes, seasonal differences (summer versus winter), alternate sediment sourcing, and placement footprints (Table 3).

Table 3. Second round of modeling scenarios testing the effect of different placement volumes, seasonality, alternate sediment sourcing and footprint sizes at the Eden Landing location.

Scenario	Placement Grid	Location	Placement Volume (10^3 CY)	Scow Volume (CY)	Minimum Time Between Placements (HRS)	Notes
6	Eden Landing	Shallow/East	100	900	1.5	From First Set
7	Eden Landing	Shallow/East	50	900	1.5	
8	Eden Landing	Shallow/East	75	900	1.5	
9	Eden Landing	Shallow/East	100	900	1.5	Winter Placement
10	Eden Landing	Shallow/East	100	900	1.5	Oakland Sediment
11	Eden Landing	Expanded East	100	900	1.5	
12	Eden Landing	Expanded East	125	900	1.5	

This second round of modeling first examined how efficient different placement volumes (50,000; 75,000; and 100,000 CY) were at Eden Landing assuming the

Shallow/East placement strategy. Another sensitivity analysis examined 100,000 CY placements subject to wind and wave climate conditions during summer and winter months. Modeling also examined placement sensitivity to the original east/shallow placement footprint versus an expanded east footprint that represented a hybrid of the shallow and intermediate depth scenarios with an overall footprint over twice the size of the original shallow-east size (Table 2). Different sediment source channels (i.e., Oakland Harbor versus Redwood City Harbor) were tested to understand the impact of different grain sizes on sediment resuspension and mobility, with coarse sediments from Oakland Harbor channel and fine sediments from Redwood City Harbor channel. Finally, different placement volumes (100,000 CY versus 125,000 CY) were tested within this expanded east footprint.

Modeling results indicated that summer placements were more efficient at delivering sediments to the target mudflat and marsh system. Analysis of wave resuspension potential indicated significantly higher transport due to waves in summer months than in winter months, due to higher wind speeds. Significantly more placed sediment transported to Eden Landing mudflat/marsh complex in the two months following summer placement than in the three months following winter placement. There was also more regional sediment transport north out of South Bay following winter placement. Dredged material placements earlier in the summer when wind speeds are seasonally high are likely to be more effective at transporting sediment into the marsh than late-fall and winter placements.

Larger placement volumes resulted in more sediment reaching the target mudflat and marsh on short time scales (on the order of one to two millimeters) and will therefore be more measurable to determine pilot project success, although millimeter-scale deposition is difficult to measure over a wide area. Placement volume and mudflat and marsh deposition volume were linearly correlated with higher detectability for the 100,000 CY placement at the shallow/east footprint (Figure 7). A larger fraction of Oakland Harbor sediment remains in the placement footprint at end of the two-month analysis period. Dredged material with lower sand content is better for strategic placement, but the differences between dredged material from Oakland Harbor and Redwood City Harbor do not have a large effect on the overall volume of sediment that reaches Eden Landing after two months.

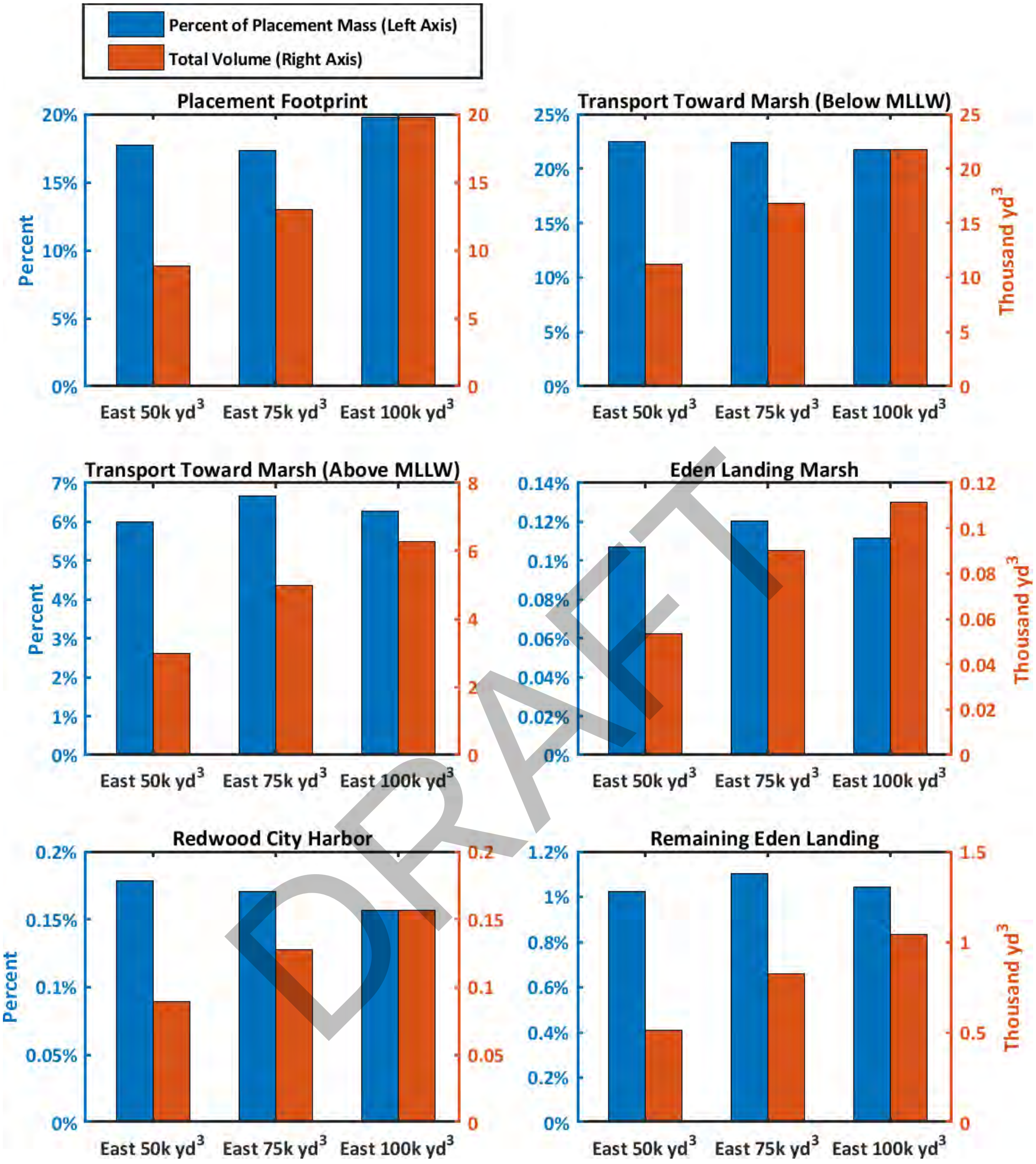


Figure 7. Predicted percentage of dredged sediment mass and dredged material volume in each region at the end of the 2-month simulations for evaluating the placement volume in the shallow/east placement footprint.

The expanded footprint includes areas of greater depth than the original footprint but allowed for thinner placements over the placement footprint. Less sediment was transported out of placement footprint in the two months following placement for the expanded footprint. Overall, results indicate that placements closest to the target marsh at the shallowest depths possible, where wave energy is highest, are most effective at transporting sediment to the marsh.

The final site selection process analyzed the percentage and volume of sediment delivered to the transition tidal flat and upland marsh, as well as the percentage dispersed outside the placement footprint but not to the target locations (i.e., nearshore tidal flat and adjacent marsh) and the percentage re-deposited in federal navigation channels or in nearby flood control channels (Figure 8). These criteria describe the efficiency and impacts of each design alternative, with the goal of maximizing sediment deposition to tidal flats/marshes, and minimizing sediment lost to the Bay, navigation channels and flood control channels. Modeling results indicated that the 100,000 CY shallow/east placement alternative at Eden Landing in the summer months using dredged material from the Redwood City Harbor federal navigation channel was the optimal strategy, which corresponds to scenario 6 (Figure 9, Figure 10, Table 2, Table 3).

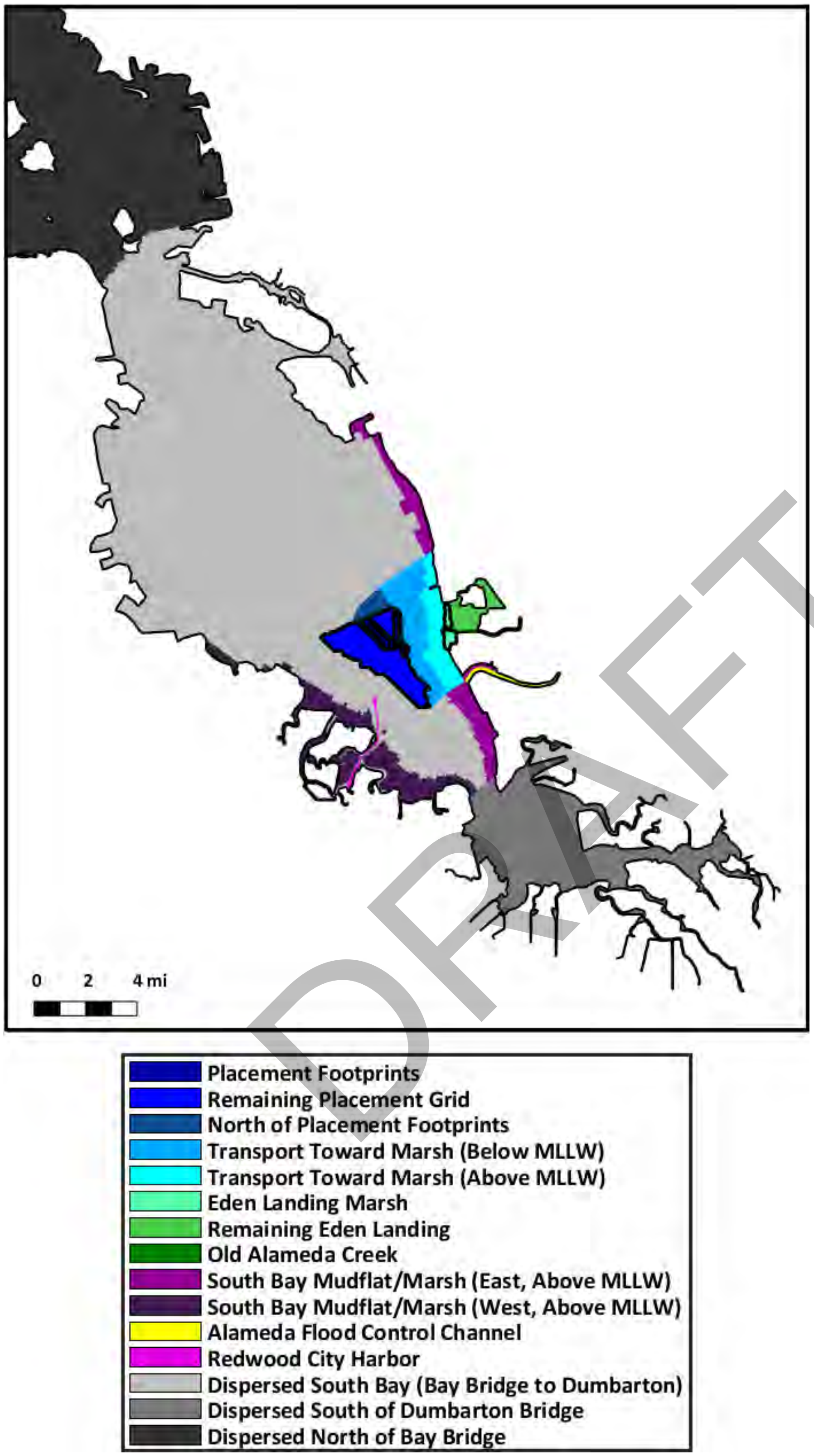


Figure 8. Binned regions to determine sediment transport fate from strategic placements toward target mudflats and marshes, ancillary mudflats and marshes, federal navigation channels, flood control channels, etc.

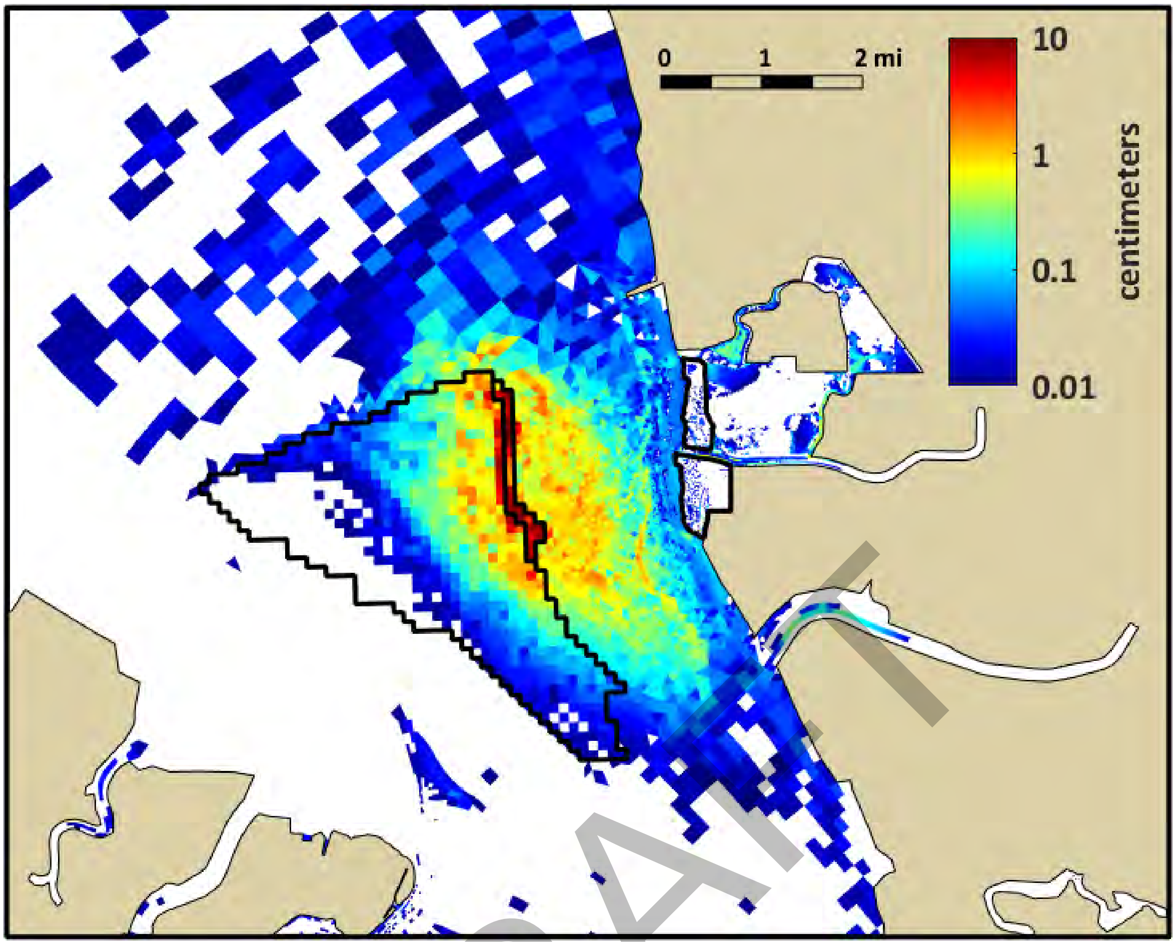
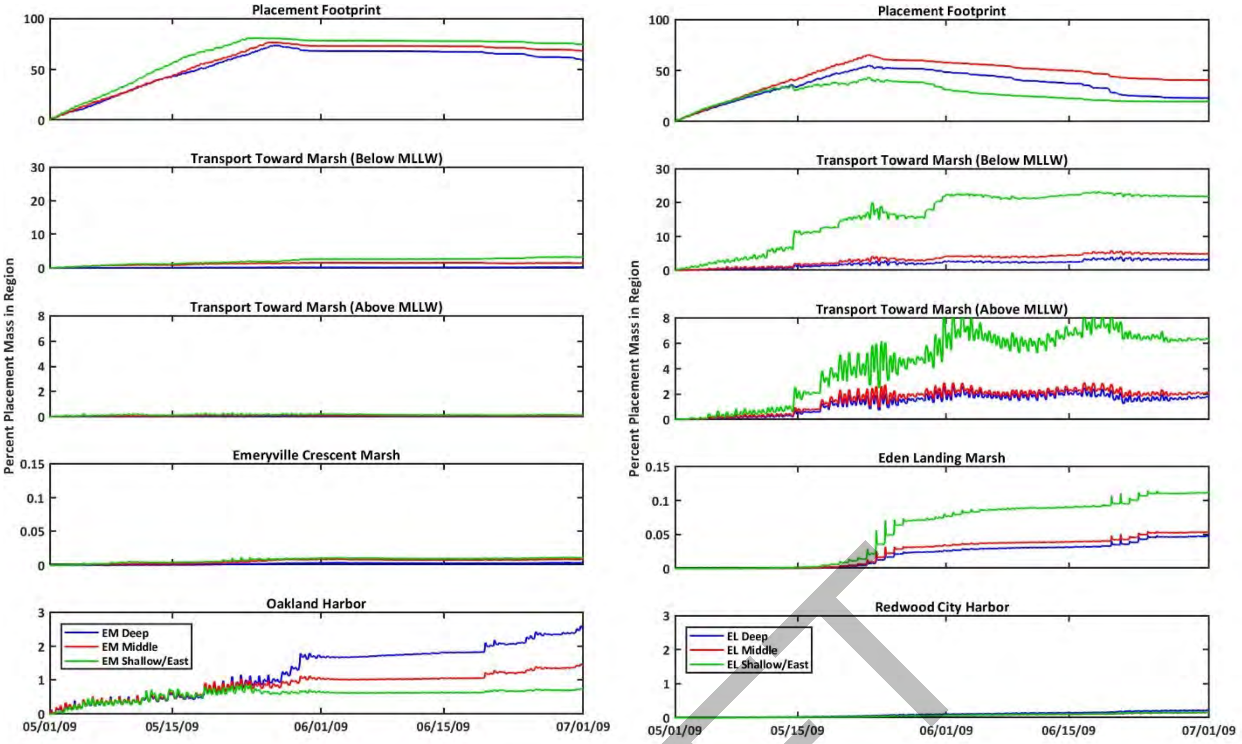


Figure 9. Eden Landing shallow/east placement planview indicating sediment deposition thickness after two-month summer model run for 100,000 CY. Note that deposition thickness is on the order of one to two millimeters in the target mudflat and marsh complex.



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Appendix C– HYDRAULIC AND SEDIMENT MODELING REPORT

August 2022
Section 1122 Pilot Project

Hydrodynamic and Sediment Transport Modeling of the San Francisco Bay to Evaluate Pilot Sites for Shallow Water Placement of Dredge Material

Prepared for U.S. Army Corps of Engineers

August 2022
Section 1122 Pilot Project

Hydrodynamic and Sediment Transport Modeling of the San Francisco Bay to Evaluate Pilot Sites for Shallow Water Placement of Dredge Material

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APPENDICES

Appendix A Model Validation
Appendix B Assumptions and Limitations of the Coupled Modeling System

ABBREVIATIONS

µm	micrometer
BAAQMD	Bay Area Air Quality Management District
BAW	Bundesanstalt für Wasserbau
CCWD	Contra Costa Water District
CIMIS	California Irrigation Management Information System
cm	centimeter
Delta	Sacramento-San Joaquin Delta
DEM	Digital Elevation Model
DICU	Delta Island Consumptive Use
Eden Landing Marsh	Whale's Tail portion of Eden Landing Marsh
FCC	flood control channel
fps	feet per second
ft	foot
kg	kilogram
kg/m^2s	kilogram per square meter per second
m	meter
m^2	square meter
m^3	cubic meter
mm	millimeter
mg/L	milligrams per liter
MHHW	mean higher high water
MHW	mean high water
MLLW	mean lower low water
mph	miles per hour
NA	not applicable
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NOAA	National Oceanic and Atmospheric Administration
Pa	pascals
PDT	Project Delivery Team
RMS	root-mean-square
$RMSD_N$	normalized root-mean-square difference
s	second
SPN	San Francisco District, USACE
SSC	suspended sediment concentration
STFATE	Short-Term Fate

SWAN	Simulating Waves Nearshore
ubRMSD	unbiased root-mean-square difference
$ubRMSD_N$	unbiased normalized root-mean-square difference
UnTRIM	Unstructured Nonlinear Tidal Residual Intertidal Mudflat
US	United States
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WRDA	Water Resources Development Act
yd^3	cubic yards

1 Introduction

Section 1122 of the Water Resources Development Act (WRDA) of 2016 required that the U.S. Army Corps of Engineers (USACE) establish a pilot program to recommend 10 projects for the beneficial use of dredged material. In October 2018, "Restoring San Francisco Bay's Natural Infrastructure with Dredged Sediment: Strategic Placement" was selected as one of the 10 nationwide 1122 Pilot Projects. This pilot project evaluates the effectiveness of strategic open-water placement of dredged material to facilitate the nature-based dispersal of dredged material to beneficial areas.

Between 1800 and 1998, it has been estimated that 79 percent of San Francisco Bay's tidal marshes (150,000 acres) and 42 percent of San Francisco Bay's tidal mudflats (21,000 acres) were lost to diking and filling (Goals Project 2015). There is concern that many of the remaining marshes and mudflats are particularly vulnerable to drowning due to the anticipated increase in sea level rise (Goals Project 2015). In this context, drowning refers to the conversion of baylands to habitats with lower relative tidal elevations (e.g., marsh changing to mudflat or mudflat changing to subtidal habitat). In particular, recent studies have shown that the accelerating sea level rise rate increases the risk of intertidal areas drowning, especially in systems with low sediment supply (Elmilady et al. 2022). If mudflat elevation does not keep up with sea level rise, more wave energy will reach the marsh edge, leading to erosion and loss of marsh extent (Goals Project 2015). In this context, providing a supplemental source of sediment to accelerate marsh and mudflat accretion has the potential to reduce the future drowning of mudflats and marshes and help offset future increases in sea level.

The overall goal of this 1122 Pilot Project is to evaluate the potential for strategic placement of dredged material to provide a supplemental source of sediment to accelerate marsh and mudflat accretion to offset future changes in sea level. This study applied a 3D hydrodynamic, wave, and sediment transport model to predict the fate and transport of open-water dredged material placements in San Francisco Bay. Modeling was used to evaluate the suitability of two potential placement sites and to assess the most effective placement strategy for each site.

Previous sediment transport modeling in San Francisco Bay focused on the dispersal of dredged material south of Dumbarton Bridge and demonstrated that dredged material could be naturally transported into breached salt ponds and onto mudflats (Bever and MacWilliams 2014; Bever et al. 2014). The study detailed in this report takes a similar approach and simulates the continual erosion, deposition, and transport of dredged material following open-water placements in San Francisco Bay. A total of 12 sediment transport modeling scenarios were conducted to evaluate how the location of the placements, total volume of placed material, dredged material source, and seasonal timing of the placement affects dispersal away from the placement location.

Dredged material placement scenarios were conducted near two marshes in San Francisco Bay: Emeryville Crescent Marsh and the Whale's Tail portion of Eden Landing Marsh (Eden Landing

Marsh). These two marshes were the target marshes for the natural dispersal of dredged material. Emeryville Crescent Marsh is located north of Oakland Harbor, and the majority of the marsh is at an elevation around mean high water (MHW) and mean higher high water (MHHW; Figure 1-1). The Whale's Tail portion of Eden Landing Marsh is located on the eastern side of South Bay, and the majority of the marsh is also at an elevation around MHW and MHHW (Figure 1-2). The surface elevations of the marshes are high enough that the majority of the inundation and sediment transport onto the marshes will occur when water surface elevations are near MHHW or higher.

This report documents the 3D hydrodynamic and sediment transport model simulations of the dispersal of dredged material and is organized into the following seven primary sections and two appendices:

- **Section 1: Introduction**: This section provides a description of the motivation for the project and a summary of the scope and organization of the report.
- **Section 2: UnTRIM Bay-Delta Model Overview**: This section provides a brief description of the high-resolution UnTRIM Bay-Delta model, the SWAN wave model, and the SediMorph morphological model.
- **Section 3: Model Simulations and Analyses**: This section describes the model simulations and analysis regions used to evaluate the dispersal of dredged material.
- **Section 4: Wave Characteristics, Shear Stress, and Residual Currents Around the Placement Locations**: This section provides the results of analyses evaluating wind waves and bed shear stress in the vicinity of the dredged material placements.
- **Section 5: Evaluation of Dredged Material Placement Scenarios**: This section describes the results of the individual dredged material placement scenarios and provides comparisons of the scenario results.
- **Section 6: Summary and Conclusions**: This section presents a summary of the work conducted and the conclusions of this study.
- **Section 7: References**: This section provides the references cited in this report and the associated appendices.
- **Appendix A: Model Validation**: This appendix documents the validation of predicted suspended sediment concentration during the two time periods simulated for the dredged material placements.
- **Appendix B: Assumptions and Limitations of the Coupled Modeling System**: This appendix details the assumptions and limitations inherent in the UnTRIM Bay-Delta hydrodynamic, wave, and sediment transport modeling system.

Figure 1-1
Map of Emeryville Crescent Marsh (Top) and Distribution of the Elevation of the Marsh Surface (Bottom)

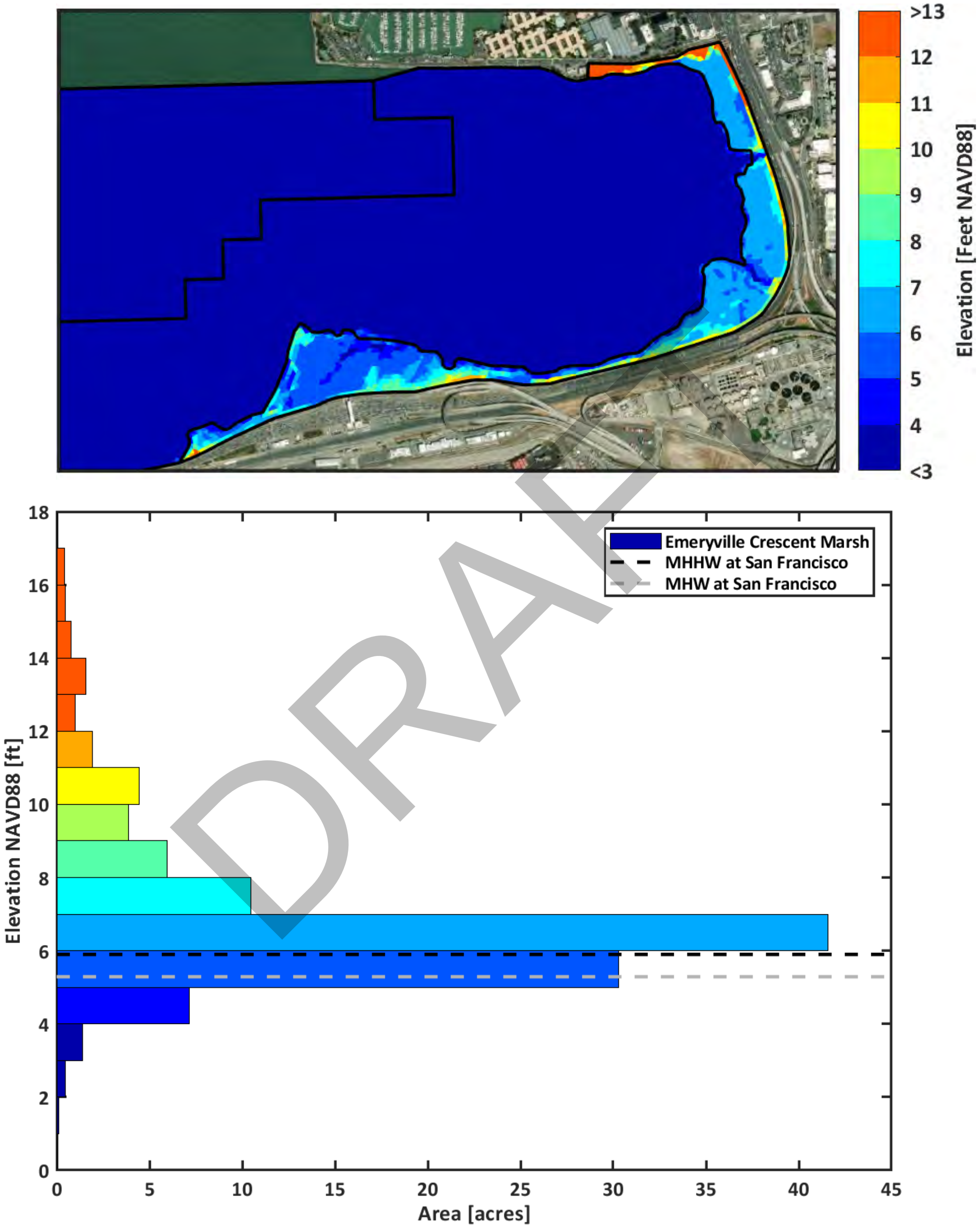
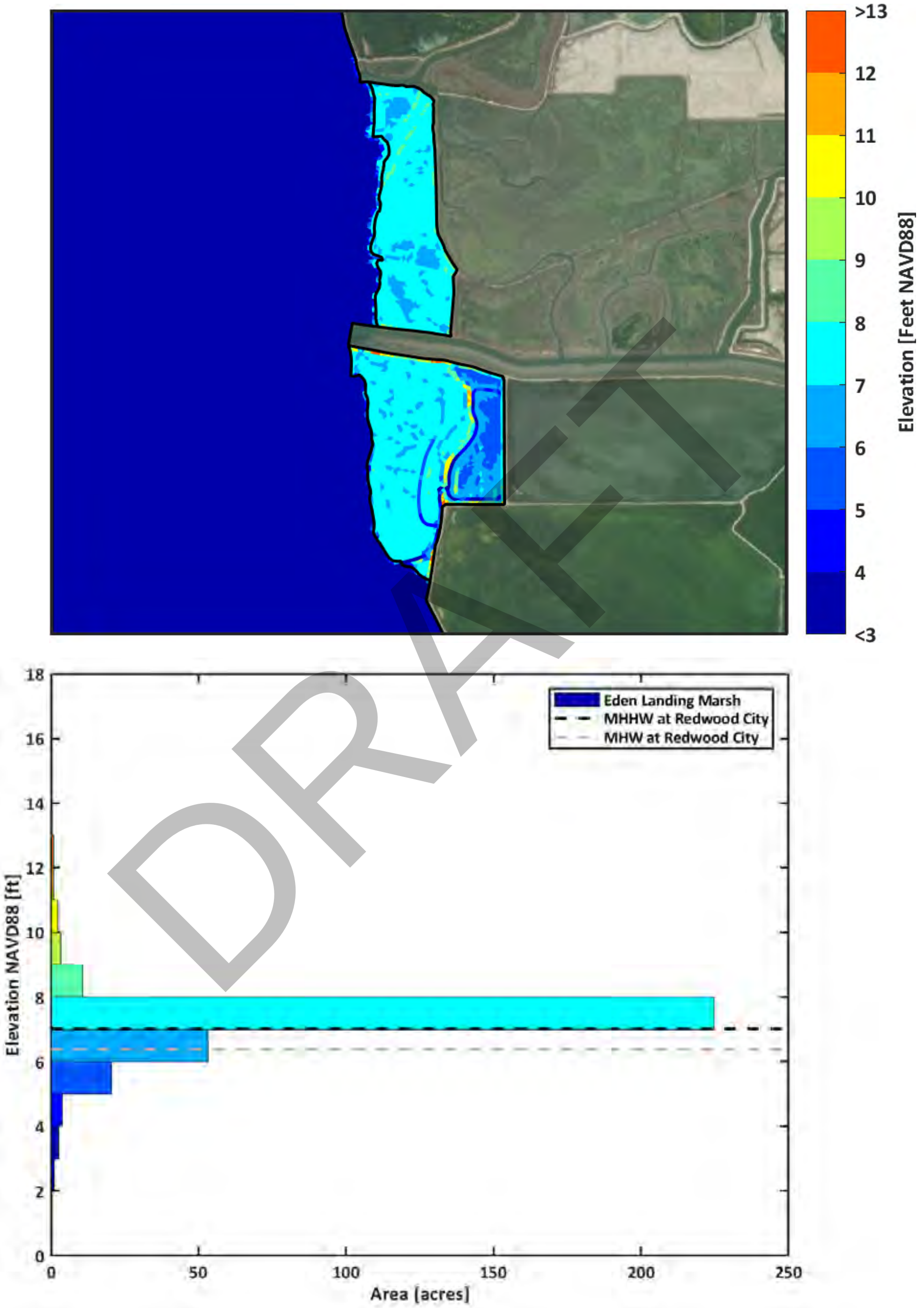


Figure 1-2
Map of Whale's Tail Portion of Eden Landing Marsh (Top) and Distribution of the Elevation of the Marsh Surface (Bottom)



2 UnTRIM Bay-Delta Model Overview

The San Francisco Estuary, comprising San Francisco Bay and the Sacramento-San Joaquin Delta, is a complex environment where freshwater from rivers mixes with saltwater from the ocean (MacWilliams et al. 2022). Important physical processes in the San Francisco Estuary, such as salinity intrusion and sediment transport, result from the complex interactions of tides, wind, and freshwater outflow and require a 3D model operating on a short time-step to accurately represent vertical and horizontal circulation processes (MacWilliams et al. 2016a). In particular, sediment transport in the San Francisco Estuary is driven by the interaction of wind-driven surface currents and wind waves and the combined shear stress of tidal currents and wind waves on sediment on the bed. Thus, the simulation of hydrodynamic and sediment transport processes that affect the deposition, resuspension, and dispersal of placed dredged material requires the application of a well-calibrated 3D hydrodynamic and sediment transport model.

The high-resolution UnTRIM Bay-Delta model is a 3D hydrodynamic model of the Bay and the Delta, which has been developed using the UnTRIM hydrodynamic model (MacWilliams et al. 2007, 2008, 2009, 2015). The UnTRIM Bay-Delta model extends from the Pacific Ocean through the entire Delta and takes advantage of the grid flexibility allowed in an unstructured mesh by gradually varying grid cell sizes, beginning with large grid cells in the Pacific Ocean and gradually transitioning to finer grid resolution in the smaller channels of the Delta. This approach offers significant advantages in terms of numerical efficiency and accuracy and allows for local grid refinement for detailed analysis of local hydrodynamics, while still incorporating the overall hydrodynamics of the larger estuary in a single model. The resulting model contains more than 130,000 horizontal grid cells and more than 1 million 3D grid cells (Figure 2-1). Extensive details of the hydrodynamic model and model inputs are available in MacWilliams et al. (2015).

The turbulence closure model used in this study is a two-equation model consisting of a turbulent kinetic energy equation and a generic length-scale equation. The parameters of the generic length-scale equation are chosen to yield the k-ε closure (Umlauf and Burchard 2003). The Kantha and Clayson (1994) quasi-equilibrium stability functions are used. All parameter values used in the k-ε closure are identical to those used by Warner et al. (2005a), except for the minimum eddy diffusivity and eddy viscosity values which were 1×10^{-6} m^2/s. In the horizontal, a constant horizontal eddy diffusivity of 0.5 m^2/s was used. The numerical method used to solve the equations of the turbulence closure is a semi-implicit method that results in tridiagonal, positive-definite matrices in each water column and ensures the turbulent variables remain positive (Deleersnijder et al. 1997).

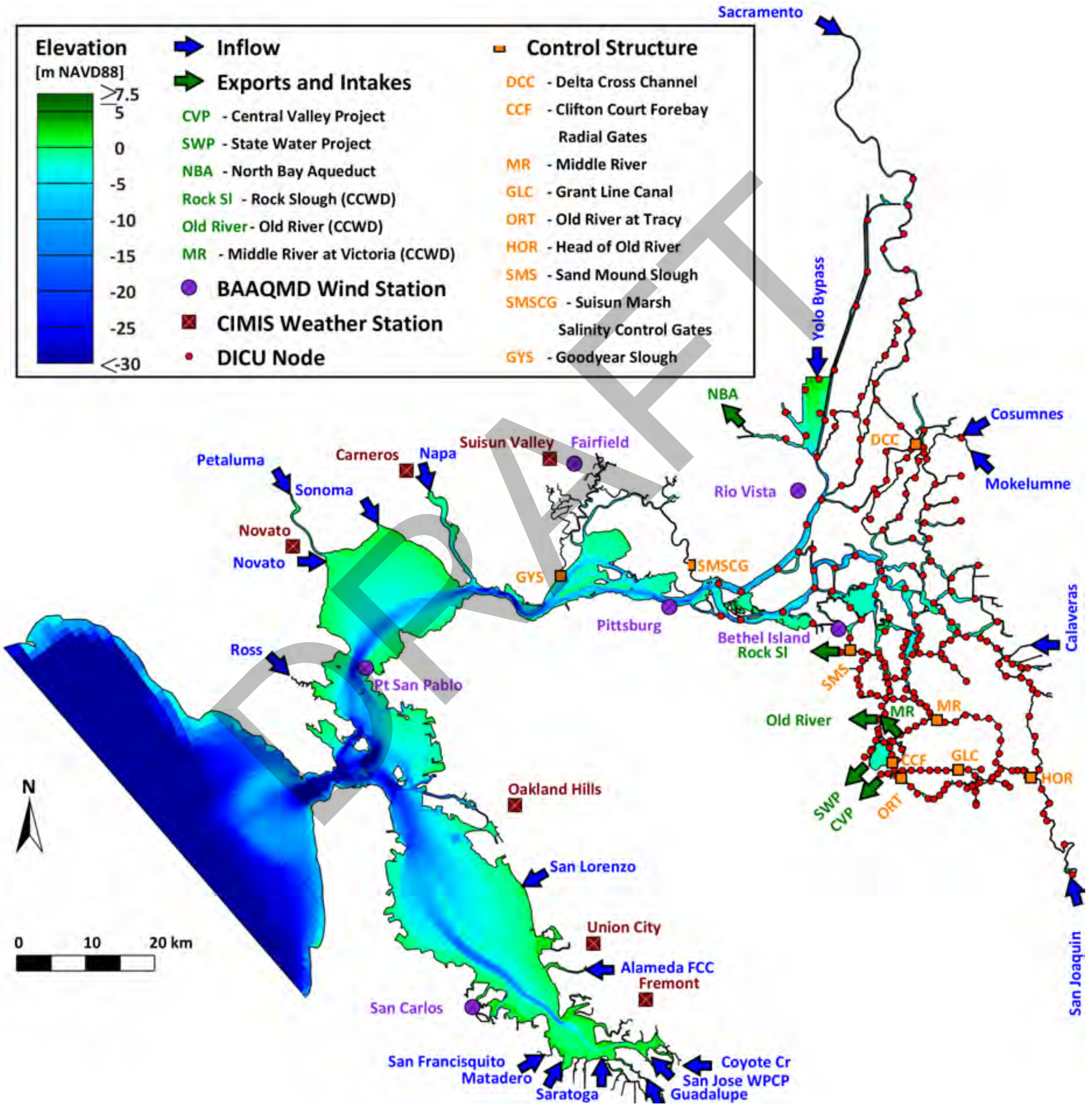
The UnTRIM Bay-Delta model has been applied to the Bay-Delta as part of the Delta Risk Management Strategy (MacWilliams and Gross 2007), several studies to evaluate the mechanisms behind the Pelagic Organism Decline (e.g., MacWilliams et al. 2008), the Bay-Delta Conservation Plan

(MacWilliams and Gross 2010), and for examining X2 and the Low Salinity Zone (MacWilliams et al. 2015). The UnTRIM Bay-Delta model has also been applied for a range of studies by USACE, including the Hamilton Wetlands Restoration Project (MacWilliams and Cheng 2007), the Sacramento River Deep Water Ship Channel Deepening Study (MacWilliams et al. 2009), the San Francisco Bay to Stockton Navigation Project Deepening Study (MacWilliams et al. 2014), and the South San Francisco Bay Shoreline Study (MacWilliams et al. 2012a). The UnTRIM Bay-Delta model has also been applied to several studies of sediment transport in support of the San Francisco Bay Regional Dredged Material Management Program (MacWilliams et al. 2012b; Bever and MacWilliams 2013, 2014; Bever et al. 2014; Delta Modeling Associates 2015) and for turbidity modeling in the Bay-Delta (Anchor QEA 2017; Bever et al. 2018).

The UnTRIM Bay-Delta model has been calibrated using water level, flow, salinity, suspended sediment concentration (SSC), and turbidity data collected in the Bay-Delta in numerous previous studies (e.g., MacWilliams et al. 2008, 2009; MacWilliams and Gross 2010; Bever and MacWilliams 2013; MacWilliams et al. 2015; MacWilliams et al. 2016b; Bever et al. 2018). The model has been shown to accurately predict salinity, tidal flows, water levels, and sediment transport throughout the Bay-Delta under a wide range of conditions (Delta Modeling Associates 2012; Bever and MacWilliams 2013; Bever and MacWilliams 2014; MacWilliams et al. 2015; MacWilliams et al. 2016b; Bever et al. 2018). This report documents the model validation for SSC in the Bay during the study period in Appendix A. Appendix B details the assumptions and limitations of the coupled modeling system that may influence model predictions and the comparison of predicted to observed values.

The hydrodynamic and sediment transport model simulations were conducted using metric units. As a result, the parameter values used in the model are presented in metric units, and the model validation and most of the analysis of the sediment transport modeling results are presented using metric units (e.g., meters, kilograms) in this report. The specifications for the dredged placement scenarios provided by the USACE San Francisco District (SPN) were developed based on United States (US) customary units (e.g., feet, cubic yards). As a result, the description of water depths, dredge material volumes, and some horizontal dimensions are presented using US customary units.

Figure 2-1
High-Resolution UnTRIM San Francisco Bay-Delta Model Domain, Bathymetry, and Locations of Model Boundary Conditions that Include Inflows, Export Facilities, Contra Costa Water District (CCWD) Intakes, Wind Stations from the Bay Area Air Quality Management District (BAAQMD), Evaporation and Precipitation from California Irrigation Management Information System (CIMIS) Weather Stations, Delta Island Consumptive Use (DICU), and Flow Control Structures



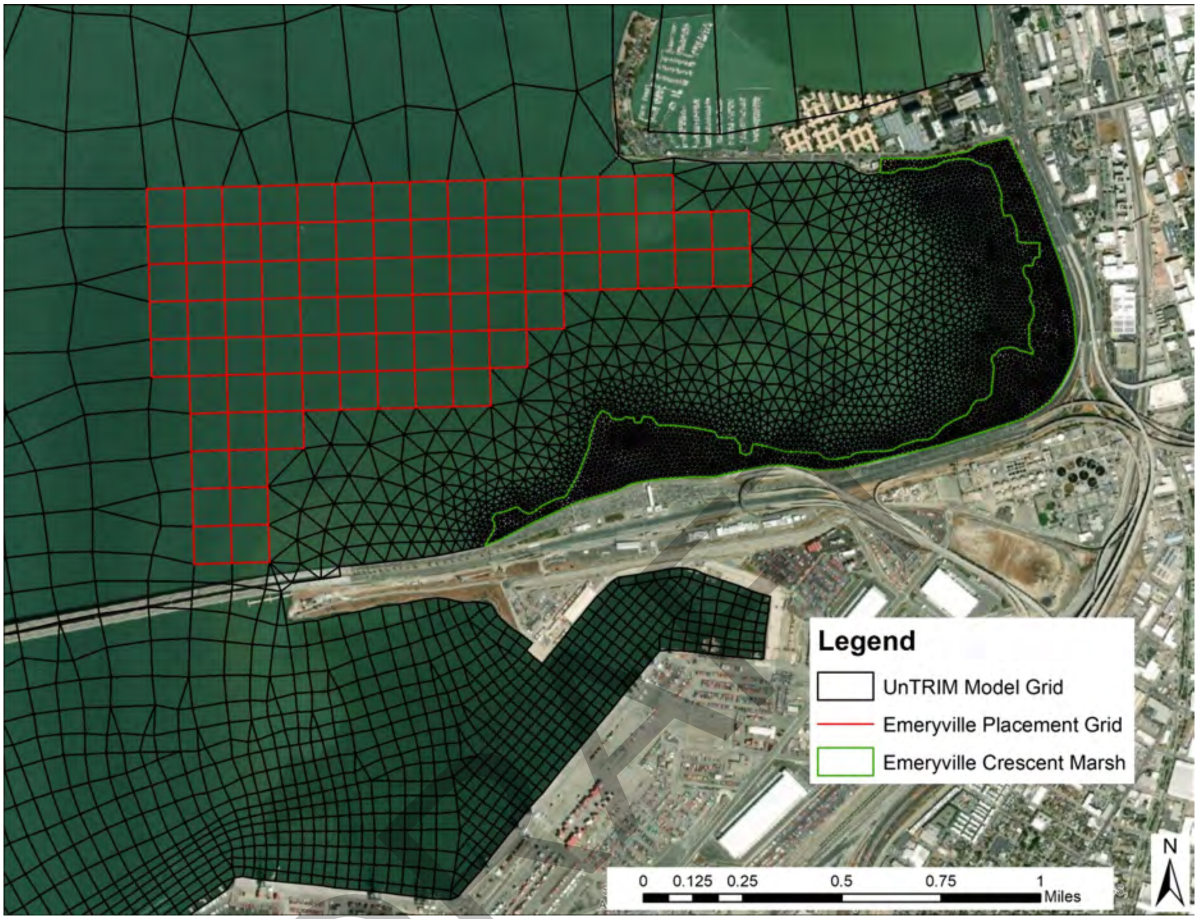
2.1 High-Resolution Grid of Placement Locations

To resolve the transport of sediment following dredged material placements at Emeryville and Eden Landing, the UnTRIM model grid was refined in the vicinity of both potential placement locations. At both locations, a placement grid was established by USACE spanning the region where placements would be evaluated. The placement grid consists of uniform 500-foot (ft) by 500 ft (152.4 m by 152.4 m) square placement cells. The model grid was refined to exactly resolve the placement grid at both potential placement sites.

At the Emeryville placement location (Figure 2-2), the model grid was refined with typical cell sizes in the marsh on the order of 20 m. Between the placement grid and the marsh, the grid cell size transitions from 152.4 m resolution of the placement grid down to approximately 20 m resolution on the edge of the marsh.

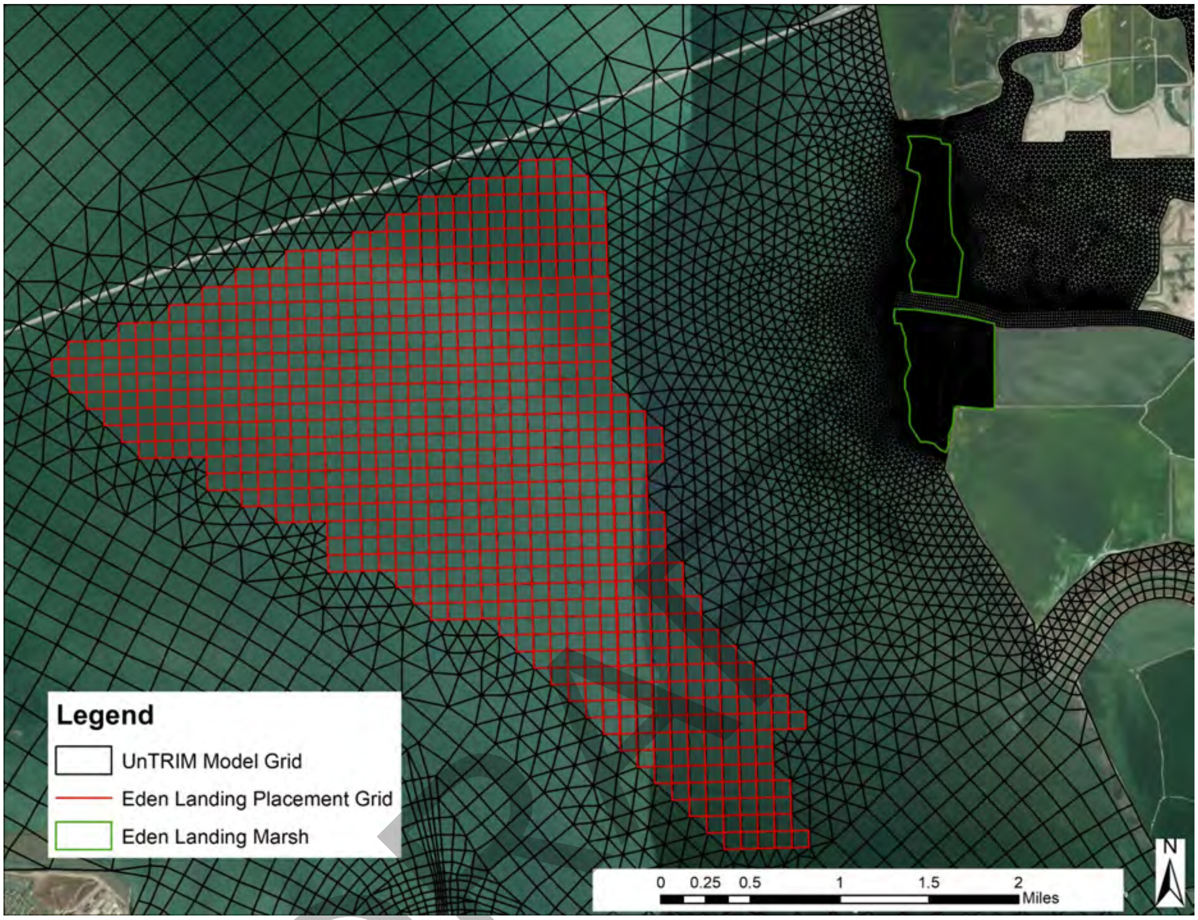
Bathymetry in the two refined portions of the UnTRIM Bay-Delta model grid was updated based on a U.S. Geological Survey (USGS) Coastal National Elevation Database topographic and bathymetric 2-meter Digital Elevation Model (DEM). This DEM spanned the entire San Francisco Bay and was selected for use in this study based on input from SPN. This DEM is referenced to the North American Datum of 1983 (NAD83) horizontal datum and North American Vertical Datum of 1988 (NAVD88) vertical datum. The DEM is available from USGS (2022).

Figure 2-2
High-Resolution Model Grid Around the Emeryville Placement Location



At the Eden Landing placement location (Figure 2-3), the model grid in the Whale’s Tail portion of Eden Landing Marsh was refined with typical cell sizes in the marsh on the order of 25 m. The remaining portions of Eden Landing were resolves using a grid resolution between 25 and 50 m. Between the placement grid and the marsh, the grid cell size transitions from the 152.4 m resolution of the placement grid down to approximately 25 m resolution on the edge of the marsh.

Figure 2-3
High-Resolution Model Grid Around the Eden Landing Placement Location



2.2 Sediment Modeling Background

The UnTRIM Bay-Delta model (MacWilliams et al. 2007, 2008, 2009, 2015) has been applied together with the Simulating Waves Nearshore (SWAN) wave model (SWAN Team 2009a) and the SediMorph sediment transport and seabed morphology model (BAW 2005) as a fully coupled hydrodynamic wave-sediment transport model. This coupled modeling system has been used previously to predict sediment transport throughout the Bay-Delta system. Most recently, the model was used to estimate reductions in turbidity throughout Suisun Bay and the confluence region from observed decreases in the wind speed (Bever et al. 2018) and for evaluating sediment flux through the Golden Gate (Anchor QEA 2021). The model has also been applied as part of two projects for USACE to investigate how sea level rise and reduced sediment supply to the Delta impacted sediment routing through the Bay-Delta system and sediment deposition within Suisun and San Pablo Bays (MacWilliams et al. 2012b; Bever and MacWilliams 2014). The coupled models were also used to investigate the effects of breaching Prospect Island on regional turbidity and sediment dynamics in the north Delta and Cache Slough region (Delta Modeling Associates 2014). Other applications of the sediment transport model include simulations of dredged material dispersal in the Northern Bay (MacWilliams et al. 2012b) and the South Bay (Bever and MacWilliams 2014; Bever et al. 2014) to determine the fate of dredged material and investigate whether open-water placements can be used to augment mudflat and marsh sedimentation. Bever and MacWilliams (2013) have also applied the coupled modeling system to investigate wave shoaling and sediment fluxes between the channel and shoals in San Pablo Bay. The UnTRIM Bay-Delta model can be used to predict turbidity as well as sediment transport.

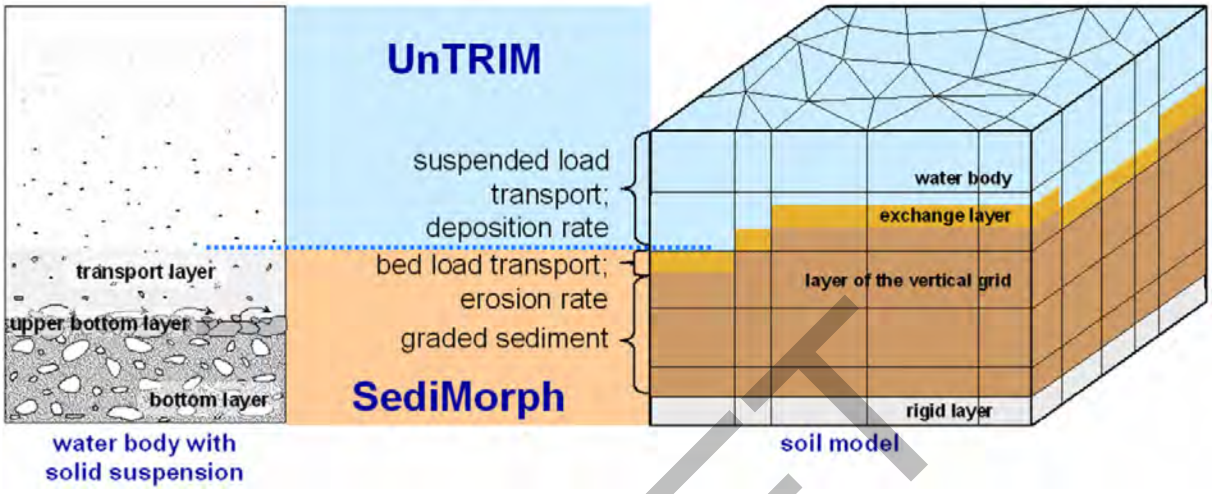
The SWAN model (SWAN Team 2009a) is a widely used model for predicting wind wave properties in coastal areas (e.g., Funakoshi et al. 2008). SWAN "represents the effects of spatial propagation, refraction, shoaling, generation, dissipation and nonlinear wave-wave interactions" (SWAN Team 2009b) on wind waves. Therefore, SWAN can estimate the wind waves in coastal regions with variable bathymetry and ambient currents. SWAN can also accommodate spatial variability in bottom friction parameters and wind velocity. In the coupled modeling system, the SWAN model runs on the same unstructured grid as UnTRIM, providing high resolution in areas where it is needed.

The primary purpose of the SediMorph module is to compute the sedimentological processes at the alluvial bed of a free-surface flow, including the following (Weilbeer 2005):

- The roughness of the bed resulting from grain and form roughness (ripples and/or dunes)
- The bottom shear stress as a result of roughness, flow, and waves
- Bed load transport rates (fractioned)
- Erosion and deposition rates (fractioned)
- Bed evolution
- Sediment distribution within the bed exchange layer

SediMorph is designed to use the same horizontal computational mesh as the UnTRIM hydrodynamic model. In the vertical, the SediMorph module allows for evolution of the bed elevation above a pre-defined rigid layer in each cell. Above the rigid layer, SediMorph includes at least one exchange layer, in which sediments are mixed and exchange processes such as erosion and deposition occur. Figure 2-4 shows the horizontal and vertical grid structure of the UnTRIM and SediMorph models and provides a schematic representation of the location of the sediment transport processes within the model grid structures.

Figure 2-4
Horizontal and Vertical Grid Structure of the UnTRIM and SediMorph Models (Right); Schematic (Left) and Process List (Middle) Show the Location of the Sediment Transport Processes within the Model Grid Structures



Source: Bundesanstalt für Wasserbau (BAW)

Sediment transport simulations using the UnTRIM Bay-Delta Model include multiple sediment classes, an initial sediment bed based on over 1,300 observed seabed grain size distributions within the Bay and Delta, sediment input from 11 Bay-Delta tributaries, and wave- and current-driven sediment resuspension and transport. In this coupled modeling system, UnTRIM calculates the flow, water level, and salinity, along with suspended sediment advection, settling, and mixing. SWAN calculates the temporally and spatially varying waves needed for accurate predictions of sediment resuspension in the presence of wind waves. SediMorph calculates the erosion and deposition of sediment and the seabed morphologic change and keeps track of the sedimentological properties within the seabed. The model bathymetry in each grid cell is adjusted each time step to account for erosion and deposition. The configuration of the coupled modeling system, the sediment transport model, and model inputs used in this study is nearly identical to that described in Bever et al. (2018). However, one additional sediment class to represent very fine sediments that settle very slowly was included to improve the predicted SSC and turbidity in the Delta (Table 2-1). Additionally, three separate sediment classes for Silt, Flocculated Silt and Clay, and Sand were included to allow for the tracking of the dredged material separately from other sediment in the system. These three sediment classes used the same sediment parameters as the other Silt, Flocculated Silt and Clay, and Sand classes (Table 2-1).

Table 2-1
Sediment Class Characteristics

Sediment Class	Settling Velocity (mm/s)	Critical Shear Stress (Pa)	Diameter	Density (kg/m^3)	Erosion Rate Parameter (kg/m^{2}s)
Fine silt	0.001	0.0379	11 µm	2,650	2.5×10^{-5} to 10×10^{-5}
Silt	0.038	0.0379	11 µm	2,650	2.5×10^{-5} to 10×10^{-5}
Flocculated silt and clay	2.25	0.15	200 µm	1,300	3×10^{-5} to 12×10^{-5}
Sand	23	0.19	250 µm	2,650	5×10^{-5} to 20×10^{-5}
Gravel	NA	NA	8 mm	2,650	NA
Silt (dredged material)	0.038	0.0379	11 µm	2,650	2.5×10^{-5} to 10×10^{-5}
Flocculated silt and clay (dredged material)	2.25	0.15	200 µm	1,300	3×10^{-5} to 12×10^{-5}
Sand (dredged material)	23	0.19	250 µm	2,650	5×10^{-5} to 20×10^{-5}

Note:
NA: not applicable

The initial sediment bed in the UnTRIM Bay-Delta model was developed by spatially interpolating observed percent mud (silt and clay), sand, and gravel distributions onto the model grid and then separating the interpolated distributions into the sediment classes noted in Table 2-1, as described in Bever and MacWilliams (2013) and Bever et al. (2018). One of the grain size distribution data points was in the Emeryville placement grid (Figure 2-2), and two grain size distribution data points were in the Eden Landing placement grid (Figure 2-3). The grain size distribution for the data point in the Emeryville placement grid included 98.9% mud, 1.1% sand, and no gravel. The average grain size distribution for the two data points in the Eden Landing placement grid included 91.2% mud, 8.8% sand, and no gravel.

2.3 Sediment Model-Data Comparisons

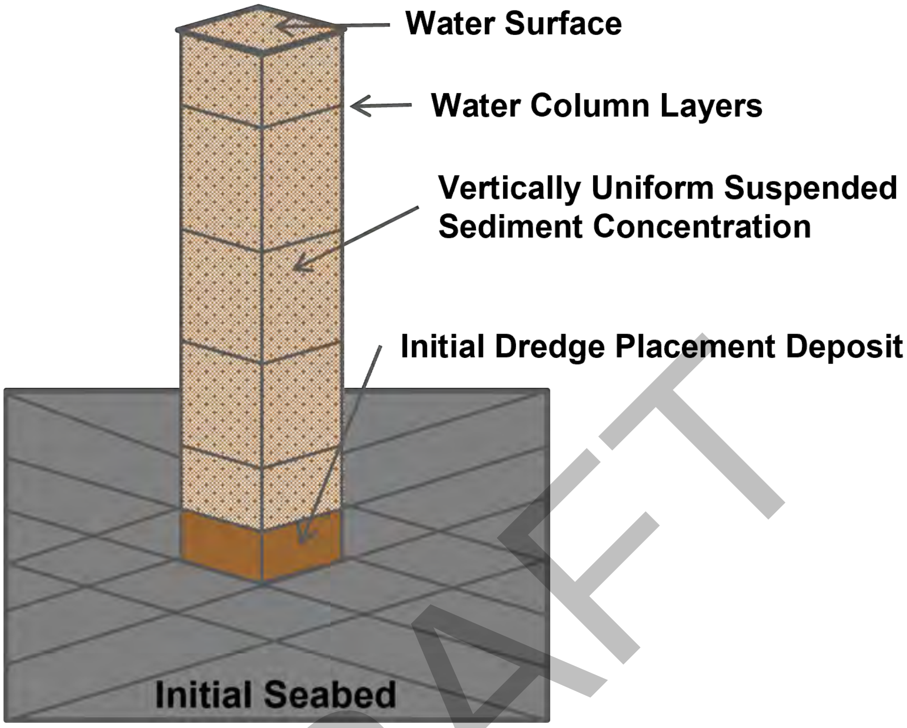
The SWAN wave results have been calibrated and validated to observed wave properties in San Pablo Bay and Suisun Bay (Delta Modeling Associates 2012) and at four locations south of Dumbarton Bridge (Bever and MacWilliams 2014). The sediment transport within the coupled modeling system has been calibrated using a variety of observed data, including SSC time series at multiple locations within the Bay, continuous monitoring stations within Suisun Bay and the Delta, and vertical profiles of SSC along a transect along the axis of the Bay from the far South Bay to Rio Vista. The model has also been validated through comparison of observed and predicted deposition within a breached salt pond during the period following the initial breach (Bever and MacWilliams 2014). Turbidity has been validated using continuous monitoring time series in the Bay and Delta and surface remotely sensed data (Anchor QEA 2017; Bever et al. 2018). The sediment validation demonstrates that the coupled hydrodynamic-wind wave-sediment model is accurately capturing the dominant processes that resuspend, deposit, and transport sediment throughout the

Bay-Delta system and would, therefore, be suitable for predicting sediment transport throughout the Bay-Delta. A detailed validation of predicted SSC using time series at discrete locations during the two time periods considered in this study is presented in Appendix A.

2.4 Sediment Transport Model Dredged Material Placement Framework

The UnTRIM Bay-Delta model can be used to simulate the transport of sediment following dredged material placement events. Dredged material placement events are initialized in the sediment transport model as the 3D sediment transport model simulation progresses. At the time of each dredged material placement event, both suspended sediment and a sediment deposit on the seabed are instantaneously initialized at a single horizontal grid cell. The suspended portion of the placement sediment is set to have a vertically uniform concentration that depends on the amount of each sediment class suspended in the water column during a placement event. The deposited portion is initialized as a sediment deposit having a thickness dependent on the added mass, density of each sediment class, and assumed porosity (Figure 2-5). A porosity of 85% was used in this study, consistent with the porosity used in previous studies (Bever and MacWilliams 2014, Delta Modeling Associates 2015). This 85% porosity value was calibrated through model comparison of predicted and observed sediment depositional volumes in navigation channels (e.g., Delta Modeling Associates 2015) and comparison of predicted and observed deposition thickness following the breach of Salt Pond A6 in the far South Bay (Bever and MacWilliams 2014). Each sediment class can represent different fractions of the total placement sediment mass and different fractions of the suspended and deposited sediment. The dredged material deposited on the seabed acts to fill up multiple seabed layers at the sediment water interface, such that the dredged placement sediment remains at the surface of the seabed where it can be eroded and is not artificially mixed within the initial sediment bed or previous dredged material placements. Sediment eroded from the surrounding initial sediment bed can deposit on top of the placement sediment as the simulations progresses, however.

Figure 2-5
Schematic of a Single Horizontal Grid Cell Immediately Following a Dredged Material Placement Event



A simplification inherent in this model setup is that for each placement the sediment is added to the model at the time of the placement event with a vertically uniform sediment concentration in the water column and a deposit on the seabed. The physics of the actual descent of the sediment from a barge to the seabed are not modeled by the coupled hydrodynamic, wave and sediment transport models. Instead, simulations using the Short-Term Fate (STFATE) model (Johnson and Fong 1995) are used to determine the amounts of dredged material suspended in the water column and deposited on the seabed during the descent from the barge. This is necessary because much of the dredged material is in large clumps that do not behave similarly to the individual sediment particles, and thus this initialization of each placement event provided the most realistic representation possible of the sediment distribution immediately following the placement event.

Following the addition of the sediment to a model grid cell, the sediment in suspension begins to settle toward the seabed and the sediment deposit erodes if the bed shear stress exceeds the critical shear stress of the sediment. The erosion, deposition, and transport of the initially suspended and deposited portions of the placement are then modeled by the coupled hydrodynamic-wave-sediment transport models.

The dredged material placement framework allows for an unrestricted number of placement events within a single simulation. Each placement event has its own date and time, location, scow size, and sediment fractions in suspension and deposition. It also allows for the placement of sediment only in suspension or only on the seabed. Placement events can also be modeled with or without an initial sediment bed and ambient suspended sediments. The sediment used for the dredged material in the model is specified as a separate sediment class to those initially on the sediment bed and discharged from tributaries (Table 2-1) to allow for the tracking of the dredged material separately from other sediment in the system.

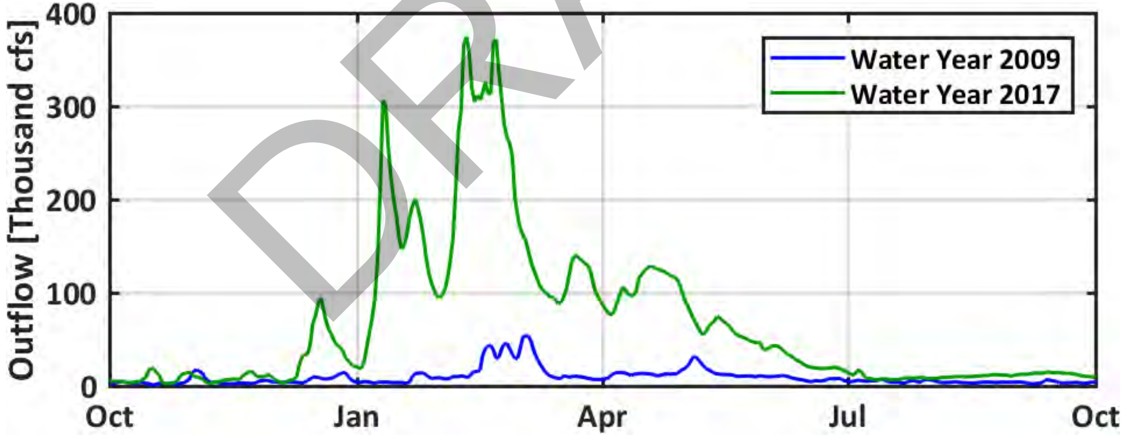
3 Model Simulations and Analyses

This section describes the model simulations and analyses used to evaluate the model predictions. These analyses were used to evaluate the average wave conditions at the two placement locations, determine the timing and model grid cell for each dredged material placement event, and evaluate the fate of the dredged material and the end of the simulation periods.

3.1 Simulation Time Periods

Two time periods were considered for simulating the dispersal of sediment away from dredged material placement locations. One time period was during the winter of a wet year when Delta outflow is relatively high, and one time period was during late spring and early summer of a dry year when wind waves are generally larger and Delta outflow is lower (Section 4). The Dayflow program provides an estimate of the daily net water outflow from the Delta to San Francisco Bay (Delta outflow; CDWR 2022), which was used to compare Delta outflow for the periods simulated. The winter model simulation period spanned 3 months. November 1, 2016, through January 31, 2017, was chosen as the winter period because it has a relatively high, although not extreme, Delta outflow compared to other recent years (Figure 3.1-1).

Figure 3.1-1
Time Series of Dayflow Delta Outflow



The wind speeds around Central Bay and South Bay were evaluated to aid in the selection of the dates for the summer simulation period. Wind direction was then evaluated for the summer and winter periods to determine any differences in wind direction between the two simulation periods. The wind speed during 2 consecutive months was used to determine the root-mean-squared (RMS) wind speed. The RMS is similar to the average, except higher values are weighted more strongly using the RMS than the average. Weighting the higher wind speeds more strongly is beneficial in this analysis because the higher wind events will result in larger wind waves and more sediment resuspension. Due to the short timeline of this study, the Project Delivery Team (PDT) determined it would be beneficial to select a period during which the sediment transport model had previously been calibrated to SSC measurements in the study area so additional model calibration would not be required. Based on a review of 11 periods simulated for previous studies, 3 years were identified for further evaluation in this analysis: 2006, 2008, and 2009. These years were selected for consideration because they had previously been simulated for other projects and the sediment transport model had already been validated to available SSC data in the study area for these periods. The years 2006, 2008, and 2009 also span the full range of water year types from wet to critical water years, to allow for consideration of both the wettest and driest water year classifications. The highest RMS wind speed in Central Bay occurred during May and June 2009 (Figure 3.1-2). The highest RMS wind speed in South Bay occurred during May and June 2008, with the second highest RMS speed in May and June 2009 (Figure 3.1-3). Based on the relatively high RMS wind speeds, May 1 through June 30, 2009, was used for the summer simulation period.

Figure 3.1-2
RMS Wind Speed in Central Bay

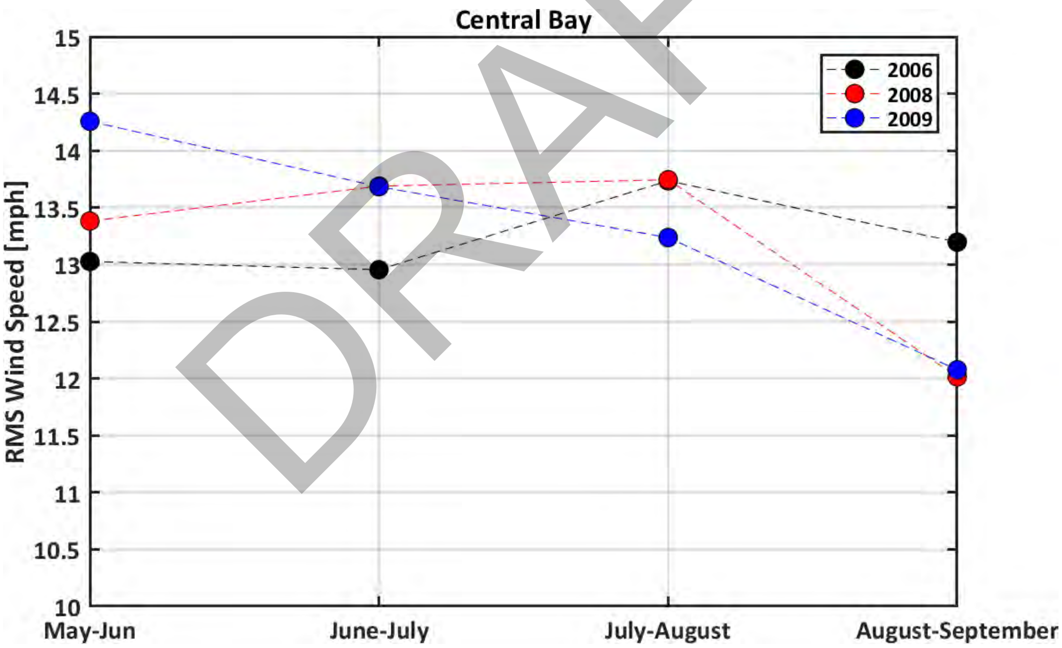
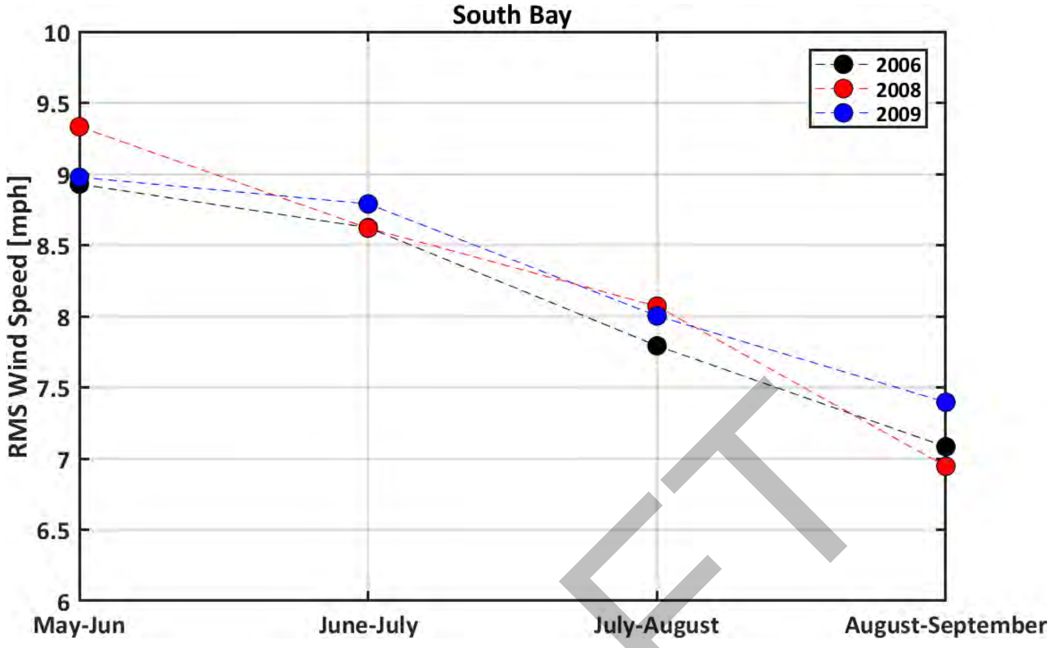


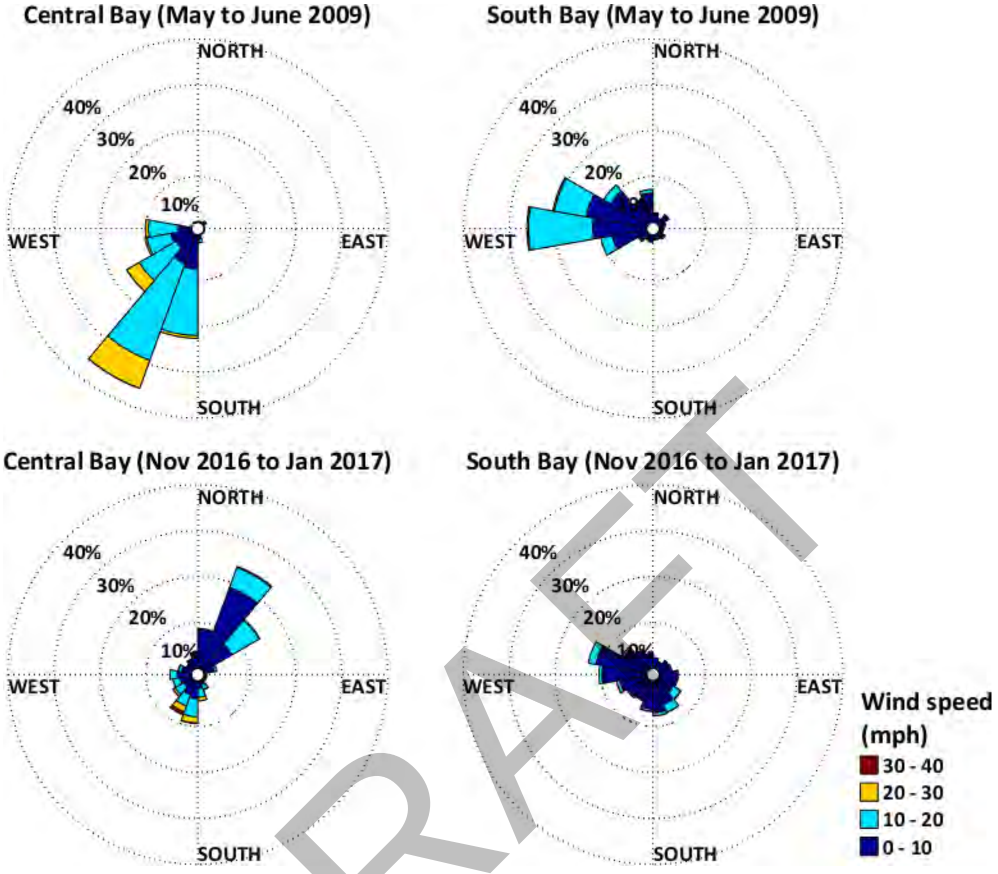
Figure 3.1-3
RMS Wind Speed in South Bay



Directional wind roses were developed from the available wind data in Central Bay and South Bay and used to evaluate differences in wind speed and direction between the summer and winter simulation periods (Figure 3.1-4). The dashed circles on the wind roses represent the percentage of time the wind was blowing from each direction, and the wind speed is represented by the colors. In the Central Bay during the summer simulation period, winds were predominantly from the southwest. A southwest wind direction allows the wind to blow across Central Bay toward the eastern side and results in a relatively long fetch for developing wind waves, compared to winds from the northwest. In the Central Bay during the winter simulation period, winds were predominantly from the northwest, with a small percentage of the winds from the southwest. Northwest winds will result in relatively small wind waves on the eastern side of Central Bay, while the few periods of strong winds from the southwest have the potential to generate relatively large wind waves on the eastern side of Central Bay.

In the South Bay during the summer simulation period, winds were predominantly from the west (Figure 3.1-4). A west wind direction allows the wind to blow across South Bay toward the eastern side and results in a relatively long fetch for developing wind waves, compared to winds from the east. In the South Bay during the winter simulation period, wind direction was more variable than during the summer period. The wind speed was also lower during the winter period than during the summer period, which is shown by most of the wind rose being the dark blue color (0 to 10 miles per hour). Lower wind speeds and some winds from the southeast and east will result in smaller wind waves on the eastern side of South Bay during the winter period than during the summer period.

Figure 3.1-4
Central Bay and South Bay Wind Roses for the Summer and Winter Simulation Periods



Note:
Direction is the direction from which the winds are blowing.

3.1.1 *Validation of Predicted Suspended Sediment Concentrations*

Because the UnTRIM Bay-Delta model has already been extensively calibrated for water levels, salinity, and flows (MacWilliams et al. 2015), no further model calibration was conducted as part of this study. To validate the prediction of SSC in the study area, the predicted SSC was compared to observed SSC at all locations in San Francisco Bay where SSC measurements were available during the two analysis periods used in this study to evaluate the dredged material placement scenarios. Appendix A provides model validations of SSC throughout the Bay during the period that dredged material dispersal was evaluated. Predicted SSC was compared to observed SSC using time series at discrete locations spanning from Dumbarton Bridge to Mallard Island. Time series data were available from six locations through USGS (USGS 2020) and at another location in San Pablo Bay (Schoellhamer et al. 2008). At the stations where SSC were available from both upper and lower sensors, both the data and the model predicted a large amount of vertical stratification in SSC.

This was particularly evident at the Richmond-San Rafael Bridge, Benicia Bridge, and Dumbarton Bridge stations in the winter period (Table A-1 in Appendix A) and at the Benicia Bridge and Dumbarton Bridge stations during the summer period (Table A-2 in Appendix A).

3.2 Dredged Material Placement Assumptions

This section describes the assumptions of scow size and necessary water depth for placements, the distribution of dredged material between various sediment types, and the estimation of the percentage of material suspended in the water column during a placement event.

3.2.1 Scow Volumes and Necessary Water Depths

Multiple assumptions regarding the amount of dredged material placed during each individual placement event and the placement strategy for each scenario were needed to determine the exact location and timing of each dredged material placement for each scenario. All scenarios assumed the use of 180 ft (length) by 50 ft (breadth) split-hulled bottom dump scow with a capacity of 1,450 cubic yards (yd^3). The dump time is assumed to be 9 minutes. To facilitate the evaluation of placements over a range of placement depths, the scows were assumed to contain either 1,400 yd^3, 1,150 yd^3, or 900 yd^3 of dredged material. The light loading of the scow allowed for a smaller draft depth and facilitated placements in shallower water (Table 3.2-1). Based on information provided by USACE, the water depths necessary for a placement event were 11 ft for the 1,400 yd^3 placements, 10 ft for the 1,150 yd^3 placements, and 9 ft for the 900 yd^3 placements. These were the minimum depth requirements for a placement event used to develop placement scenarios (Table 3.2-1) and included the draft depth plus 1 ft of clearance. Light-loading the barge to less than 900 yd^3 of dredged material was not evaluated in this study. Further reducing the loading of the barge from 900 to 550 yd^3 was considered by the PDT to be impractical due to the increasing number of individual placements and associated costs.

Table 3.2-1
Scow Loading and Draft Assumptions Provided by USACE

Scow Loading (yd^3)	Draft Depth (ft)	Minimum Required Placement Depth (ft)
1,400	10	11
1,150	9	10
900	8	9
550	7	8
0	2.5	NA

3.2.2 *Composition of Dredged Material*

Data on the sediment dredged from Oakland Harbor and Redwood City Harbor were used to specify the proportion of silt, flocs, and sand model sediment classes in the dredged material. USACE provided the percentage of the dredged material in the barges composed of clumps, sand, silt, clay, and water for material dredged from Oakland Harbor (Table 3.2-2) and Redwood City Harbor (Table 3.2-3). For the specification of the grain sizes of the placed sediment in the sediment transport model, the clumps were assumed to be composed of the same relative fractions of sand, silt, and clay as the values for those constituents provide by USACE. The silt and clay fractions were added together to determine the total percentage of fine sediment in a scow because silt and clay in San Francisco Bay aggregate to form flocs. The total percentage of fine sediment was then separated into the modeled silt and flocs sediment classes by assuming 30% of the fine sediment was disaggregated silt and 70% of the fine sediment was flocs, similar to the assumption made previously when modeling the dispersal of dredged material in far South Bay (Bever and MacWilliams 2014). The resulting percentages of each sediment class for the dredged material used in this study were 20% sand, 24% silt, and 56% flocs for the Oakland Harbor sediment and 10% sand, 27% silt, and 63% flocs for the Redwood City Harbor sediment. The placement scenarios at Emeryville assumed the use of dredged material from Oakland Harbor. The placement scenarios at Eden Landing assumed the use of dredged material from Redwood City Harbor, with the exception of one scenario that evaluated the placement of sediment from Oakland Harbor at Eden Landing.

Table 3.2-2
Dredged Material Characteristics for Oakland Harbor

Material	USACE Provided Percentage of Scow Volume	Percent Sediment	Percent Sand/Silt/Clay	USACE Provided Fall Velocity (fps)
Clumps	20.08%	55.00%	NA	3
Sand	3.31%	9.07%	20.15%	0.025
Silt	5.92%	36.03%	36.03%	0.003
Clay	7.20%	43.82%	43.82%	0.003
Water	63.50%	NA	NA	NA

Note:
NA: not applicable

Table 3.2-3
Dredged Material Characteristics for Redwood City Harbor

Material	USACE Provided Percentage of Scow Volume	Percent Sediment	Percent Sand/Silt/Clay	USACE Provided Fall Velocity (fps)
Clumps	20.07%	54.99%	NA	3
Sand	1.59%	4.36%	9.68%	0.025
Silt	4.66%	12.77%	28.36%	0.003

Material	USACE Provided Percentage of Scow Volume	Percent Sediment	Percent Sand/Silt/Clay	USACE Provided Fall Velocity (fps)
Clay	10.18%	27.89%	61.96%	0.003
Water	63.50%	NA	NA	NA

Note:
NA: not applicable

The percentages of mud, sand, and gravel in the Oakland Harbor and Redwood City Harbor sediment were similar to the available observed grain size distribution data available in the placement grids. Oakland Harbor sediment contained 79.85% mud (silt plus clay), 20.15% sand, and no gravel (Table 3.2-2). The bed grain size distribution data in the Emeryville placement grid included 98.9% mud, 1.1% sand, and no gravel (Section 2.2). The majority of the sediment in both the Oakland Harbor sediment and bed grain size distribution data was mud, although the Oakland Harbor sediment had a higher percentage of sand than the bed grain size distribution data. Some of the difference in the mud and sand percentages may be attributed to only having a single bed grain size distribution sample in the Emeryville placement grid and Oakland Harbor extending west into deeper water where sand is more prevalent.

Redwood City Harbor sediment contained 90.32% mud (silt plus clay), 9.68% sand, and no gravel (Table 3.2-3). The bed grain size distribution data in the Eden Landing placement grid included 91.2% mud, 8.8% sand, and no gravel (Section 2.2). The majority of the sediment in both the Redwood City Harbor sediment and bed grain size distribution data was mud, and the percentages of mud, sand, and gravel were very similar between the Redwood City Harbor sediment and bed grain size distribution data available in the Eden Landing placement grid.

3.2.3 Fraction of Dredged Material Suspended in the Water Column

The dredged material placement framework in the UnTRIM Bay-Delta model assumes the dredged material is added into the simulation after the barge is empty (Section 2.4). Results from the STFATE model (Johnson and Fong 1995) were used to estimate the percentage of the sediment suspended in the water column during descent from the barge. The STFATE simulations used the percentage of clumps, sand, silt, clay, and water in the scow based on the Oakland Harbor and Redwood City Harbor data provided by USACE (Tables 3.2-2 and 3.2-3). The fall velocity of the sediment was also provided by USACE.

Hydrodynamic model simulations were used to determine background current speeds and ranges of water depths over which the placement events could occur for the STFATE simulations. The predicted depth-averaged RMS current speed from May 1 to June 30, 2009, was calculated from the hydrodynamic model output at three locations in the Emeryville and Eden Landing placement grids (Table 3.2-4). The three locations spanned from relatively deep to shallow areas of the placement grids. At each placement depth, the RMS current speeds at Eden Landing were higher than the RMS current speeds at Emeryville.

Table 3.2-4
Current Speed and Range in Water Depth Used for STFATE Simulations

Placement Grid	RMS Current Speed (fps)			Range in Water Depth (feet)		
	Deep	Middle	Shallow/East	Deep	Middle	Shallow/East
Emeryville	0.60	0.41	0.38	11 to 13.5	10 to 12	9 to 11.5
Eden Landing	0.74	0.64	0.59	11 to 14	10 to 13	9 to 12

Completely emptying of the barge during a placement event was assumed to take 9 minutes, and the STFATE results were evaluated 1 minute after the emptying of the barge to estimate the percentage of sediment suspended in the water column during placement. The volume of sediment predicted to remain in suspension and predicted to be deposited on the bed 1 minute after the emptying of the barge was used to determine the percentage of clumps, sand, silt, and clay suspended in the water column during the placement. For each STFATE simulation, 100% of the clumps were predicted to be deposited on the bed at 1 minute after the barge was empty. The total percentages of sand, silt, and clay suspended in the water column were then weighted based on 100% of the clumps being deposited on the bed. The percentages of silt and clay predicted to be suspended in the water column were the same within each STFATE simulation and were used as the stripping percentage for the silt and flocs sediment classes in the sediment transport model. The STFATE simulations resulted in 17.8% to 30.2% of the sand being suspended in the water column and 41.8% to 43.0% of the silt and flocs being suspended in the water column during the placement event (Table 3.2-5). The percentage of sand suspended in the water column used in this study is considerably higher than the percentage used in the previous study evaluating dispersal of dredged material in the far South Bay, in which the sand stripping percentage ranged from 0% to 4.7% (Bever and MacWilliams 2014).
For the far South Bay modeling (Bever and MacWilliams 2014), the STFATE results were evaluated approximately 16 minutes after the barge was emptied, 15 minutes later than was assumed for this study. Based on the fall velocity of 0.025 feet per second for sand (Table 3.2-3), the settling depth of sand over 15 minutes is 24 feet. Because this study evaluated the STFATE results 1 minute after the barge was emptied rather than 16 minutes after the barge was emptied, the percentages of sand suspended in the water column are higher than those used in the previous study focused on the far South Bay, which used the percentages still in suspension 15 minutes later.

Table 3.2-5
STFATE Simulations and Percentages Suspended in the Water Column

Placement Grid	Location (Scow Volume)	Current Speed (fps)	Water Depth (feet)	Percentage Stripped		
				Sand	Silt	Flocs
Emeryville	Deep (1,400 yd^3)	0.60	11	23.6	42.5	42.5
			13.5	27.6	42.9	42.9
	Middle (1,150 yd^3)	0.41	10	21.2	42.2	42.2
			12	25.8	42.7	42.7
	Shallow/East (900 yd^3)	0.38	9	17.8	41.8	41.8
			11.5	24.4	42.5	42.5
Eden Landing	Deep (1,400 yd^3)	0.74	11	30.2	42.5	42.5
			14	29.4	43.0	43.0
	Middle (1,150 yd^3)	0.64	10	26.4	42.2	42.2
			13	26.5	42.8	42.8
	Shallow/East (900 yd^3)	0.59	9	27.5	41.8	41.8
			12	26.4	42.6	42.6

3.2.4 Conversion of Scow Volume to Sediment Mass

The sediment transport model simulates the transport of sediment mass throughout the Bay-Delta. However, the dredged material placement events were developed based on the volume of dredged material in a scow, and some of the volume in a scow is composed of water (Tables 3.2-2 and 3.2-3). This necessitated converting the volume of the scow to the total mass of each sediment class in the scow for simulating the dispersal of dredged material. The volume of sediment in the scow was calculated by assuming 63.5% of the scow volume was water (Tables 3.2-2 and 3.2-3). The resulting sediment volumes for the sand, silt, and flocs sediment classes were then converted to mass using the density of each sediment class (Table 2-1).

Calculations of sediment mass in the scow assumed a porosity of 63.5% (Tables 3.2-2 and 3.2-3), while the sediment bed in the sediment transport model assumed a porosity of 85%. The 85% porosity in the sediment transport model is based on previous calibrations of predicted sediment depositional thickness and volumes. The increase in assumed porosity from the scow to the sediment bed results in a thicker dredged material deposit on the sediment bed than had a 65% porosity been used for the sediment bed. Differences in assumed porosity between in the scow and deposited on the bed are reasonable because some disaggregation of the sediment and increase in porosity will occur during the descent from the scow and subsequent deposition on the bed.

3.2.5 *Emeryville and Eden Landing Placement Grids*

Grids composed of 500 ft by 500 ft squares were developed by USACE near Emeryville Crescent Marsh and Eden Landing Marsh for potential dredged material placement locations (Figures 2-2 and 2-3). The Emeryville placement grid was composed of 84 individual 500 ft by 500 ft grid cells. The Eden Landing placement grid was composed of 729 individual 500 ft by 500 ft grid cells. Individual dredged material placements in the sediment transport model were specified to occur in one of the placement grid cells. The placement grid cells that included a dredged material placement in a model scenario are termed the "placement footprint." The placement footprint represents the spatial area over which dredged material placements were conducted in any individual scenario.

Figure 3.2-1
Dredged Material Placement Grids

Note:
Red squares are the placement grid cells near Emeryville Crescent Marsh (north) and Eden Landing Marsh (south). The entire extent of the placement cells is termed the "placement grid."

3.3 Dredged Material Placement Sediment Transport Scenarios

A total of 12 dredged material placement scenarios were conducted using the UnTRIM Bay-Delta model. A two-stage approach was used to develop the assumptions for the 12 scenarios. The first six scenarios were used to evaluate whether Emeryville or Eden Landing was most suitable for pilot study and to evaluate different placement strategies at each location to narrow in on most effective placement strategy. At both Emeryville and Eden Landing, three scenarios were developed to simulate placements of fully loaded scows containing 1,400 yd^3 of dredged material at a deep location, partially loaded scows containing 1,150 yd^3 of dredged material near the middle of the placement grid, and partially loaded scows containing 900 yd^3 of dredged material in the shallow/east portion of the placement grid nearest to the target marsh (Table 3.3-1). Based on the results of these first six scenarios, the remaining six scenarios evaluated the effect of different placement volumes, seasonal differences, and other refinements to the placement strategy at Eden Landing (Table 3.3-1). The specific assumptions for all 12 of the placement scenarios were developed through discussion with SPN and the PDT, which included both USACE staff and other stakeholders.

3.3.1 Description of Initial Six Scenarios

The initial six dredged material placement scenarios were designed to evaluate how the locations of the placements affected the amount of material predicted to be transported onto the mudflats and marshes. All six scenarios simulated the May through June 2009 period with faster winds and resulting larger wind waves than the December 2016 through January 2017 period (see Section 4 for a description of the waves and bed shear stress). The larger wind waves result in more sediment resuspension following the dredged material placements.

The initial six dredged material placement scenarios assumed placement of a total of 100,000 yd^3 of dredged material. Using 100,000 yd^3 of material resulted in a total of 72 placement events using a scow loaded with 1,400 yd^3 of dredged material, 87 placement events using a scow loaded with 1,150 yd^3 of dredged material, and 112 placement events using a scow loaded with 900 yd^3 of dredged material. The final placement event in each scenario used a smaller volume of dredged material so that the total volume placed for each scenario was exactly 100,000 yd^3.

Of the first six scenarios, three scenarios were conducted with placements in the Emeryville placement grid, and three were conducted with placements in the Eden Landing placement grid (Table 3.3-1). The scenarios at Emeryville and Eden Landing considered three different locations within each placement grid, representing relatively deep, middle, and shallow locations. Within the Emeryville placement grid, the deep and middle placement locations each consisted of 24 individual placement grid cells, but space constraints limited the shallow location to 12 individual placement grid cells. Within the Eden Landing placement grid, the deep, middle, and shallow placement locations each consisted of 24 individual placement grid cells.

While it was assumed the same size scow was used for all scenarios, different volumes of sediment in the scow were used for the deep, middle, and shallow placement locations to allow for larger placement volumes and fewer placement events in deeper water. The deep locations used a scow loaded with 1,400 yd^3 of dredged material, and each placement event required a minimum water depth of 11 feet. The middle locations used a scow loaded with 1,150 yd^3 of dredged material, and each placement event required a minimum water depth of 10 feet. The shallow locations used a scow loaded with 900 yd^3 of dredged material, and each placement event required a minimum water depth of 9 feet. Sediment characteristics (Section 3.2.2) and stripping percentages (Section 3.2.3) for the Emeryville placement grid scenarios were based on the sediment from Oakland Harbor. Sediment characteristics and stripping percentages for the Eden Landing placement grid scenarios were based on the sediment from Redwood City Harbor.

A hydrodynamic model simulation was used to determine the time-varying water depths in the placement grids for specifying exact locations and times of placement events. Starting at 00:00 on May 1, 2009, every 15 minutes the predicted water depth in each placement grid cell was evaluated to determine whether any water depths were sufficient for a placement event. If no water depths were greater than the minimum depth needed for the scow, the next 15-minute interval was evaluated. If any water depths were sufficient for a placement event, a placement event was specified to occur in the shallowest placement cell with water depths sufficient for a placement. Following each placement event, it was assumed that a minimum amount of time passed before the subsequent placement could occur. The minimum amount of time between placements was determined for each scenario to be as long as possible, while still allowing for all of the placements to occur in less than 28 days. This was necessary because the total duration of most placement simulations was only 2 months. Placements were required to be as evenly spread out in the placement grid as possible, such that if an individual placement cell reached the maximum number of placement events it was removed from consideration for further placements, regardless of the water depth in the placement cell.

The shallow placement locations were more restrictive on when placement events could occur because they required the tidal water surface elevation to be near high water for the water depth to be deep enough to allow for a placement.

For the middle placement locations, the placement events were required to occur during a flooding tide. When placements occur on flood tide the sediment suspended in the water column during placement will initially be transported toward the marsh, potentially resulting in a more effective placement strategy than if placements occur on ebb tide. The change in water surface elevation was used to determine whether the tide was flooding or ebbing. A positive change in water surface elevation indicates the water surface elevation is increasing and the tide is flooding, while a negative change in water surface elevation indicates a decreasing water surface elevation and an ebb tide. To classify as a flooding tide for a dredged material placement, the change in water surface elevation needed to be positive at both the potential time of the placement and 15 minutes after the time of the placement. This ensured that the placements occurred during flood tide and that the tide did not reverse immediately following the placements.

Table 3.3-1
Summary of Dredged Material Placement Scenarios

Scenario Number	Scenario Name	Location	Scow Loading	Dredged Material Placement Volume	Notes
1	Emeryville Deep	Deep	1,400 yd^3	100,000 yd^3	
2	Emeryville Middle	Middle	1,150 yd^3	100,000 yd^3	Placements during flood tide
3	Emeryville Shallow/East	Shallow/East	900 yd^3	100,000 yd^3	
4	Eden Landing Deep	Deep	1,400 yd^3	100,000 yd^3	
5	Eden Landing Middle	Middle	1,150 yd^3	100,000 yd^3	Placements during flood tide
6	Eden Landing Shallow/East	Shallow/East	900 yd^3	100,000 yd^3	
7	Eden Landing 50,000 yd^3	Shallow/East	900 yd^3	50,000 yd^3	Smaller total placement volume
8	Eden Landing 75,000 yd^3	Shallow/East	900 yd^3	75,000 yd^3	Smaller total placement volume
9	Eden Landing Winter	Shallow/East	900 yd^3	100,000 yd^3	Winter period of November 2016 through January 2017—3-month simulation
10	Eden Landing Oakland Harbor Sediment	Shallow/East	900 yd^3	100,000 yd^3	Dredged material based on Oakland Harbor sediment
11	Eden Landing Larger Placement Footprint	Expanded Shallow/East	900 yd^3	100,000 yd^3	Shallow placement location but with a larger placement footprint
12	Eden Landing Larger Placement Footprint 125,000 yd^3	Expanded Shallow/East	900 yd^3	125,000 yd^3	Shallow placement location but with a larger placement footprint and larger placement volume

3.3.1.1 Scenario 1: Emeryville Deep

The Emeryville Deep scenario consisted of 72 placement events in 24 placement grid cells, with three placements in each placement grid cell (Figure 3.3-1). Placements were located in the western deeper portion of the placement grid. Placements were spaced at least 6 hours apart (Figure 3.3-2). The scenario included 100,000 yd^3 of dredged material that was assumed to come from Oakland Harbor and evaluated dispersal from May 1, 2009, through June 30, 2009. Scows were assumed to hold 1,400 yd^3 of dredged material and require a minimum water depth of 11 ft.

Figure 3.3-1
Number of Placement Events in Each Placement Grid Cell: Scenario 1 Emeryville Deep

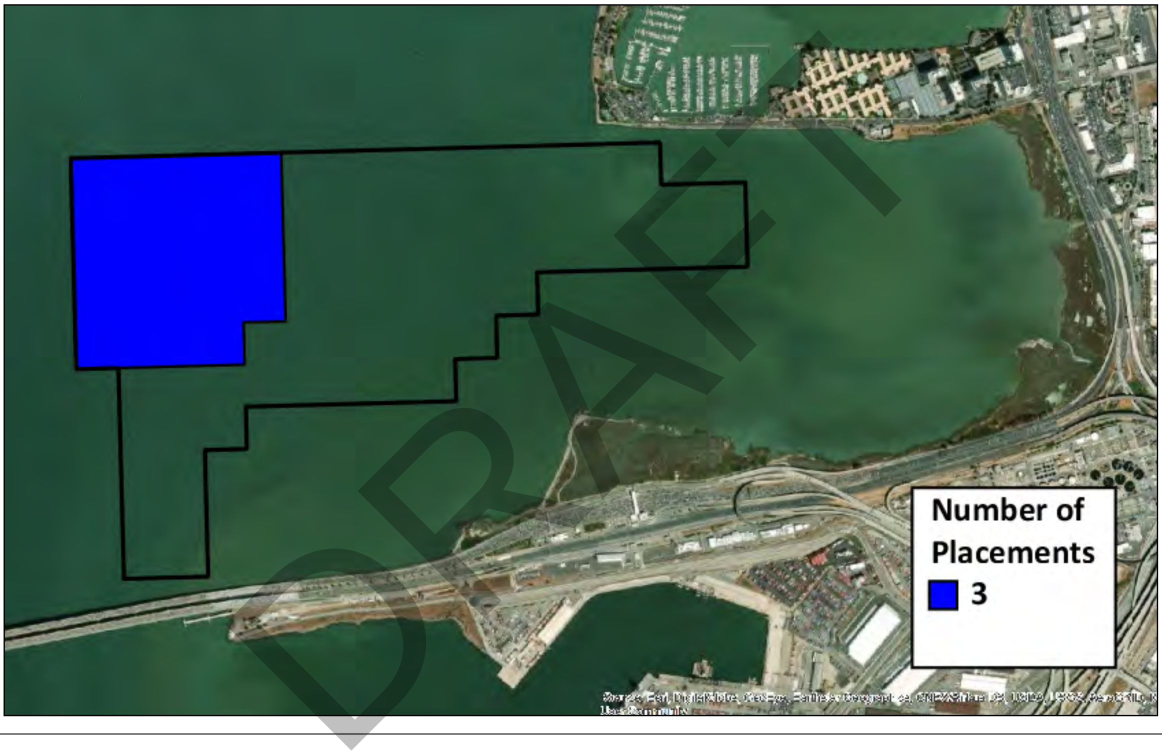
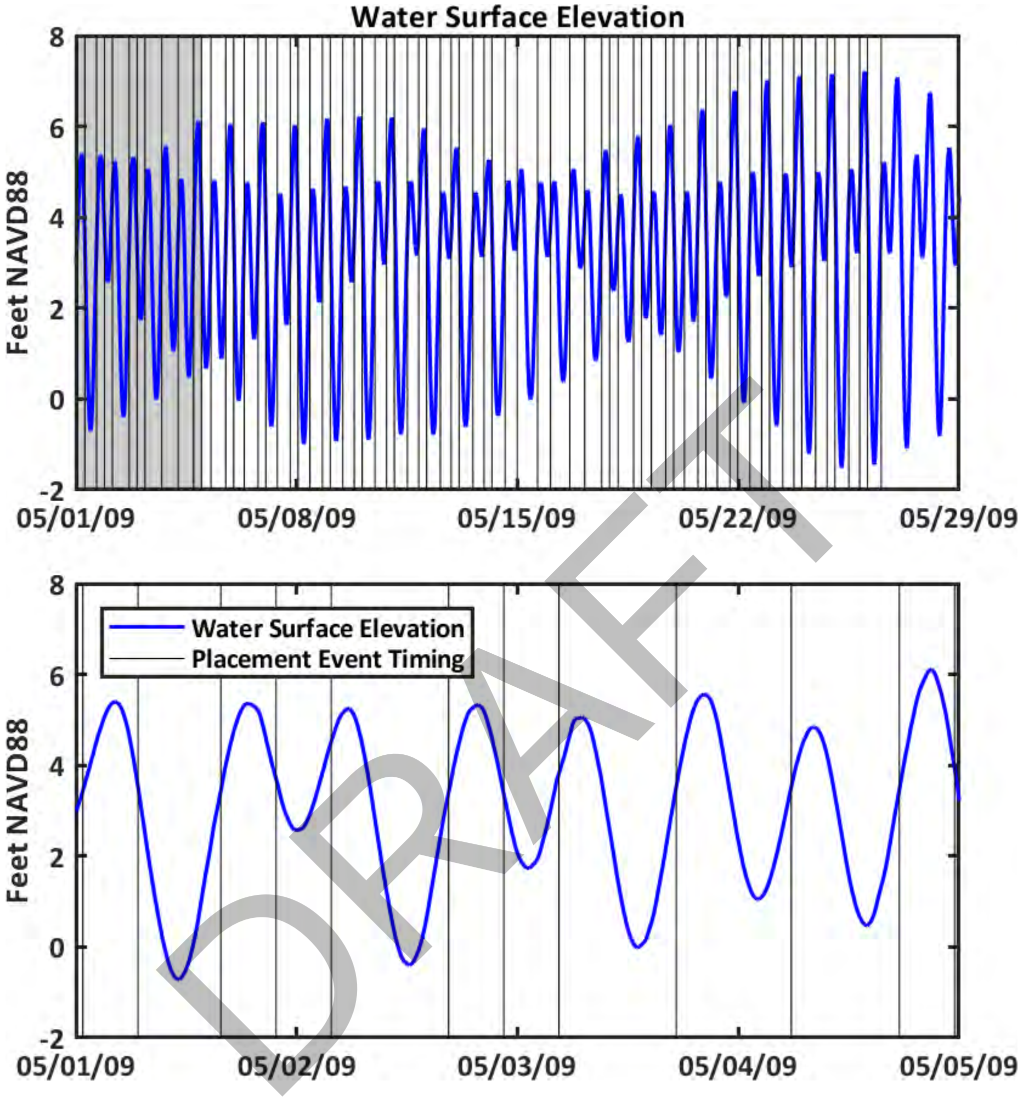


Figure 3.3-2
Water Surface Elevation During Placement Events: Scenario 1 Emeryville Deep

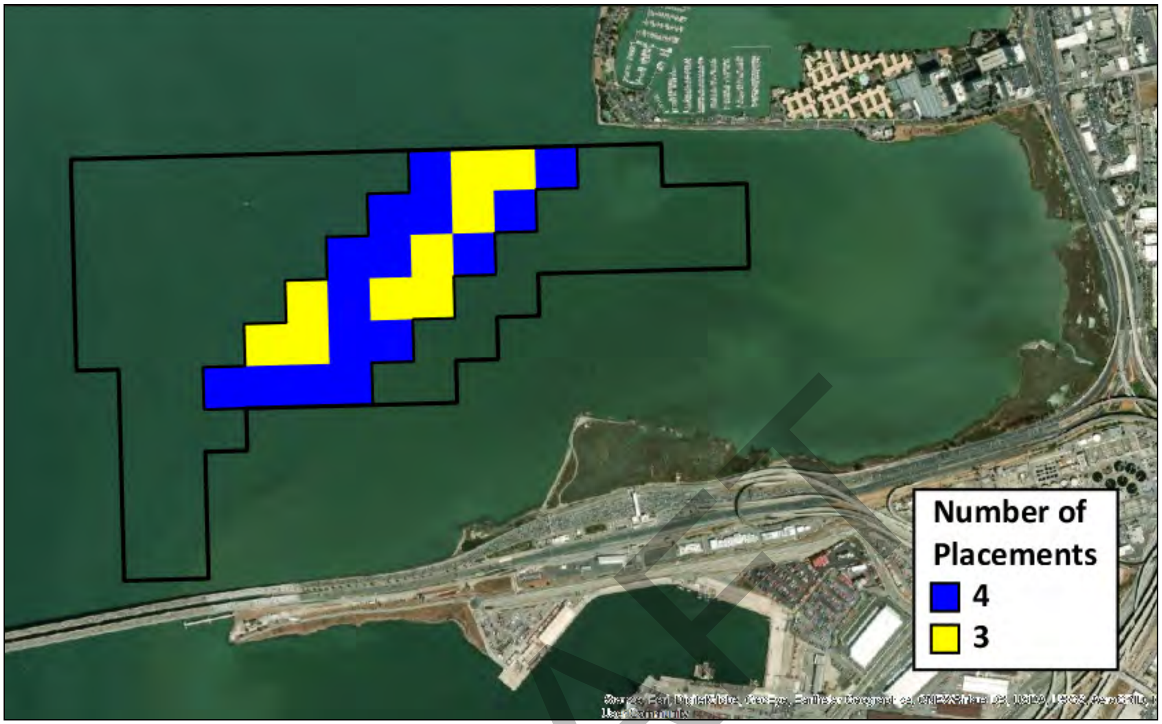


Note:
Shading denotes the time period of the bottom panel.

3.3.1.2 Scenario 2: Emeryville Middle

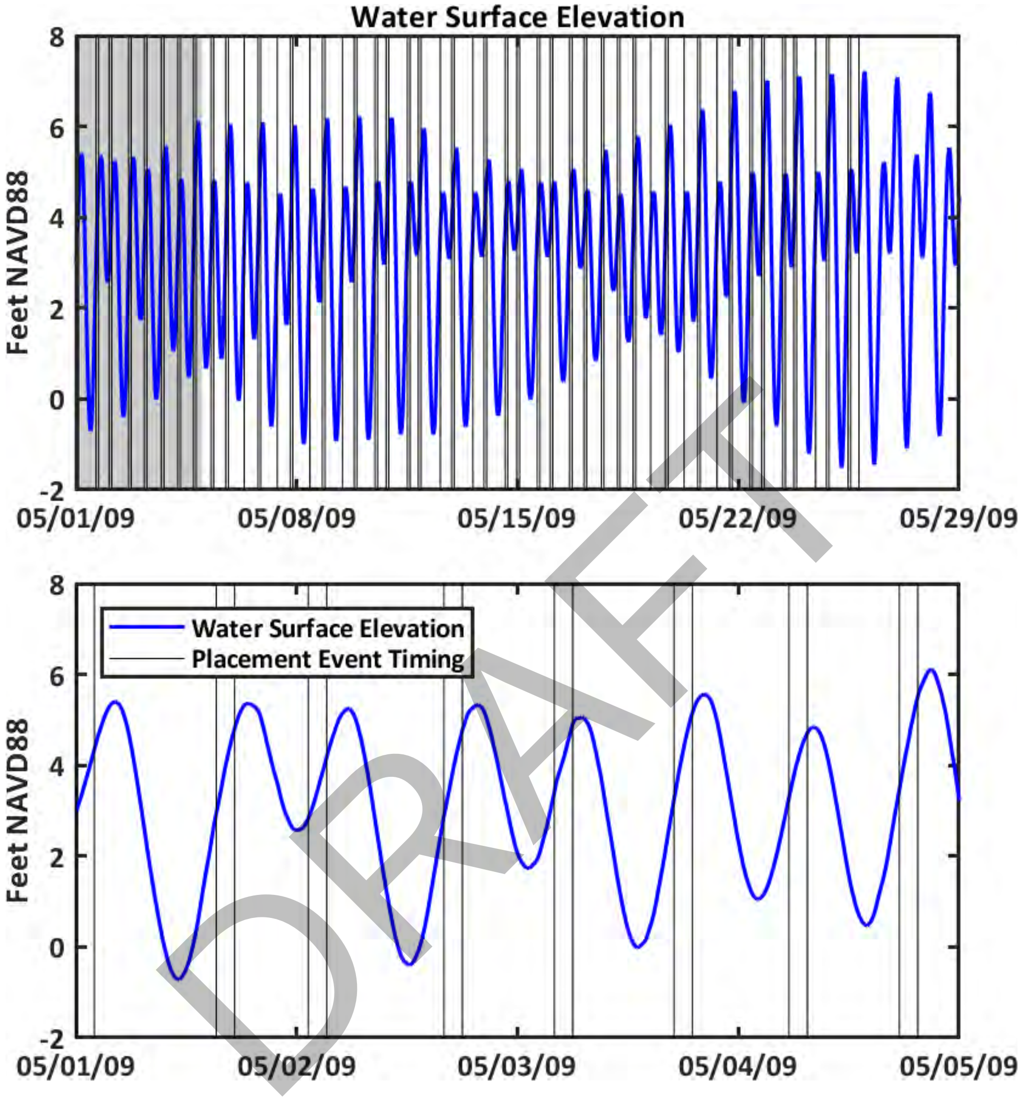
The Emeryville Middle scenario consisted of 87 placement events in 24 placement grid cells, with three or four placements in each placement grid cell (Figure 3.3-3). Placements were located in the middle portion of the placement grid. Placements were spaced at least 2 hours apart (Figure 3.3-4) and occurred during flooding tide, as described in Section 3.3.1. The scenario included 100,000 yd^3 of dredged material that was assumed to come from Oakland Harbor and evaluated dispersal from May 1, 2009, through June 30, 2009. Scows were assumed to hold 1,150 yd^3 of dredged material and require a minimum water depth of 10 ft.

Figure 3.3-3
Number of Placement Events in Each Placement Grid Cell: Scenario 2 Emeryville Middle



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID,
User Community

Figure 3.3-4
Water Surface Elevation During Placement Events: Scenario 2 Emeryville Middle

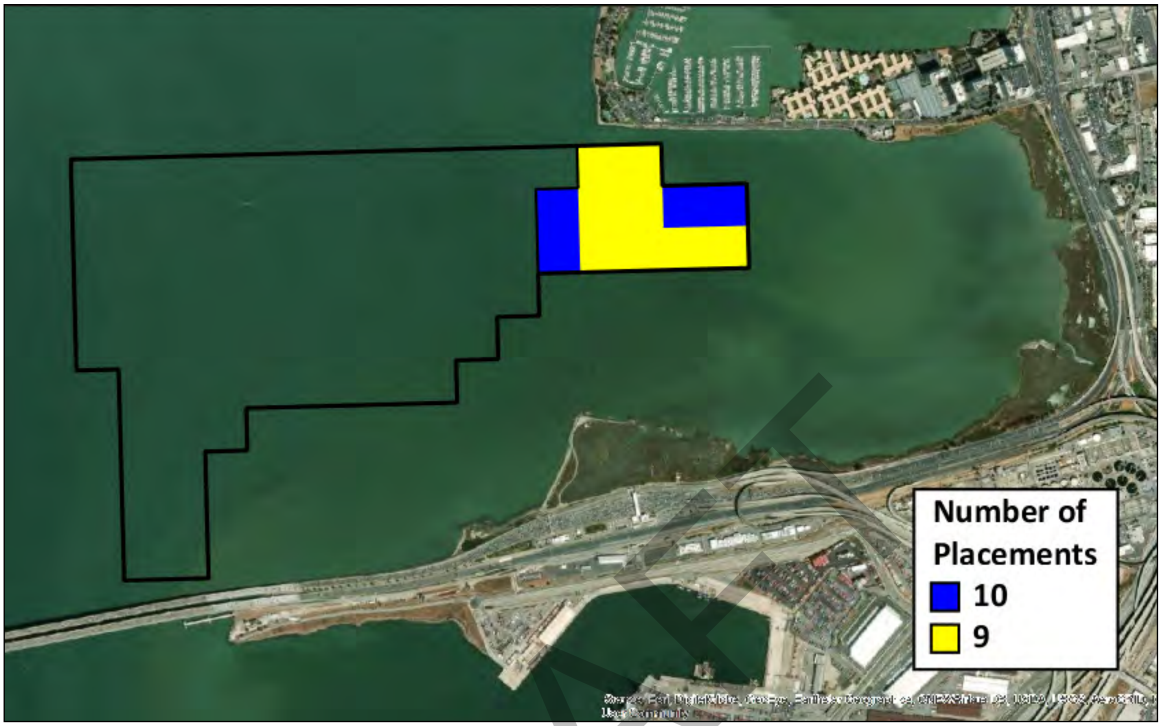


Note:
Shading denotes the time period of the bottom panel.

3.3.1.3 Scenario 3: Emeryville Shallow/East

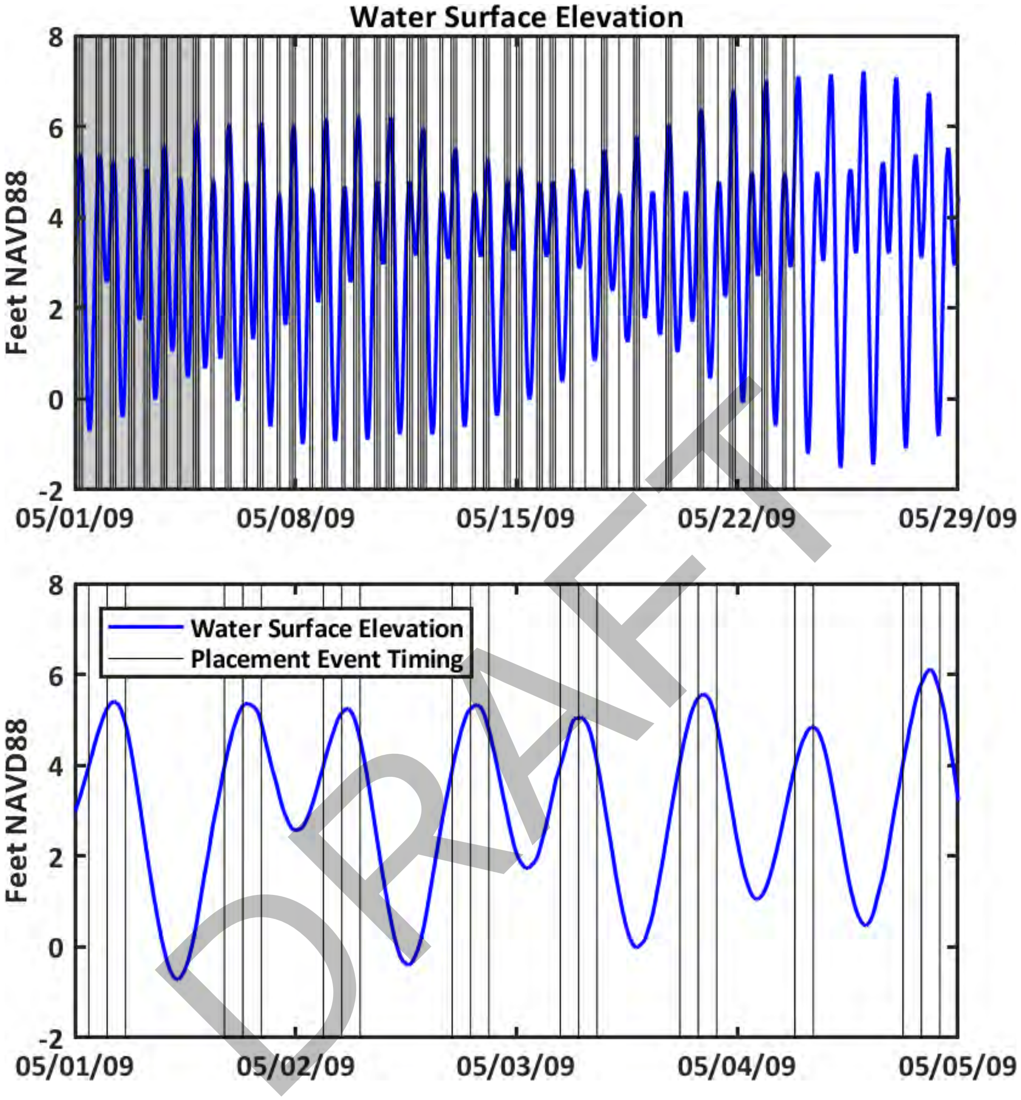
The Emeryville Shallow/East scenario consisted of 112 placement events in 12 placement grid cells, with nine or ten placements in each placement grid cell (Figure 3.3-5). Placements were located in the eastern shallower portion of the placement grid. Placements were spaced at least 2 hours apart (Figure 3.3-6). The scenario included 100,000 yd^3 of dredged material that was assumed to come from Oakland Harbor and evaluated dispersal from May 1, 2009, through June 30, 2009. Scows were assumed to hold 900 yd^3 of dredged material and require a minimum water depth of 9 ft.

Figure 3.3-5
Number of Placement Events in Each Placement Grid Cell: Scenario 3 Emeryville Shallow/East



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID,
User Community

Figure 3.3-6
Water Surface Elevation During Placement Events: Scenario 3 Emeryville Shallow/East



Note:
Shading denotes the time period of the bottom panel.

3.3.1.4 Scenario 4: Eden Landing Deep

The Eden Landing Deep scenario consisted of 72 placement events in 24 placement grid cells, with three placements in each placement grid cell (Figure 3.3-7). Placements were located approximately in the east/west center of the placement grid. Placements were spaced at least 5 hours apart (Figure 3.3-8). The scenario included 100,000 yd^3 of dredged material that was assumed to come from Redwood City Harbor and evaluated dispersal from May 1, 2009, through June 30, 2009. Scows were assumed to hold 1,400 yd^3 of dredged material and require a minimum water depth of 11 ft.

Figure 3.3-7
Number of Placement Events in Each Placement Grid Cell: Scenario 4 Eden Landing Deep

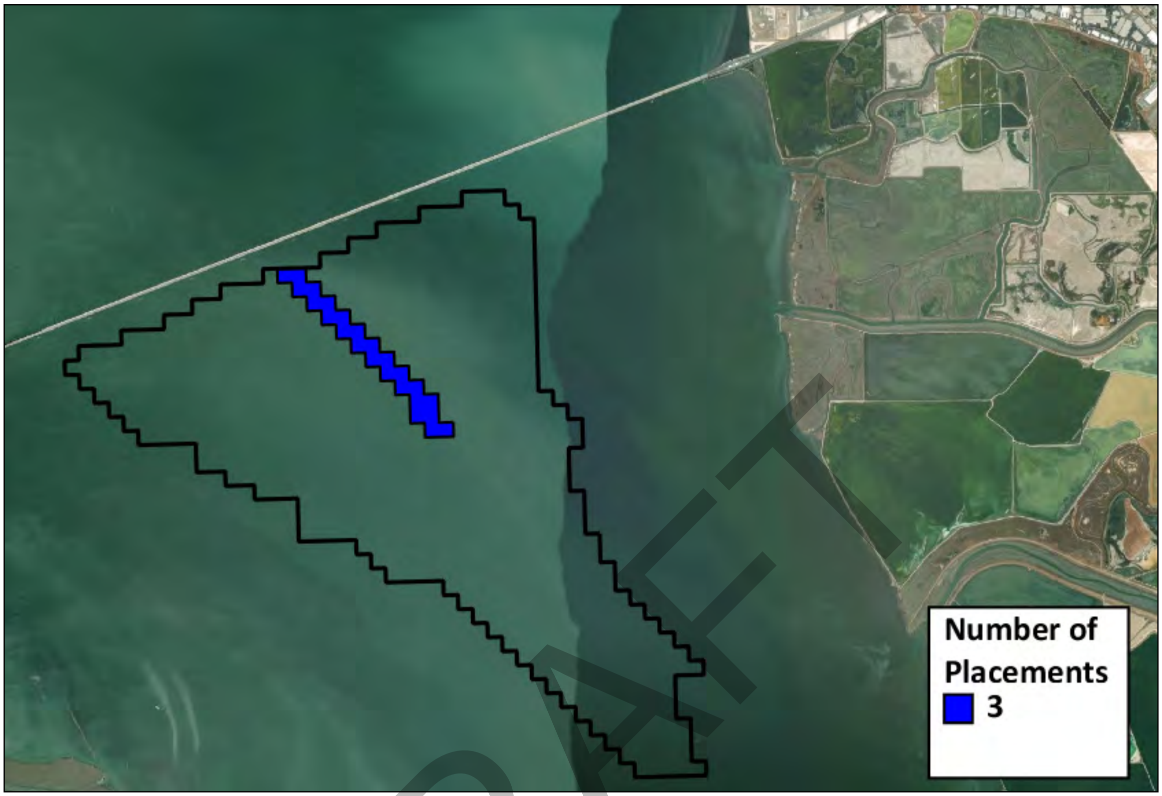
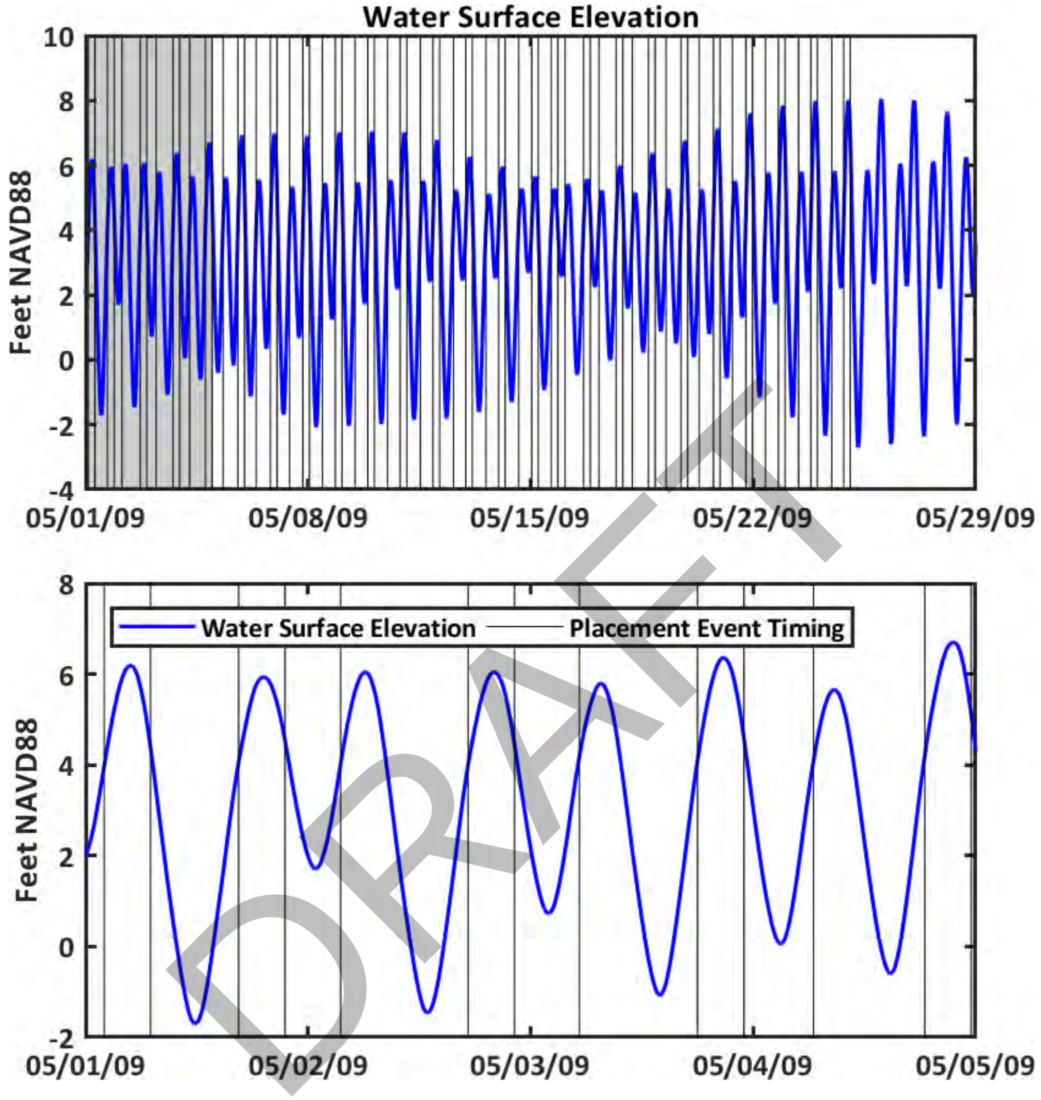


Figure 3.3-8
Water Surface Elevation During Placement Events: Scenario 4 Eden Landing Deep



Note:
Shading denotes the time period of the bottom panel.

3.3.1.5 Scenario 5: Eden Landing Middle

The Eden Landing Middle scenario consisted of 87 placement events in 24 placement grid cells, with three or four placements in each placement grid cell (Figure 3.3-9). Placements were located east of the approximate east/west center of the placement grid. Placements were spaced at least 1.5 hours apart (Figure 3.3-10) and occurred during flooding tide, as described in Section 3.3.1. The scenario included 100,000 yd^3 of dredged material that was assumed to come from Redwood City Harbor and evaluated dispersal from May 1, 2009, through June 30, 2009. Scows were assumed to hold 1,150 yd^3 of dredged material and require a minimum water depth of 10 ft.

Figure 3.3-9
Number of Placement Events in Each Placement Grid Cell: Scenario 5 Eden Landing Middle

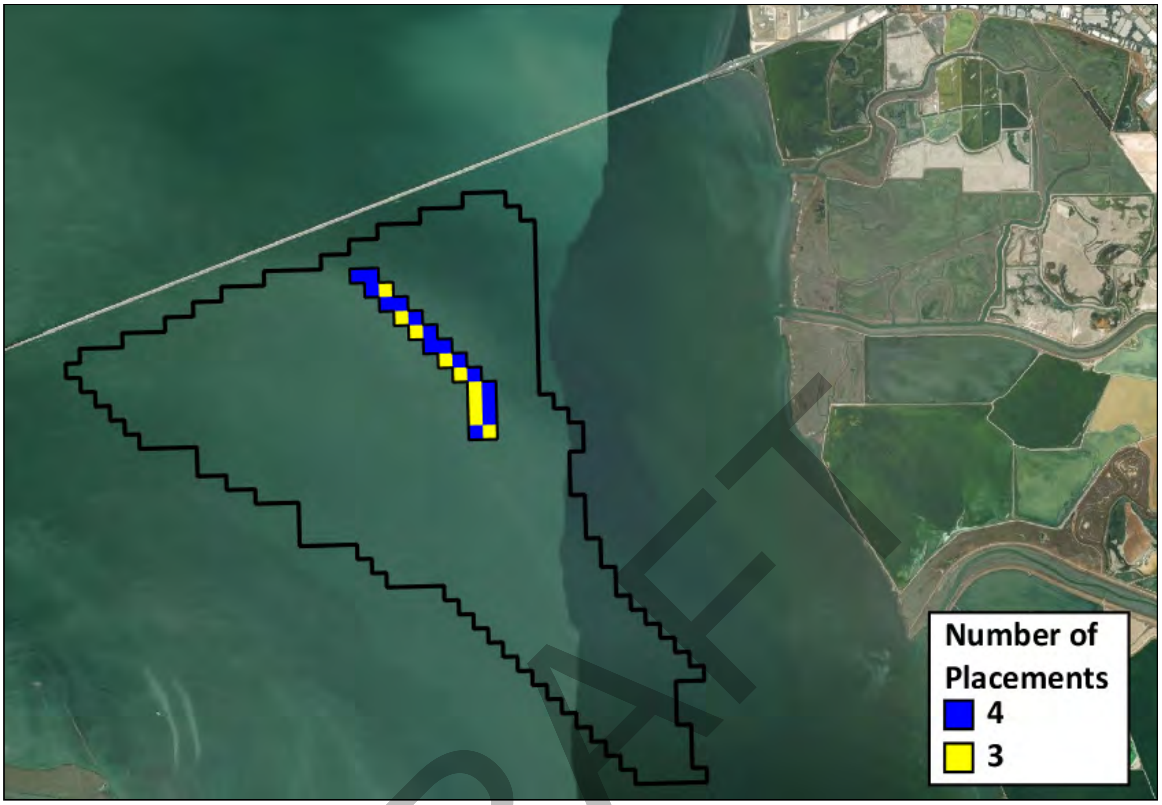
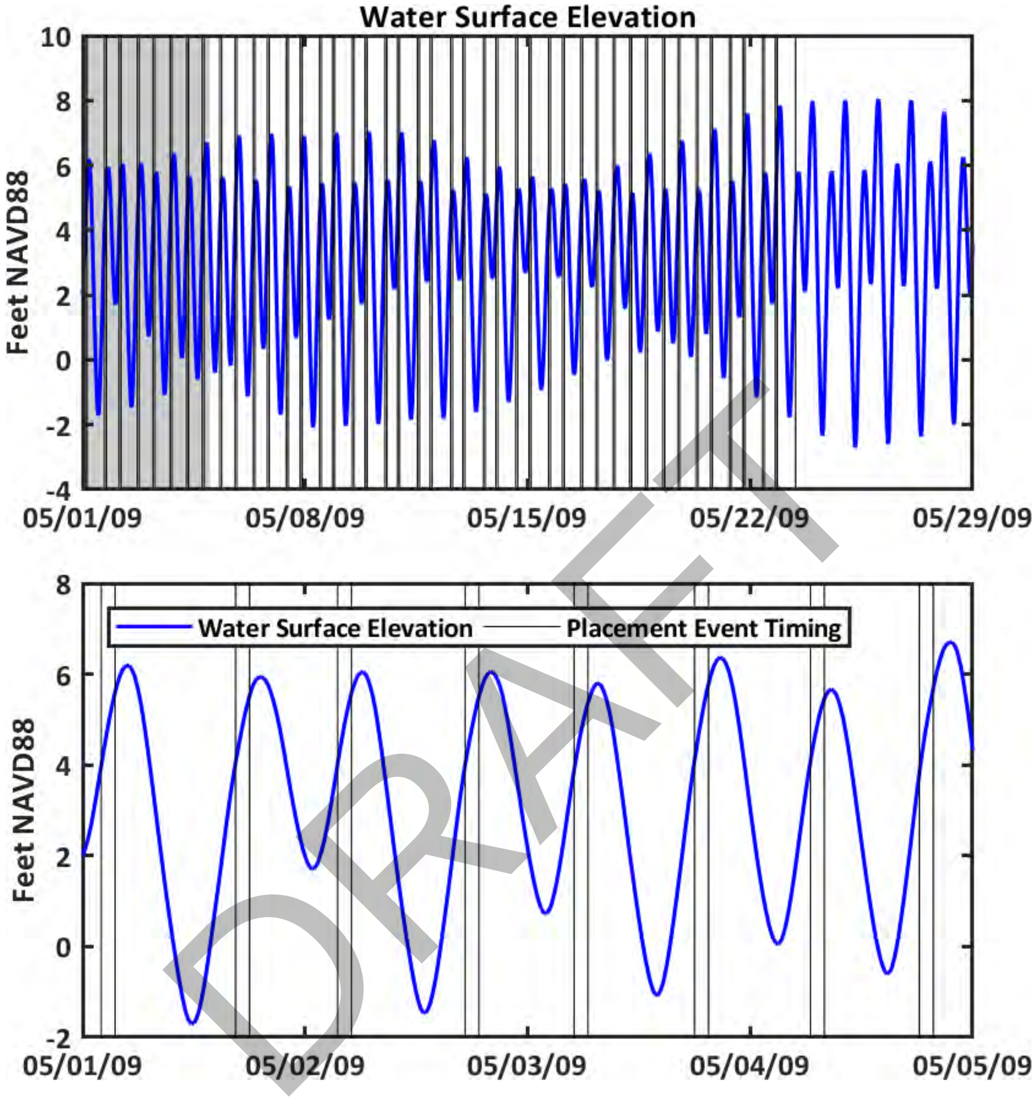


Figure 3.3-10
Water Surface Elevation During Placement Events: Scenario 5 Eden Landing Middle



Note:
Shading denotes the time period of the bottom panel.

3.3.1.6 Scenario 6: Eden Landing Shallow/East

The Eden Landing Shallow/East scenario consisted of 112 placement events in 24 placement grid cells, with four or five placements in each placement grid cell (Figure 3.3-11). Placements were located in the eastern shallower portion of the placement grid. Placements were spaced at least 1.5 hours apart (Figure 3.3-12). The scenario included 100,000 yd^3 of dredged material that was assumed to come from Redwood City Harbor and evaluated dispersal from May 1, 2009, through June 30, 2009. Scows were assumed to hold 900 yd^3 of dredged material and require a minimum water depth of 9 ft.

Figure 3.3-11
Number of Placement Events in Each Placement Grid Cell: Scenario 6 Eden Landing Shallow/East

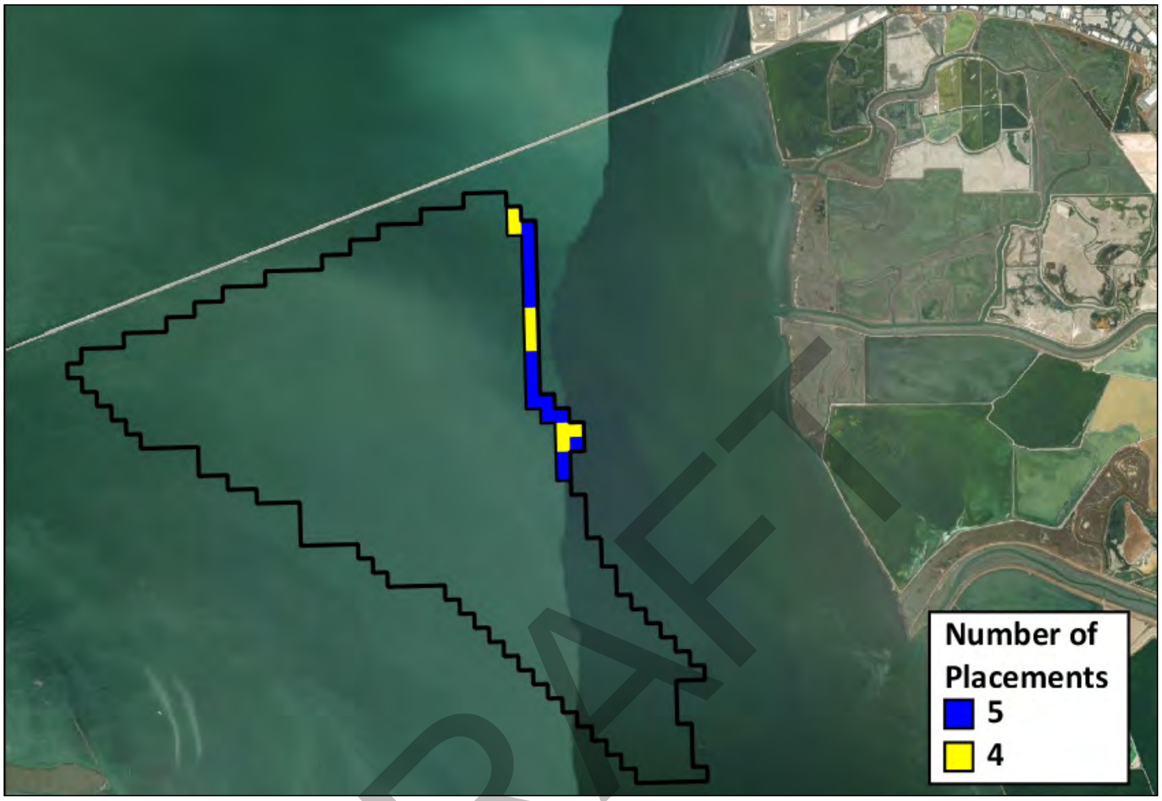
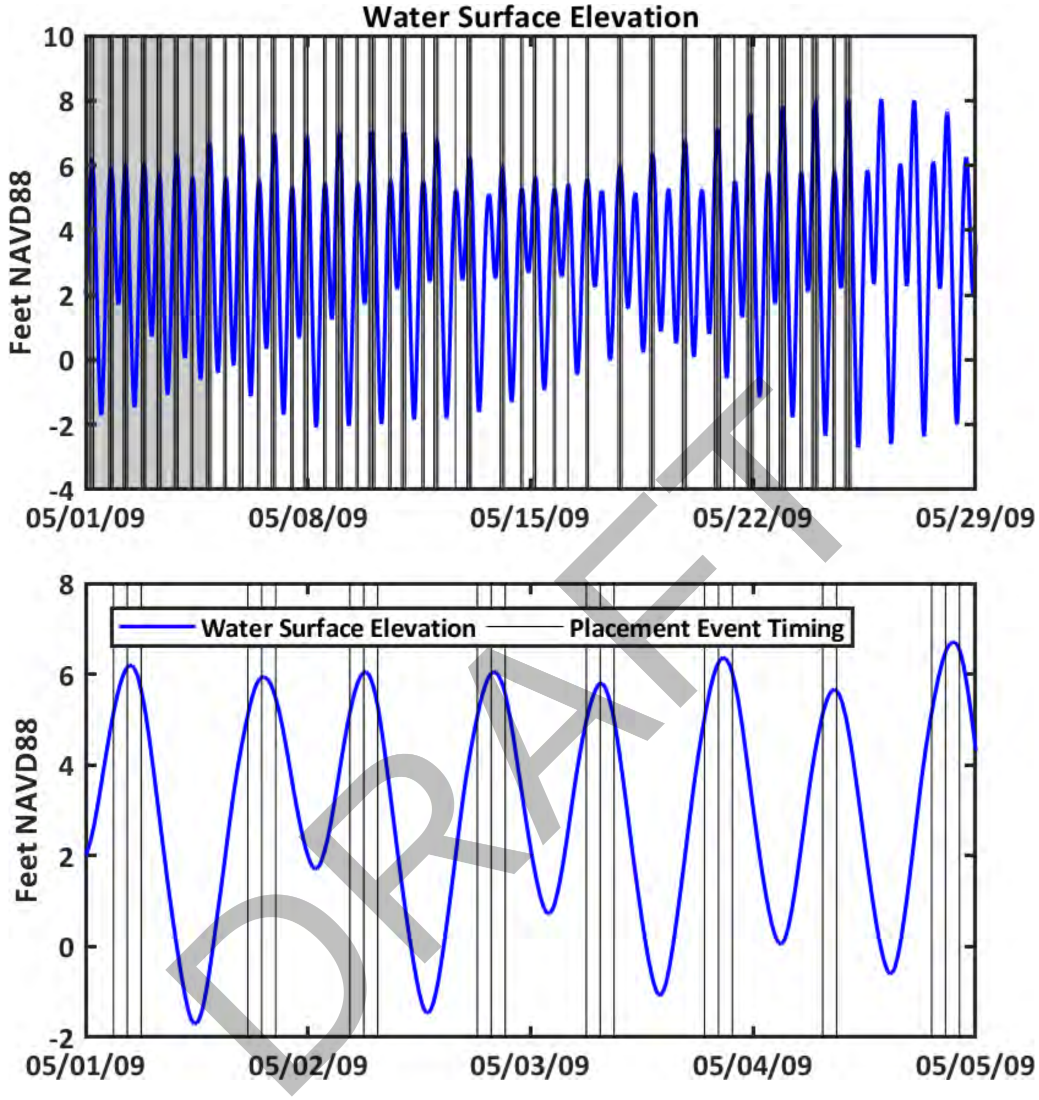


Figure 3.3-12
Water Surface Elevation During Placement Events: Scenario 6 Eden Landing Shallow/East



Note:
Shading denotes the time period of the bottom panel.

3.3.2 Description of Six Additional Eden Landing Scenarios

The initial six scenarios described in Section 3.3.1 indicated more dredged material would be dispersed to mudflats and marshes from the Eden Landing placement location than the Emeryville placement location and that the shallow/east scenario had the most transport of dredged material toward the marsh (Section 5.2). Because of this, the final six scenarios focused on dredged material placements in the shallower eastern portion of the Eden Landing placement grid. These scenarios evaluated using lower volumes of dredged material, conducting placements in the winter, using sediment from Oakland Harbor, and using a larger placement footprint with two volumes of dredged material (Table 3.3-1).

3.3.2.1 Scenario 7: Eden Landing Shallow/East 50,000 yd^3 of Dredged Material

The Eden Landing Shallow/East 50,000 yd^3 of Dredged Material scenario consisted of 56 placement events in the 24 placement grid cells of the Eden Landing shallow/east placement footprint, with two or three placements in each placement grid cell (Figure 3.3-13). Placements were located in the eastern shallower portion of the placement grid. Placements were spaced at least 1.5 hours apart (Figure 3.3-14). The scenario included 50,000 yd^3 of dredged material that was assumed to come from Redwood City Harbor and evaluated dispersal from May 1, 2009, through June 30, 2009. Scows were assumed to hold 900 yd^3 of dredged material and require a minimum water depth of 9 ft.

Figure 3.3-13
Number of Placement Events in Each Placement Grid Cell: Scenario 7 Eden Landing 50,000 yd^3

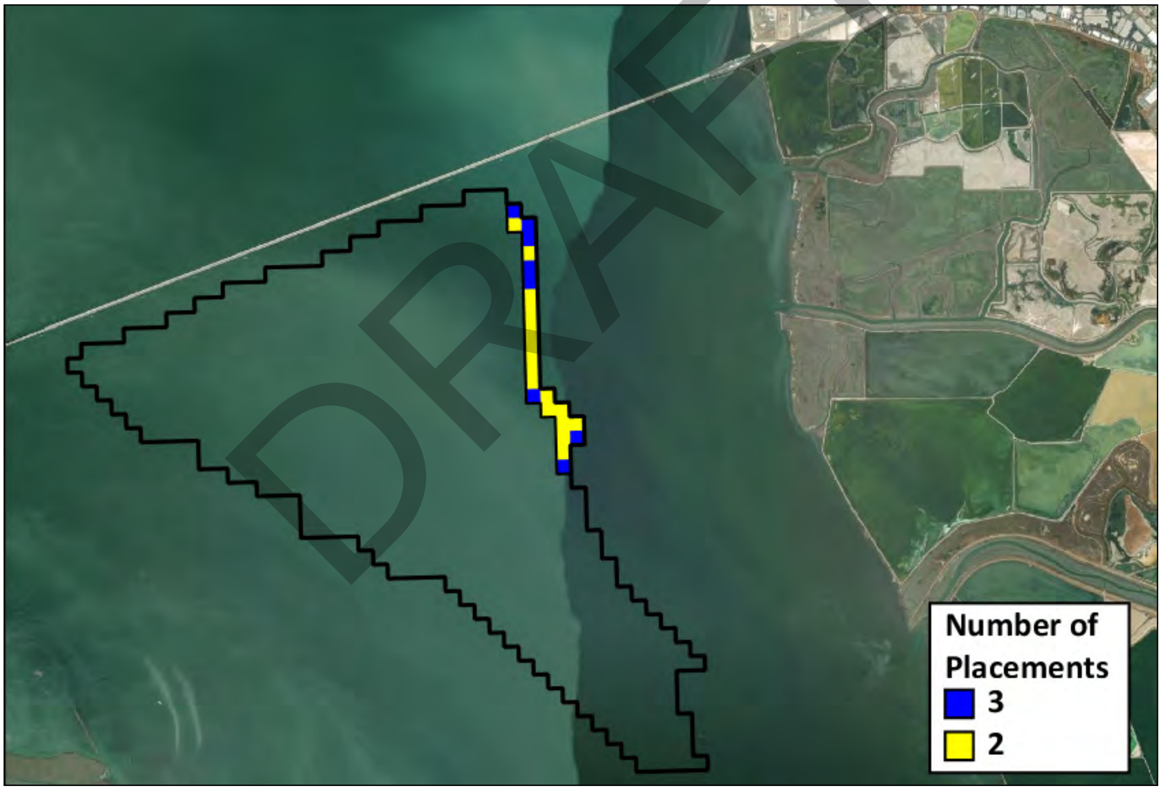
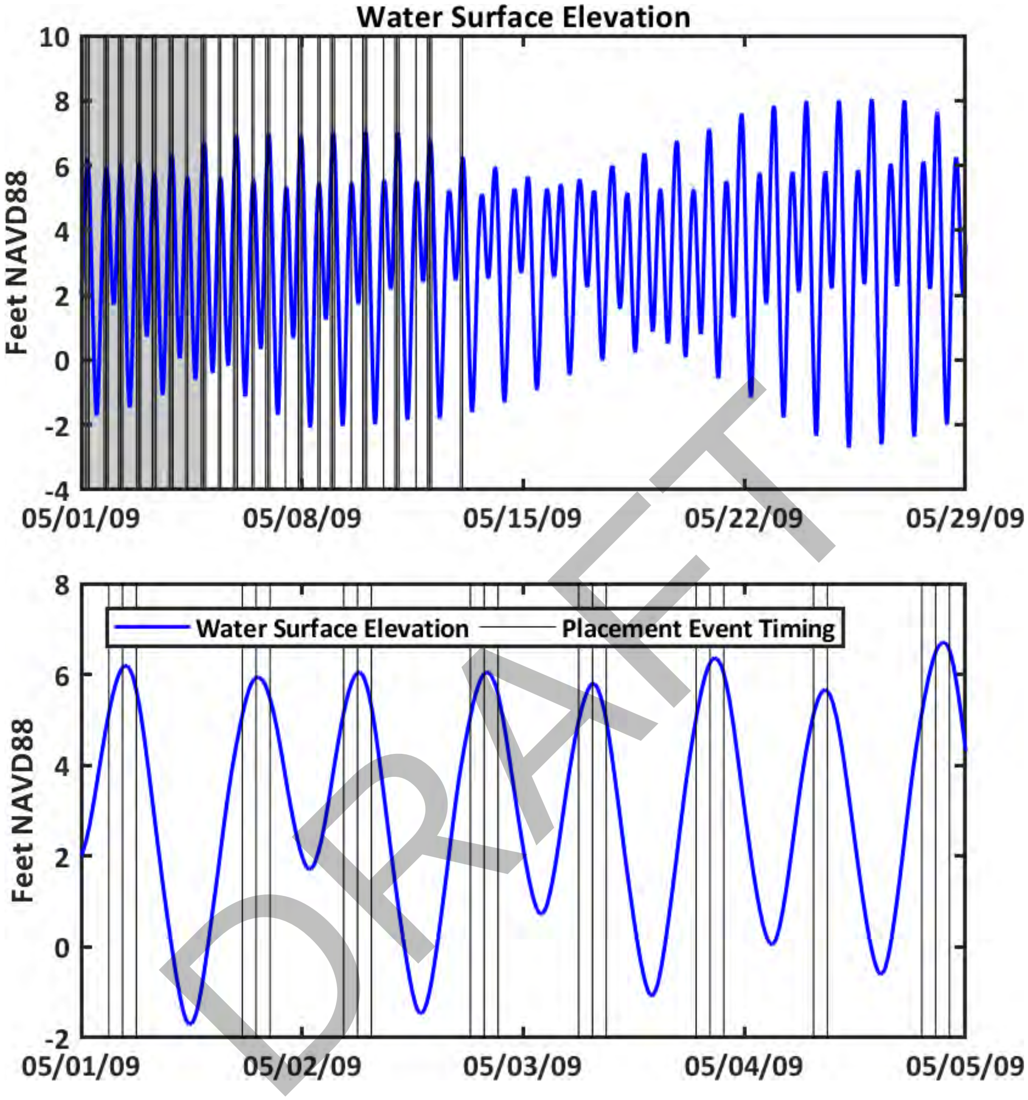


Figure 3.3-14
Water Surface Elevation During Placement Events: Scenario 7 Eden Landing 50,000 yd^3



Note:
Shading denotes the time period of the bottom panel.

3.3.2.2 Scenario 8: Eden Landing Shallow/East 75,000 yd^3 of Dredged Material

The Eden Landing Shallow/East 75,000 yd^3 of Dredged Material scenario consisted of 84 placement events in the 24 placement grid cells of the Eden Landing shallow/east placement footprint, with three or four placements in each placement grid cell (Figure 3.3-15). Placements were located in the eastern shallower portion of the placement grid. Placements were spaced at least 1.5 hours apart (Figure 3.3-16). The scenario included 75,000 yd^3 of dredged material that was assumed to come from Redwood City Harbor and evaluated dispersal from May 1, 2009, through June 30, 2009. Scows were assumed to hold 900 yd^3 of dredged material and require a minimum water depth of 9 ft.

Figure 3.3-15
Number of Placement Events in Each Placement Grid Cell: Scenario 8 Eden Landing 75,000 yd^3

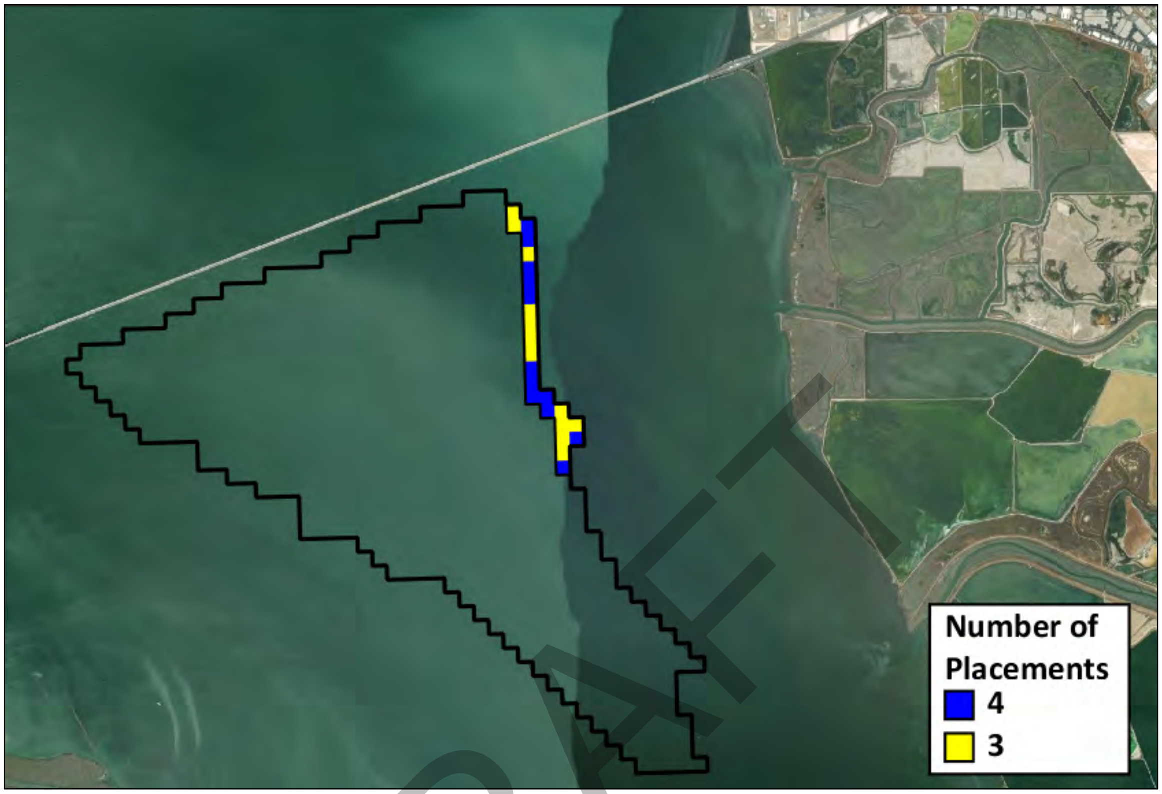
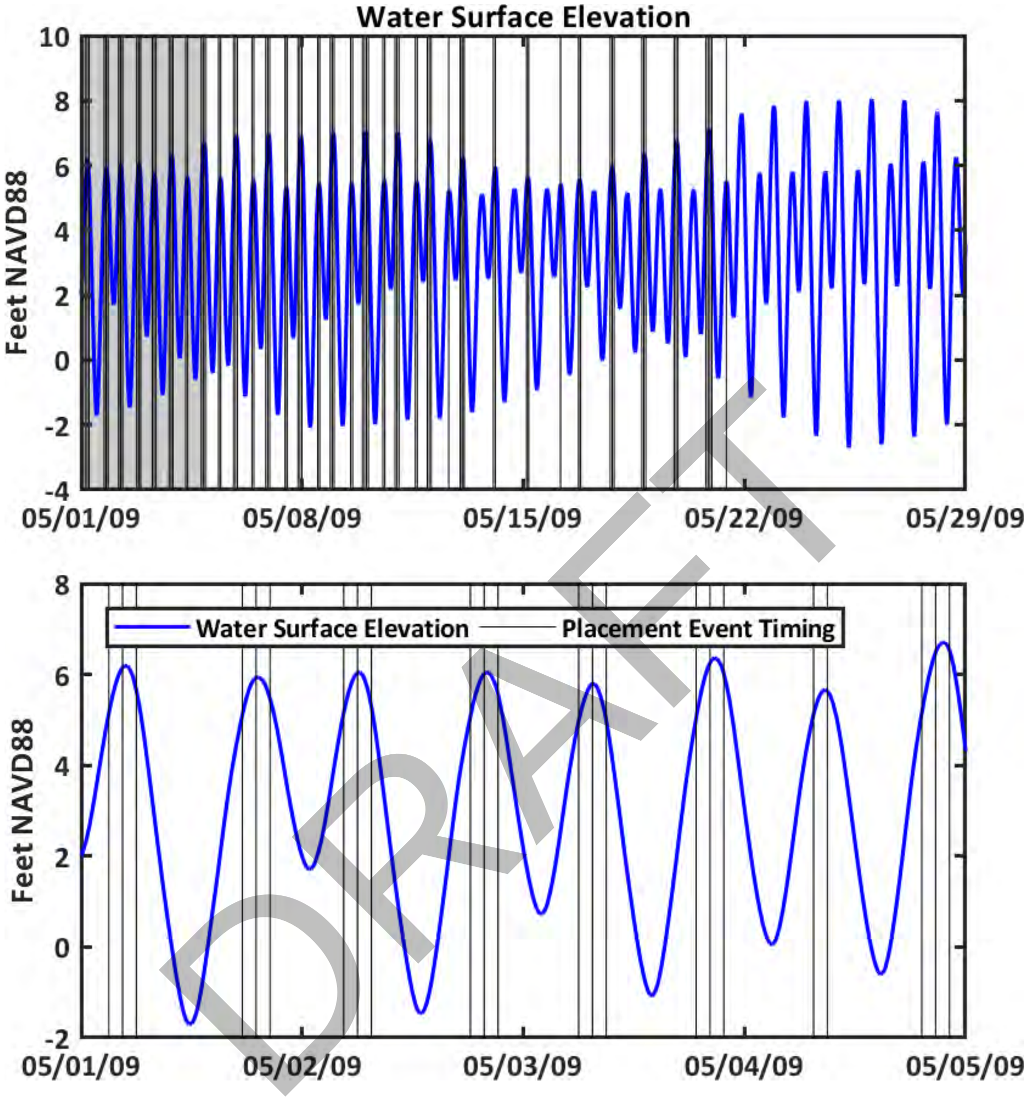


Figure 3.3-16
Water Surface Elevation During Placement Events: Scenario 8 Eden Landing 75,000 yd^3



Note:
Shading denotes the time period of the bottom panel.

3.3.2.3 Scenario 9: Eden Landing Shallow/East Winter

The Eden Landing Shallow/East Winter scenario consisted of 112 placement events in 24 placement grid cells, with four or five placements in each placement grid cell (Figure 3.3-17). Placements were located in the eastern shallower portion of the placement grid. Placements were spaced at least 1.5 hours apart (Figure 3.3-18). For this scenario, placements started at 00:00 on November 1, 2016, and the timing of the placements occurred relative to water depths in November 2016 using the same logic as described in Section 3.3.1. The scenario included 100,000 yd^3 of dredged material that was assumed to come from Redwood City Harbor and evaluated dispersal from November 1, 2016, through January 31, 2017. The winter period for this scenario included the month of November so the placements would occur during the last month of the dredging window. The scenario was 3 months long, 1 month longer than the other scenarios. Scows were assumed to hold 900 yd^3 of dredged material and require a minimum water depth of 9 ft.

Figure 3.3-17
Number of Placement Events in Each Placement Grid Cell: Scenario 9 Eden Landing Winter

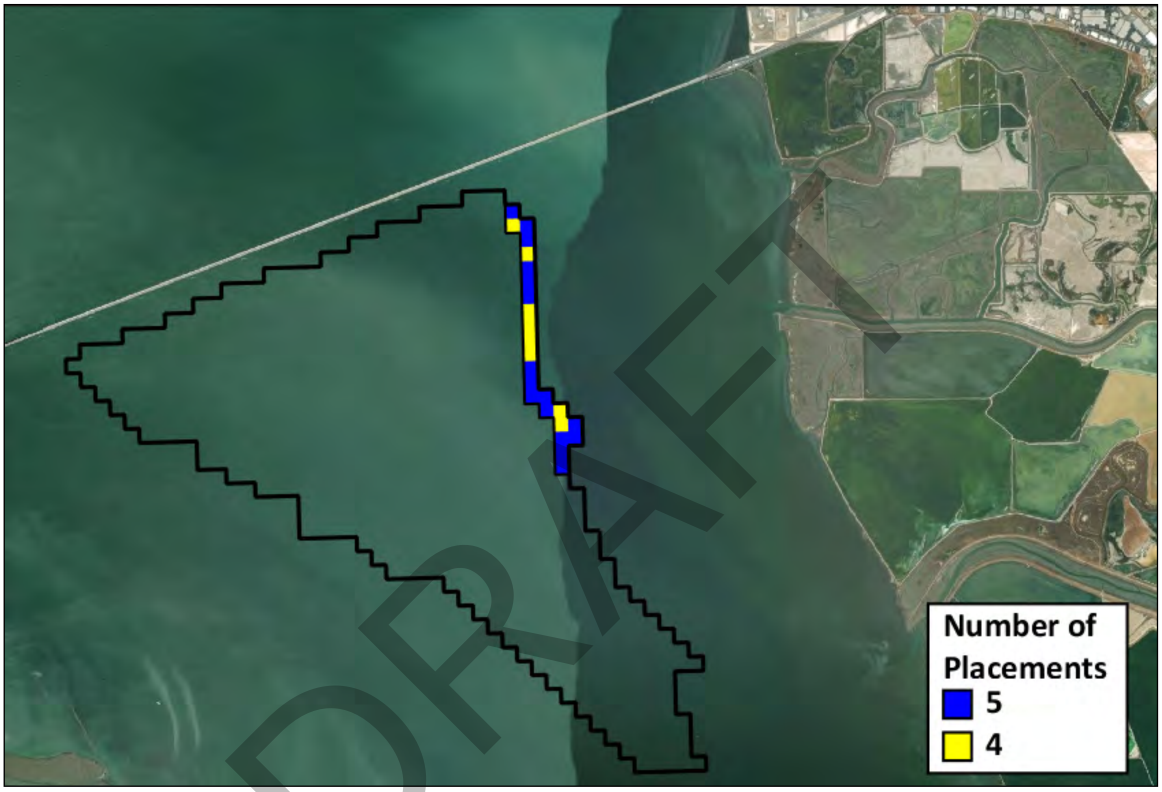
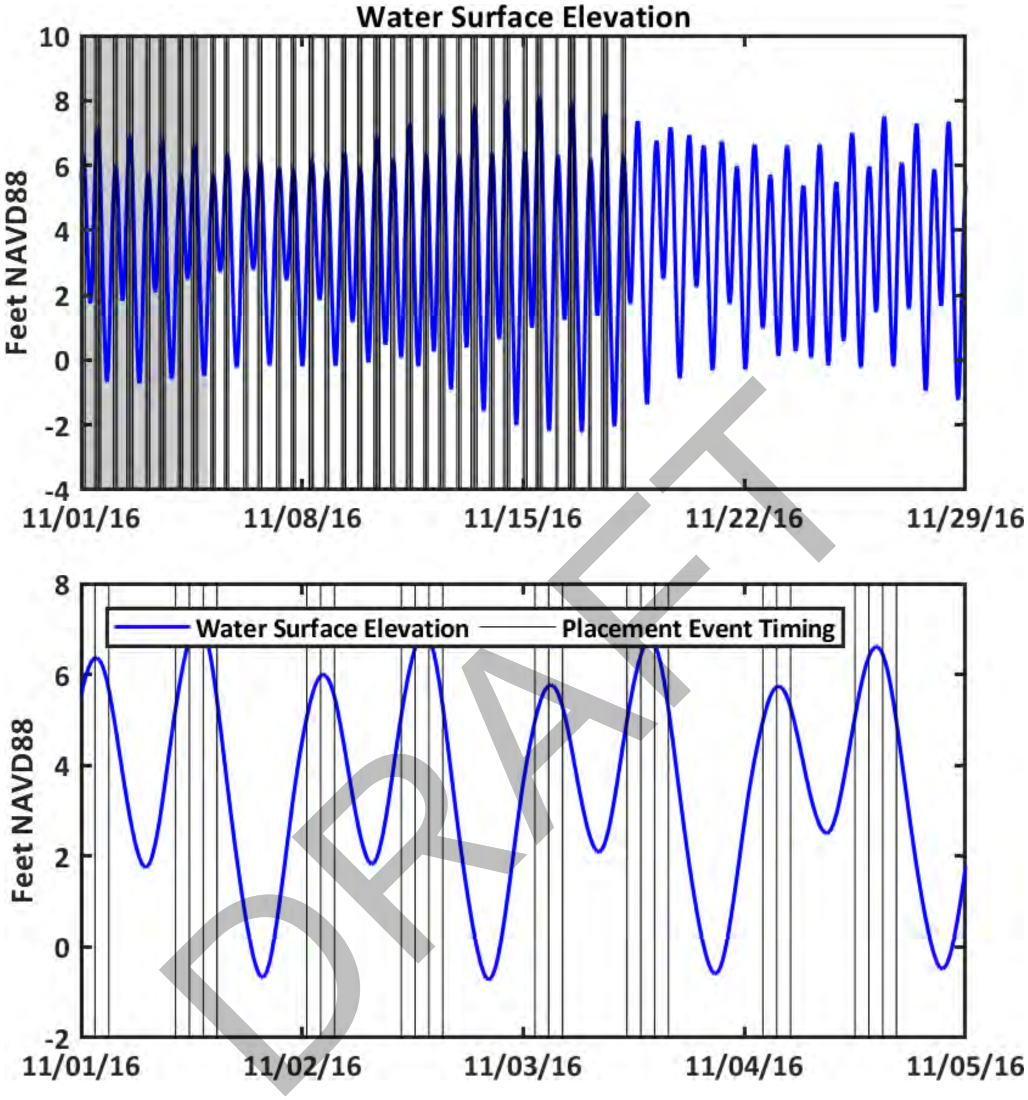


Figure 3.3-18
Water Surface Elevation During Placement Events: Scenario 9 Eden Landing Winter



Note:
Shading denotes the time period of the bottom panel.

3.3.2.4 Scenario 10: Eden Landing Shallow/East Oakland Harbor Sediment

The Eden Landing Shallow/East Oakland Harbor Sediment scenario consisted of 112 placement events in 24 placement grid cells, with four or five placements in each placement grid cell (Figure 3.3-19). Placements were located in the eastern shallower portion of the placement grid. Placements were spaced at least 1.5 hours apart (Figure 3.3-20). The scenario included 100,000 yd^3 of dredged material that was assumed to come from Oakland Harbor and evaluated dispersal from May 1, 2009, through June 30, 2009. Scows were assumed to hold 900 yd^3 of dredged material and require a minimum water depth of 9 ft.

Figure 3.3-19
Number of Placement Events in Each Placement Grid Cell: Scenario 10 Eden Landing Oakland Harbor Sediment

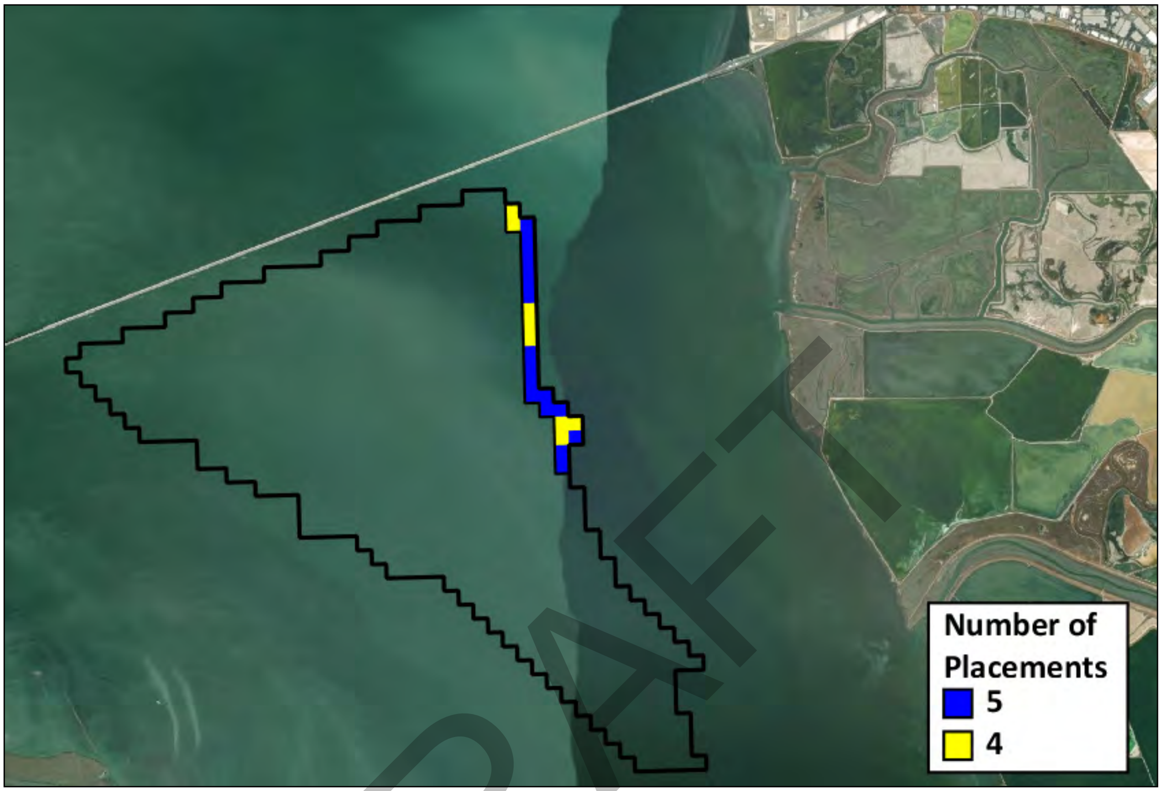
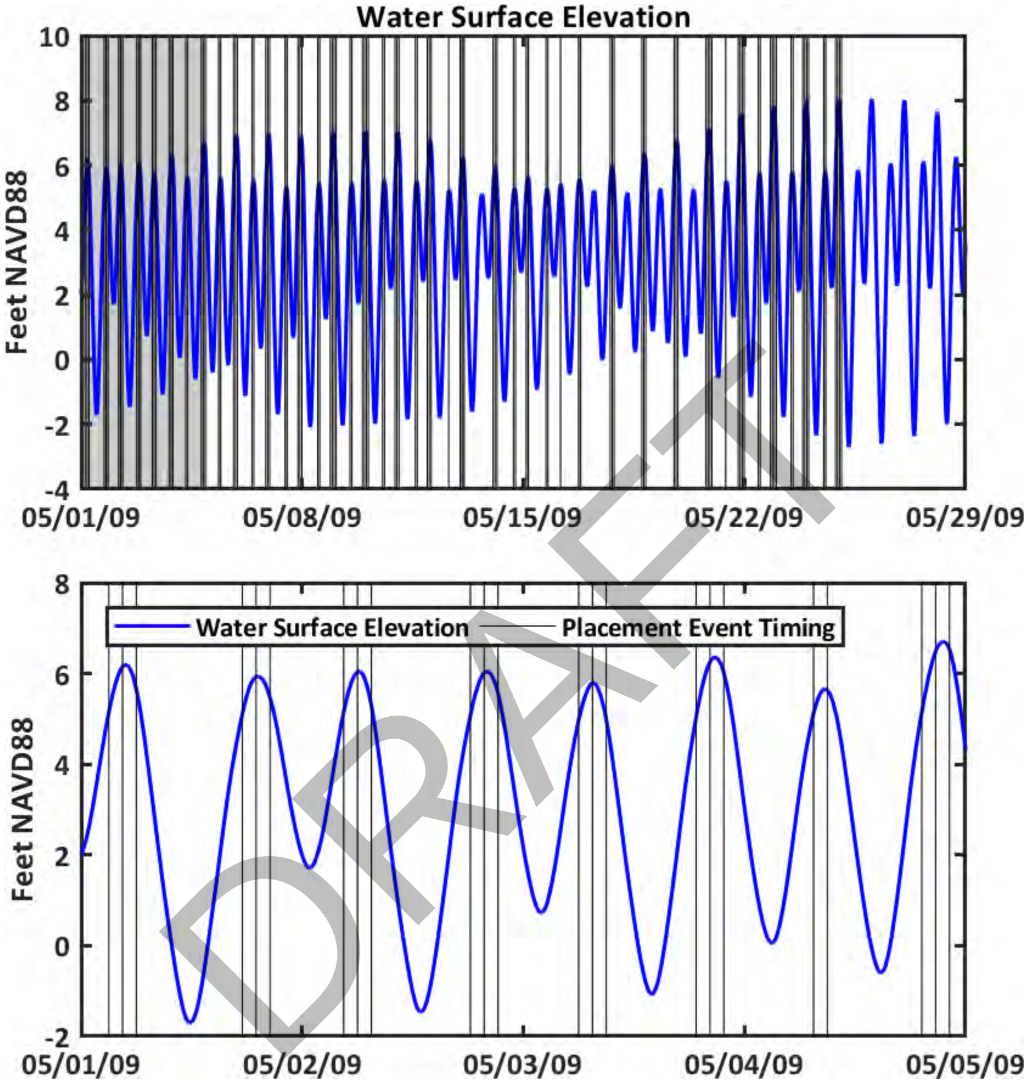


Figure 3.3-20
Water Surface Elevation During Placement Events: Scenario 10 Eden Landing Oakland Harbor Sediment



Note:
Shading denotes the time period of the bottom panel.

3.3.2.5 Scenario 11: Eden Landing Larger Placement Footprint

The Eden Landing Larger Placement Footprint scenario consisted of 112 placement events in 56 placement grid cells, with two placements in each placement grid cell (Figure 3.3-21). Placements were located in the eastern shallower portion of the placement grid. The placement footprint included the 24 placement grid cells in the Eden Landing Shallow/East scenario and an additional 32 placement grid cells directly west. Placements were spaced at least 1.5 hours apart (Figure 3.3-22). The scenario included 100,000 yd^3 of dredged material that was assumed to come from

Redwood City Harbor and evaluated dispersal from May 1, 2009, through June 30, 2009. Scows were assumed to hold 900 yd^3 of dredged material and require a minimum water depth of 9 ft.

Figure 3.3-21
Number of Placement Events in Each Placement Grid Cell: Scenario 11 Eden Landing Larger Placement Footprint

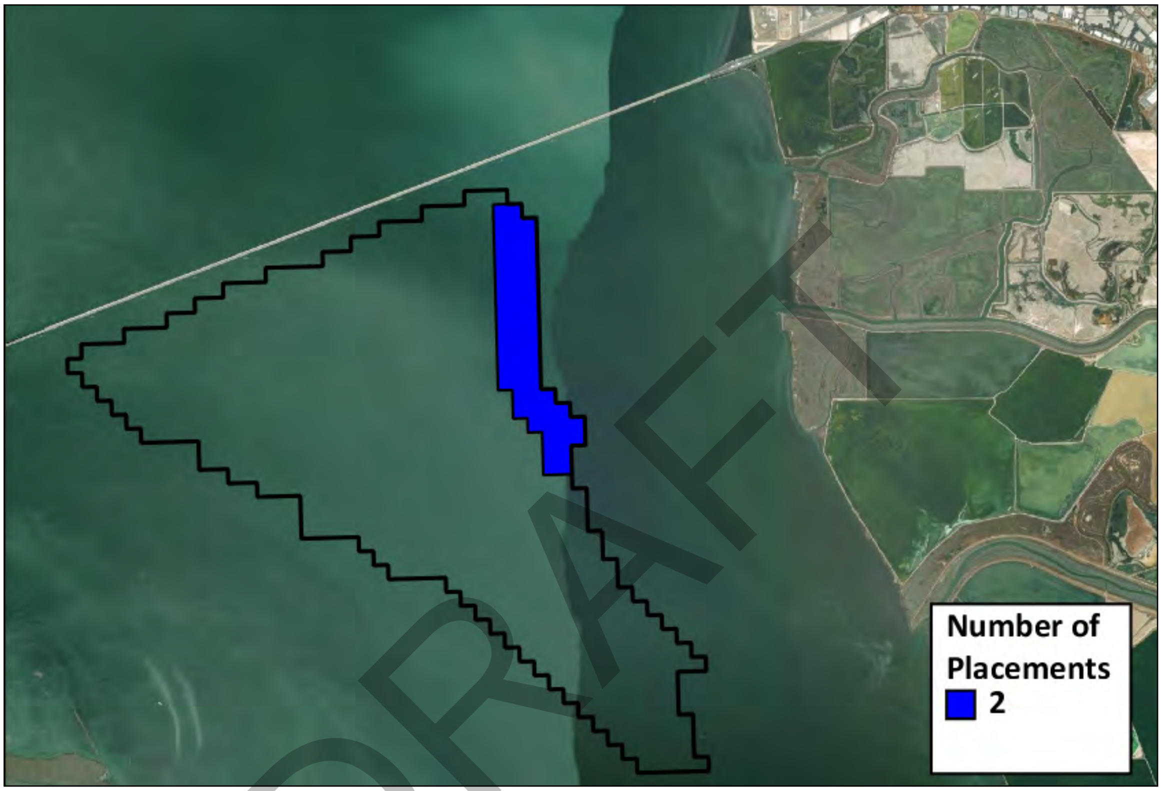
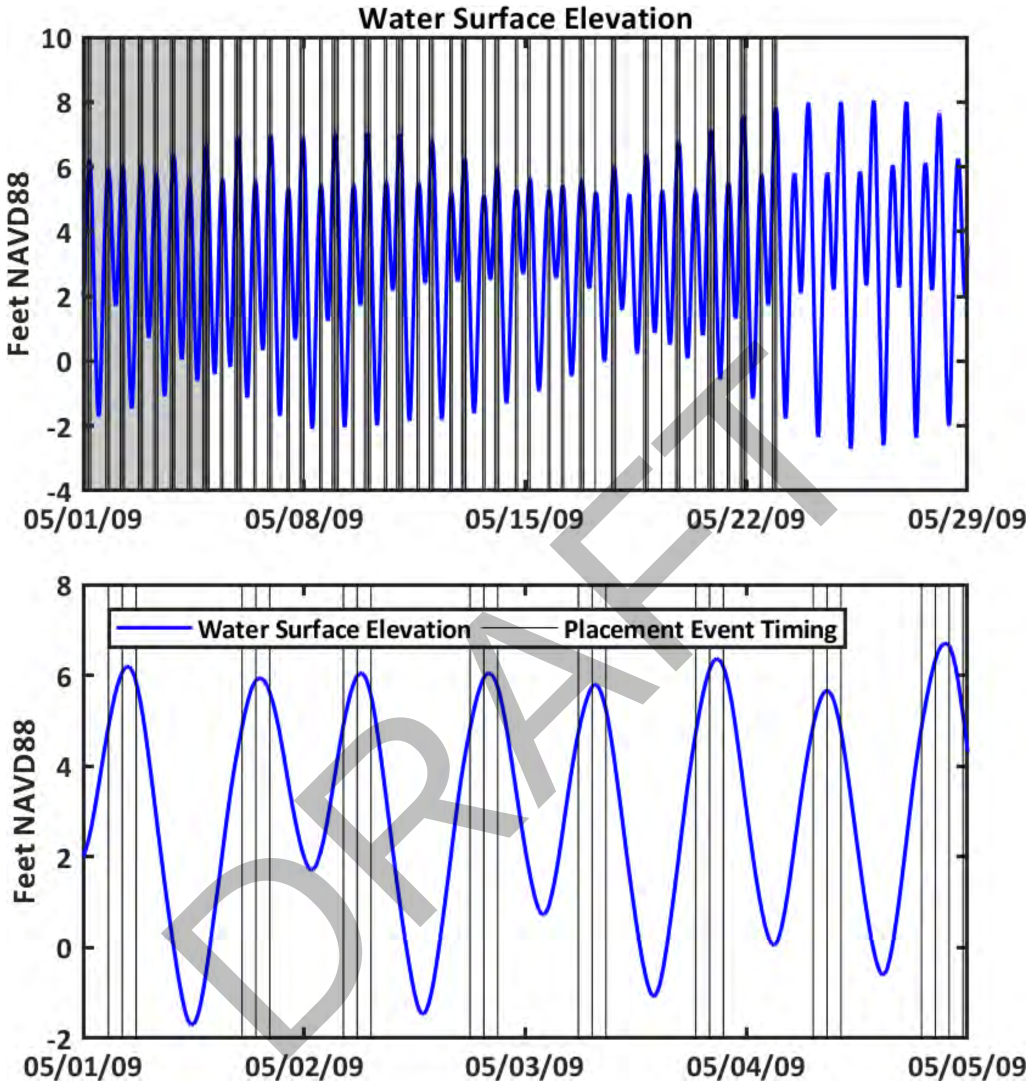


Figure 3.3-22
Water Surface Elevation During Placement Events: Scenario 11 Eden Landing Larger Placement Footprint



Note:
Shading denotes the time period of the bottom panel.

3.3.2.6 Scenario 12: Eden Landing Larger Placement Footprint 125,000 yd^3

The Eden Landing Larger Placement Footprint 125,000 yd^3 scenario consisted of 139 placement events in 56 placement grid cells, with two or three placements in each placement grid cell (Figure 3.3-23). Placements were located in the eastern shallower portion of the placement grid. The placement footprint included the 24 placement grid cells in the Eden Landing Shallow/East scenario and an additional 32 placement grid cells directly west. Placements were spaced at least 1.5 hours apart (Figure 3.3-24). The scenario included 125,000 yd^3 of dredged material that was assumed to come from

Redwood City Harbor and evaluated dispersal from May 1, 2009, through June 30, 2009. Scows were assumed to hold 900 yd^3 of dredged material and require a minimum water depth of 9 ft.

Figure 3.3-23
Number of Placement Events in Each Placement Grid Cell: Scenario 12 Eden Landing Larger Placement Footprint 125,000 yd^3

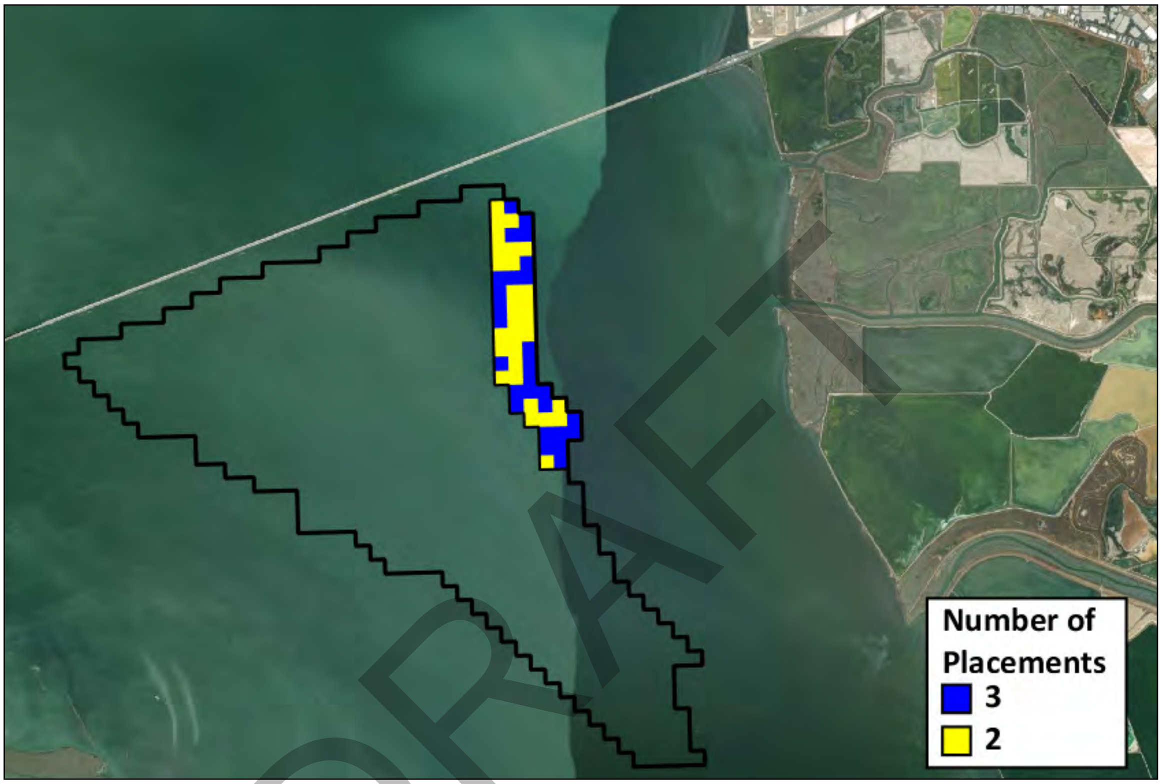
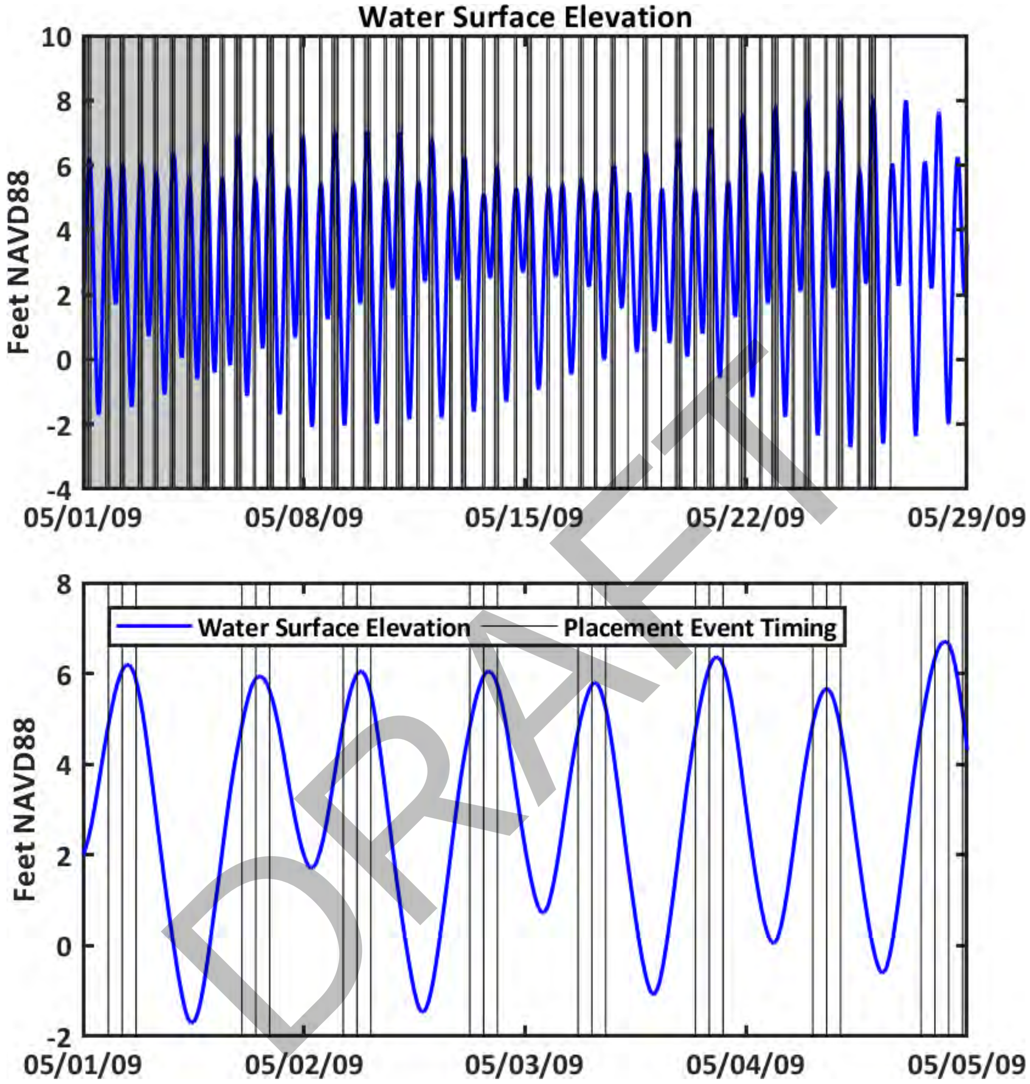


Figure 3.3-24
Water Surface Elevation During Placement Events: Scenario 12 Eden Landing Larger Placement Footprint 125,000 yd³



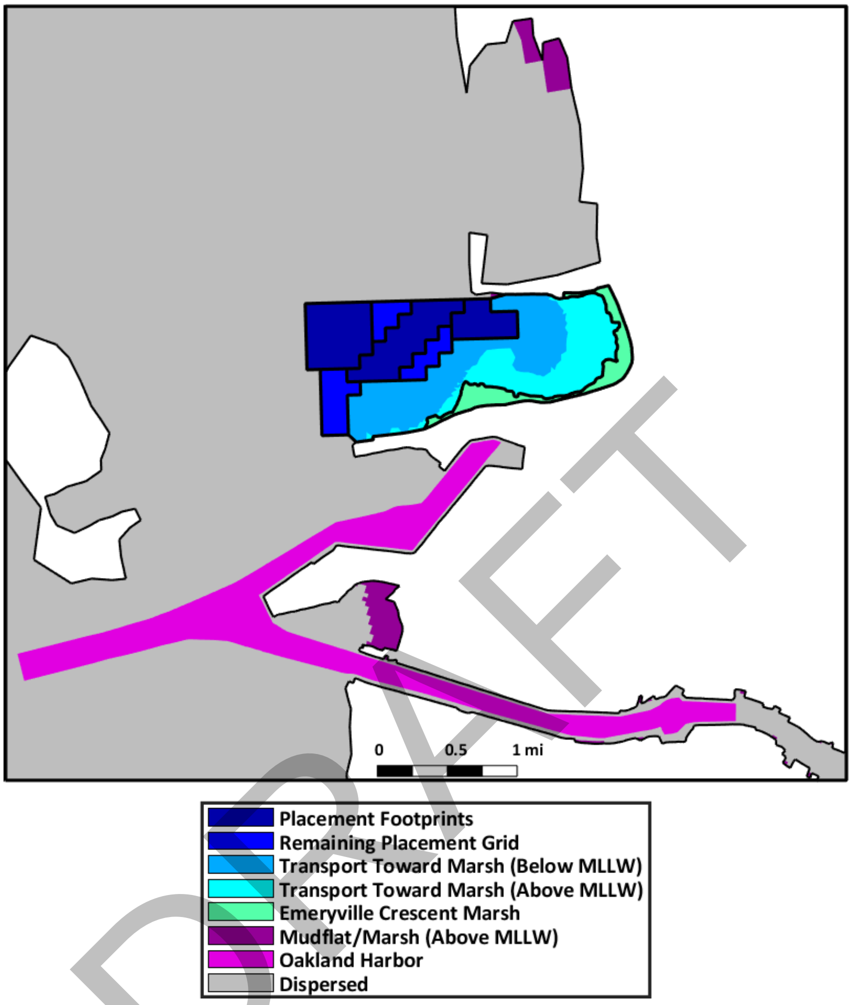
Note:
Shading denotes the time period of the bottom panel.

3.4 Analysis Regions

San Francisco Bay was divided into discrete analysis regions for the analysis of the dredged material placement scenarios. These analysis regions allowed for detailed tracking of where the dredged material was transported throughout the duration of the simulations and for the evaluation of the predicted fate of the dredged material at the end of the simulations. Different analysis regions were used for Emeryville and Eden Landing to tailor the analysis regions to the specifics of each site. The mass of dredged material in each region was tracked throughout each simulation to evaluate the amount of dredged material in each region. Results of the dredged material placement scenarios presented in Section 5 are based on the mass of dredged material in each region. The volume of dredged material in each region is estimated based on the percentage of the total mass of placed dredged material in each region and the total placement sediment mass. The analysis is based on the placement sediment mass because the sediment transport model simulates the continual erosion, deposition, and transport of sediment mass.

Eight analysis regions were identified for evaluating the fate of the dredged material placement near Emeryville (Figure 3.4-1). These analysis regions included the individual placement footprints where the dredged material placements occurred and the remainder of the placement grid. While all the placement footprints are shown on Figure 3.4-1, the subregion for analysis consisted of only the placement footprint associated with a specific dredged material placement scenario. The region representing transport from the placement grid toward Emeryville Crescent Marsh was separated into below and above mean lower low water (MLLW) regions, based on the tidal datum at the San Francisco National Oceanic and Atmospheric Administration (NOAA) station. Emeryville Crescent Marsh was also considered as a separate analysis region. Mudflats and marshes in areas above MLLW close to the placement grid was another analysis region. Oakland Harbor and any other areas below MLLW (dispersed) were also specified as analysis regions. These analysis regions allowed for the thorough tracking of the fate of the dredged material and quantification of where the dredged material was transported during the simulation.

Figure 3.4-1
Analysis Regions Around Emeryville Crescent Marsh



Fifteen analysis regions were identified for evaluating the fate of the dredged material placement near Eden Landing (Figures 3.4-2 and 3.4-3). These analysis regions included the placement footprints where the dredged material placements occurred and the remainder of the placement grid. While all the placement footprints are shown on Figures 3.4-2 and 3.4-3, the subregion for analysis consisted of only the placement footprint associated with a specific dredged material placement scenario. The region representing transport from the placement grid toward Eden Landing Marsh was separated into below and above MLLW regions, based on the tidal datum at the Redwood City NOAA station. The Eden Landing Marsh analysis region consisted of the Whale’s Tail portion of the marsh, while then the remaining portions of Eden Landing were considered as a separate analysis region. Old Alameda Creek was also evaluated as a separate region. Other analysis regions included an area north of the placement grid, the Alameda flood control channel (FCC), and the mudflats on the east and west sides of South Bay, and the remaining portions of South Bay below MLLW (dispersed South Bay). For this analysis, South Bay analysis region was defined as the area between the Bay Bridge and Dumbarton Bridge. Mudflats were defined based on the areas with seabed elevation above MLLW. Analysis regions north of the Bay Bridge, south of Dumbarton Bridge, and in Redwood City Harbor were included in the analysis. This large number of analysis regions allowed for thorough tracking of where the dredged material was transported during the simulation.

Figure 3.4-2
Analysis Regions Around Eden Landing Marsh

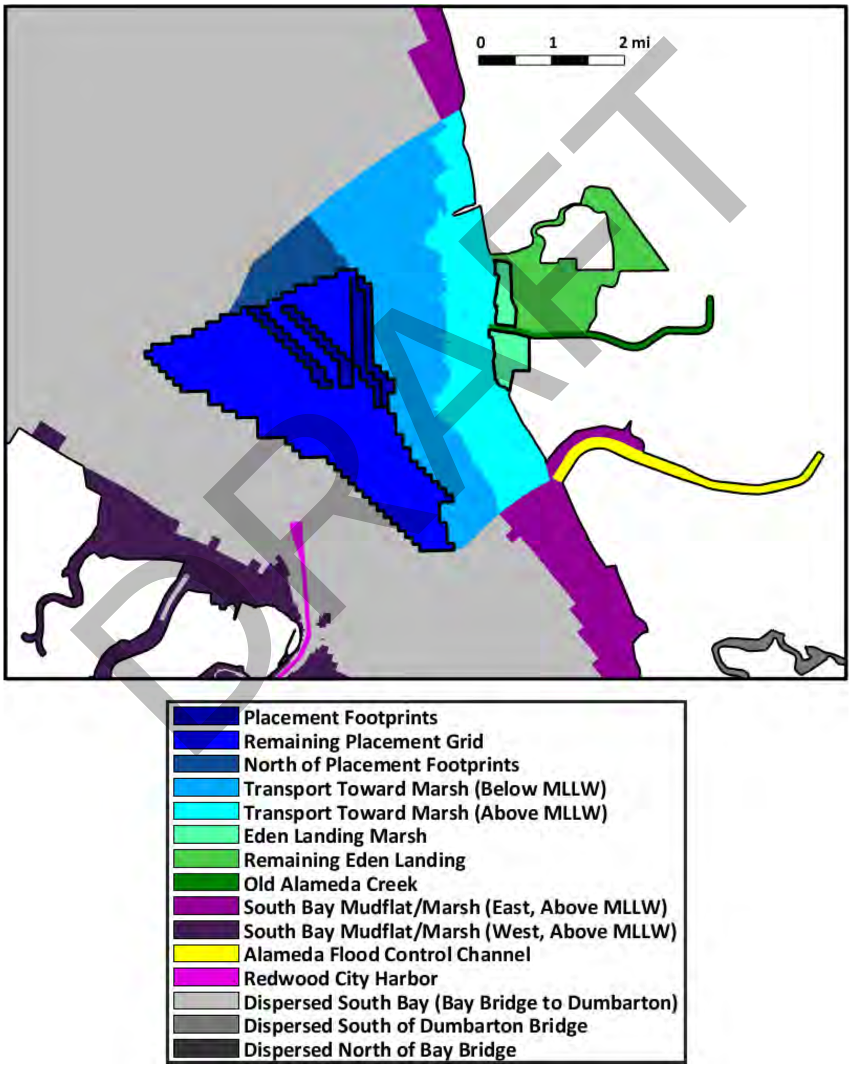
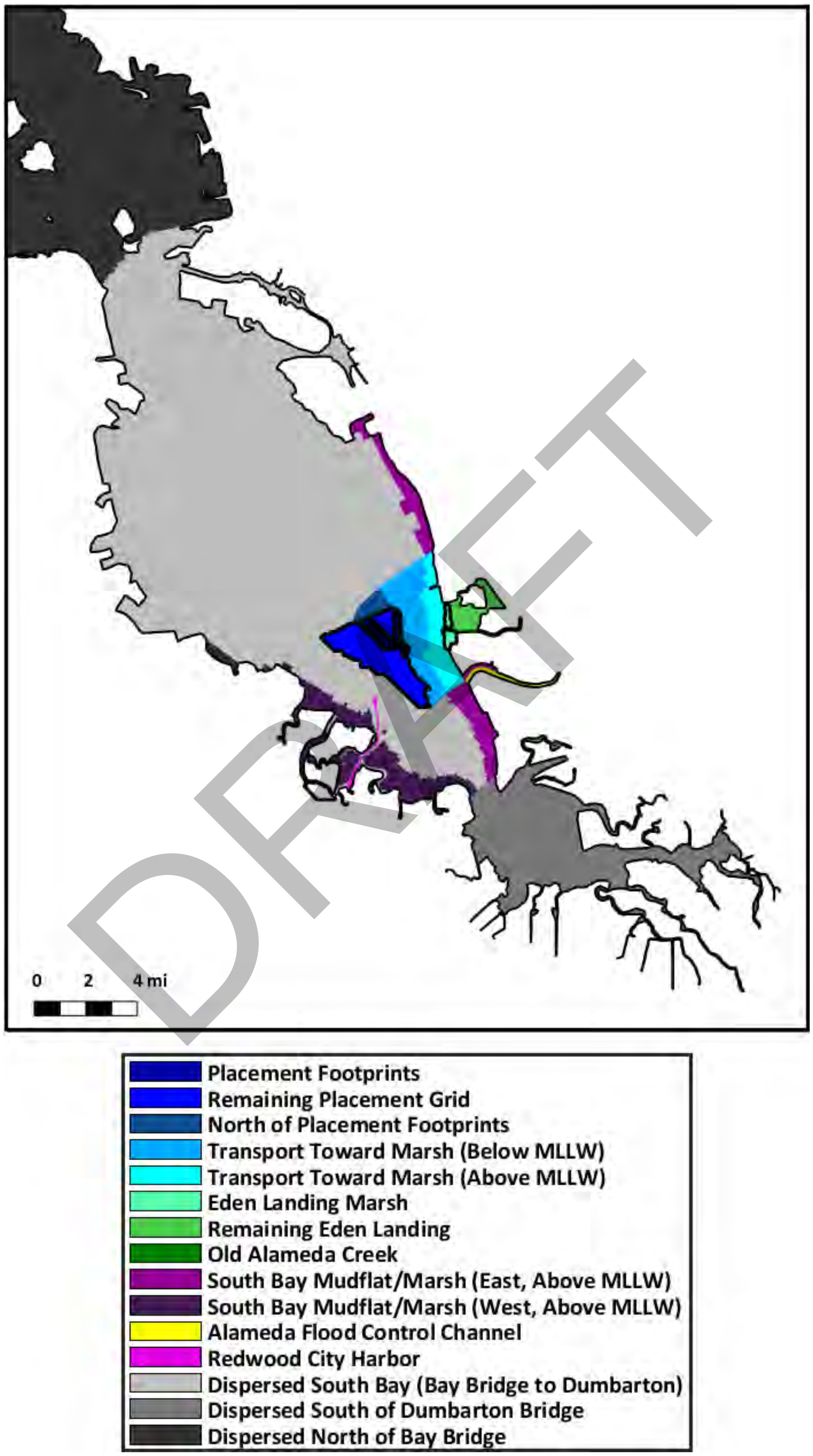


Figure 3.4-3
Wide View of the Analysis Regions Around Eden Landing Marsh



4 Wave Characteristics, Shear Stress, and Residual Currents Around the Placement Locations

This section describes the average wave characteristic and wave-induced bed shear stress in and around the placement grids. This information was used to understand the potential for wind-wave sediment resuspension when developing the specifics of the dredged material placement scenarios. Predicted wave characteristics and wave-induced bed shear stress were evaluated to qualitatively determine differences within a placement area based on varying water depths, between summer versus winter periods, and between the Emeryville and Eden Landing placement areas.

This section also describes the predicted residual (time-averaged) currents around the placement grids, which were used to understand how the average current direction may impact the results of the dredged material placement scenarios—that is, determining whether the residual currents were directed toward the marsh, away from the marsh, or along the shoreline.

4.1 Waves

Predicted wave height and bottom orbital velocity were output hourly from the SWAN wave model, matching the hourly frequency of the available wind data used for model inputs. The bottom orbital velocity is the speed of the back-and-forth water velocity near the bed as a result of the waves, which acts to resuspend sediment. The RMS significant wave height and bottom orbital velocity were calculated from the hourly predictions spanning May 1, 2009, through June 30, 2009 (summer) and December 1, 2016, through January 31, 2017 (winter). The RMS is a type of averaging that weights the larger values stronger than the smaller values. The RMS was used because the larger waves will result in more sediment resuspension than the smaller waves.

The bottom orbital velocity and wave period were used to calculate a wave-induced bed shear stress to better understand the potential for sediment resuspension. Current speed was not included in the bed shear stress calculation, to focus on the potential for wind-wave induced sediment resuspension. The bed shear stress was calculated hourly using the method of Soulsby (1997) shown in Equation 1, and then the RMS bed shear stress was calculated from the hourly predictions.

Equation 1

$$\tau_w = \frac{1}{2}\rho f_w U_w^2$$

where:

τ_w = Wave-induced bed shear stress (Pa)
ρ = Water density (kg/m^3)
f_w = Friction factor (unitless)
U_w = Wave bottom orbital velocity (m/s)

The wave friction factor was calculated following Equations 2 and 3.

Equation 2

$$f_w = 1.39(A/Z_o)^{-0.52}$$

where:

f_w = Friction factor (unitless)
Z_o = Bed roughness (m)

Equation 3

$$\mathrm{A} = \frac{U_w T}{2\pi}$$

where:

U_w = Wave bottom orbital velocity (m/s)
T = Wave period (s)

The bed roughness (*Zo*) was set to the diameter of the flocculated silt and clay sediment class (200 µm) because that sediment class represents the largest percentage of both the sediment transport model initial sediment bed and the dredged material in the scenarios.

4.1.1 Emeryville Waves and Bed Shear Stress

Around the Emeryville placement area, the RMS significant wave height decreased from the deeper (western) portion of the placement grid into shallower (eastern) water (Figures 4.1-1 and 4.1-2). RMS significant wave height was larger during the summer than the winter period. In the placement grid, RMS significant wave height was 20% to 50% larger during the summer than the winter period, with the percentage increase larger in the shallower eastern portion of the placement grid than the deeper western portion of the placement grid. In the area between the placement grid and Emeryville Crescent Marsh, RMS significant wave height was 10% to 50% higher during the summer period than during the winter, with the percentage increase larger in the shallower western portion of this area.

The RMS bottom orbital velocity during winter was relatively uniform across the placement grid, with the smallest values in the deepest southwest corner of the placement grid (Figure 4.1-3). The RMS bottom orbital velocity increased from the placement grid across the transition mudflat to the marsh as a result of decreasing water depth. During summer, the RMS bottom orbital velocity increased toward the shallowest eastern portion of the placement grid and was relatively high across the majority of the transition mudflat and onto the marsh (Figure 4.1-4). RMS bottom orbital velocities were higher during the summer period than during the winter. In the placement grid, RMS bottom orbital velocities were 10% to 50% higher during the summer period than during the winter, with the percentage increase larger in the shallower eastern portion of the placement grid than the deeper western portion of the placement grid. In the area between the placement grid and Emeryville Crescent Marsh, RMS bottom orbital velocities were 10% to 80% higher during the summer period than during the winter, with the percentage increase larger in the shallower western portion of this area.

RMS bed shear stress showed the same general pattern as the RMS bottom orbital velocity. The RMS bed shear stress during winter was relatively uniform across the placement grid and increased from the placement grid across the transition mudflat to the marsh (Figure 4.1-5). During summer, the RMS bed shear stress increased toward the shallowest eastern portion of the placement grid and was relatively high across the majority of the transition mudflat and onto the marsh (Figure 4.1-6). RMS bed shear stress was higher during the summer period than during the winter. In the placement grid, RMS bed shear stress was little changed to 50% higher during the summer period than during the winter period, with the percentage increase larger in the shallower eastern portion of the placement grid than the deeper western portion of the placement grid. In the area between the placement grid and Emeryville Crescent Marsh, RMS bed shear stress was 10% to 80% higher during the summer period than during the winter, with the percentage increase larger in the shallower western portion of this area. The critical shear stress for the silt, flocculated silt and clay, and sand sediment classes were 0.0379, 0.15, and 0.19 pascals (Pa), respectively (Table 2-1). As such, the RMS wave-induced bed shear stress was high enough to resuspend the dredged material across most of the placement grid.

The maximum bed shear stress was high enough to resuspend the dredged material over the entire placement grid during both the summer and winter periods. This indicates that at some point during each period some of the dredged material would be resuspended by wind waves and there was not a maximum depth in the placement grid beyond which wind-wave induced resuspension would cease to occur. However, because of the differences in the RMS shear stress in the placement grid, the frequency and amount of resuspension will not be consistent throughout the placement grid.

Figure 4.1-1
RMS Significant Wave Height Near the Emeryville Placement Area for Winter

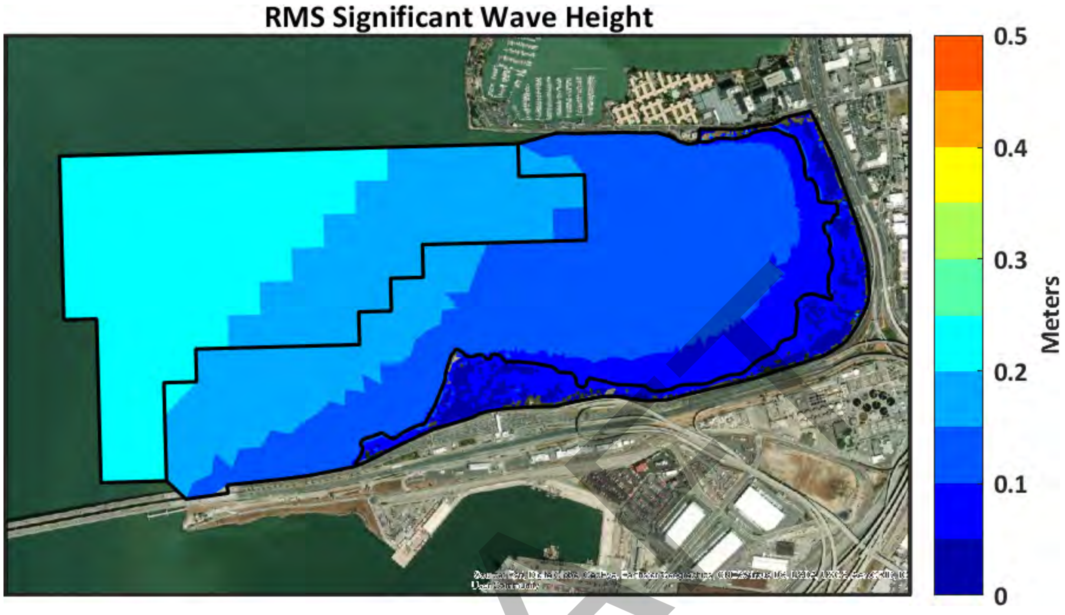


Figure 4.1-2
RMS Significant Wave Height Near the Emeryville Placement Area for Summer

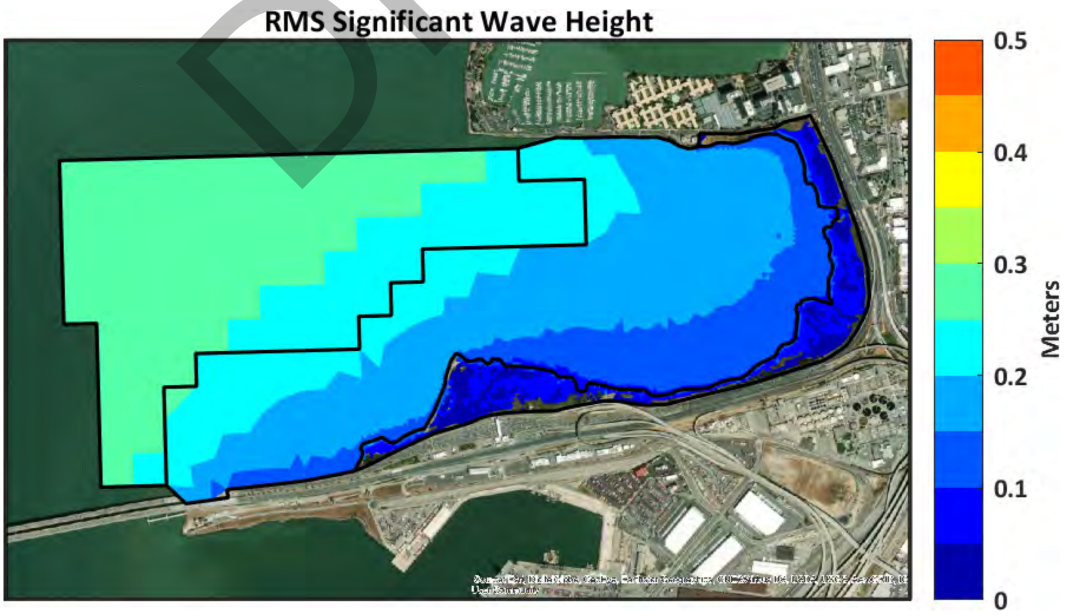


Figure 4.1-3
RMS Bottom Orbital Velocity Near the Emeryville Placement Area for Winter

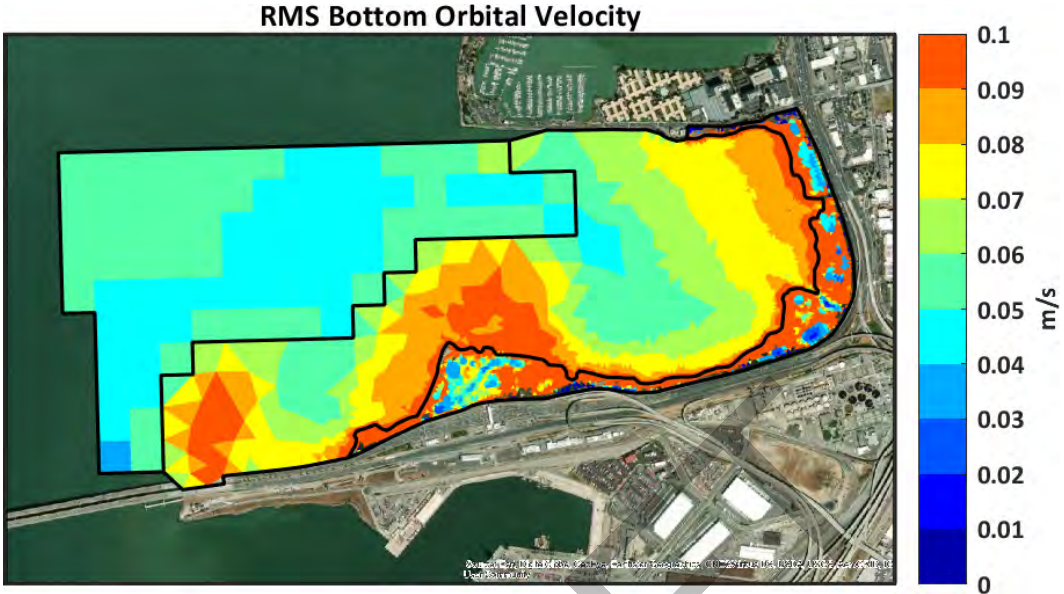


Figure 4.1-4
RMS Bottom Orbital Velocity Near the Emeryville Placement Area for Summer

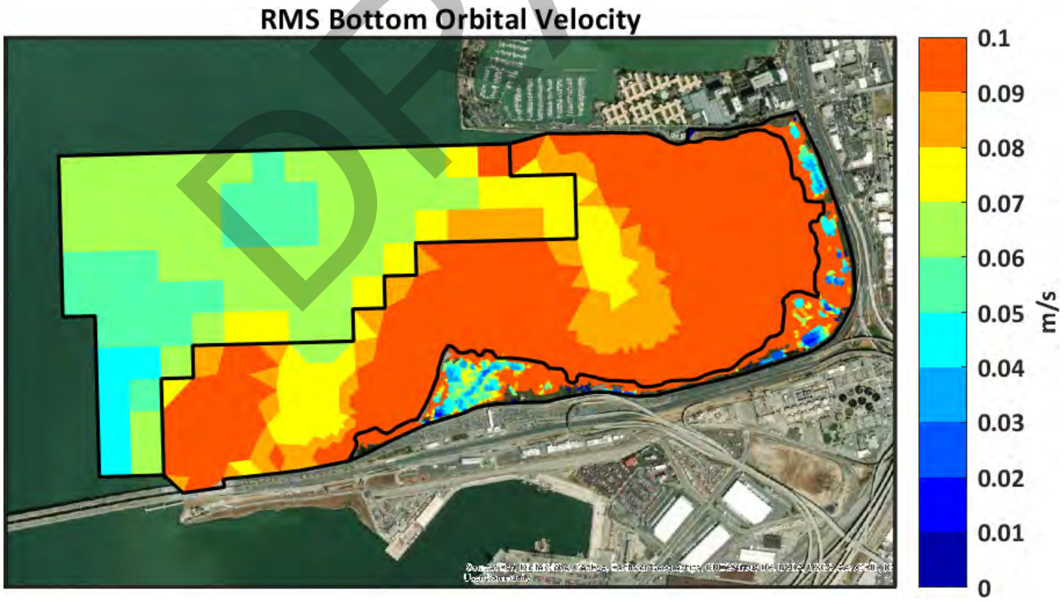


Figure 4.1-5
RMS Bed Shear Stress Near the Emeryville Placement Area for Winter

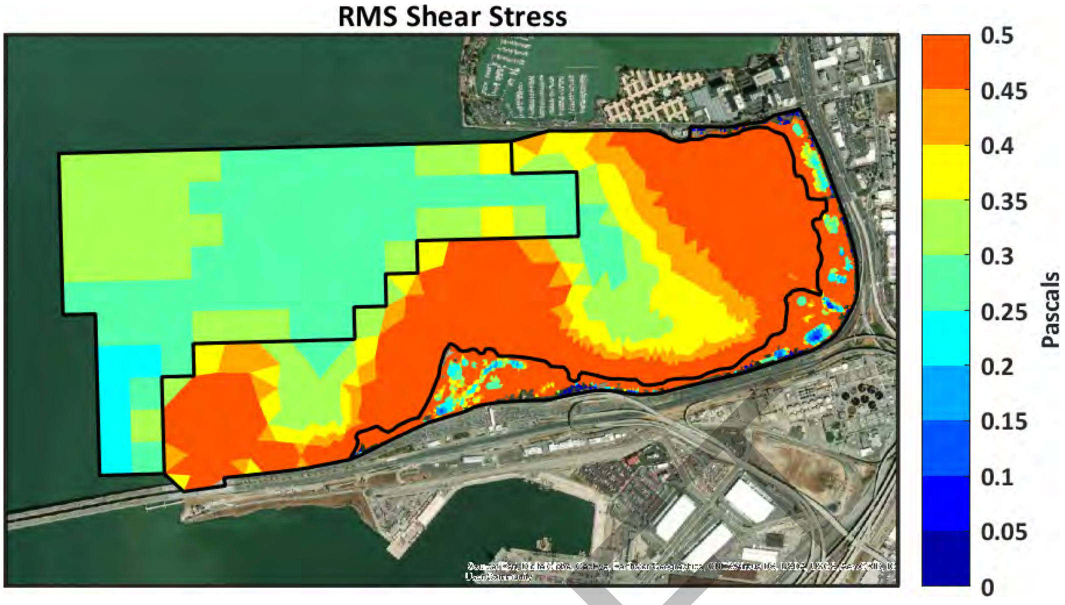
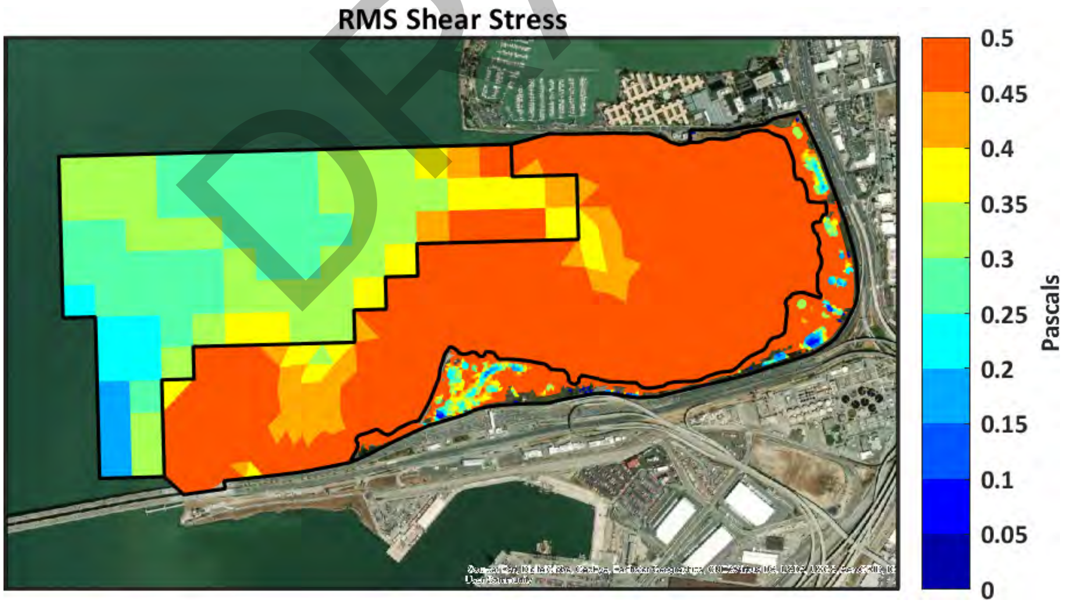


Figure 4.1-6
RMS Bed Shear Stress Near the Emeryville Placement Area for Summer



4.1.2 Eden Landing Waves and Bed Shear Stress

Around the Eden Landing placement area, the RMS significant wave height was relatively uniform throughout the placement grid and across the transition mudflat (Figures 4.1-7 and 4.1-8). RMS significant wave height was larger during the summer than the winter period. In the placement grid, RMS significant wave height was approximately 65% larger during the summer than the winter period. In the area between the placement grid and Eden Landing Marsh, RMS significant wave height was 65% to 90% higher during the summer period than during the winter, with the percentage increase larger in the shallower western portion of this area.

The RMS bottom orbital velocity increased from the deeper western portion of the placement grid across the transition mudflat to the marsh as a result of decreasing water depth (Figures 4.1-9 and 4.1-10). RMS bottom orbital velocities were higher during the summer period than during the winter. In the placement grid in the vicinity of the placement footprints, RMS bottom orbital velocities were 90% to 110% higher during the summer period than during the winter, with the percentage increase larger toward the southern end of the placement footprints. In the area between the placement grid and Eden Landing Marsh, RMS bottom orbital velocities were 110% to 140% higher during the summer period than during the winter, with the percentage increase larger in the shallower western portion of this area.

RMS bed shear stress showed the same general pattern as the RMS bottom orbital velocity. The RMS bed shear stress increased from the deeper western portion of the placement grid across the transition mudflat to the marsh as a result of decreasing water depth (Figures 4.1-11 and 4.1-12). RMS bed shear stresses were higher during the summer period than during the winter. In the placement grid in the vicinity of the placement footprints, RMS bed shear stress was 90% to 120% higher during the summer period than during the winter period, with the percentage increase larger toward the southern end of the placement footprints. In the area between the placement grid and Eden Landing Marsh, RMS bed shear stress was 100% to 150% higher during the summer period than during the winter, with the percentage increase larger in the shallower western portion of this area. The critical shear stress for the silt, flocculated silt and clay, and sand sediment classes were 0.0379, 0.15, and 0.19 Pa, respectively (Table 2-1). As such, during winter, the RMS wave-induced bed shear stress was high enough to resuspend the flocculated silts and clays and sand dredged material only in the eastern shallower portion of the placement grid (Figure 4.1-11). RMS wave-induced bed shear stress was high enough to resuspend the silt sediment class over the entire placement grid. During summer, the RMS wave-induced bed shear stress was high enough to resuspend the silt and flocculated silt and clay dredged material in the majority of the placement grid and the sand dredged material in the eastern half of the placement grid (Figure 4.1-12).

The maximum bed shear stress was high enough to resuspend the dredged material over the entire placement grid during both the summer and winter periods. This indicates that at some point during each period some of the dredged material would be resuspended by wind waves and there was not a maximum depth in the placement grid beyond which wind-wave induced resuspension would cease to occur. However, because of the differences in the RMS shear stress in the placement grid, the frequency and amount of resuspension will not be consistent throughout the placement grid.

Figure 4.1-7
RMS Significant Wave Height Near the Eden Landing Placement Area for Winter

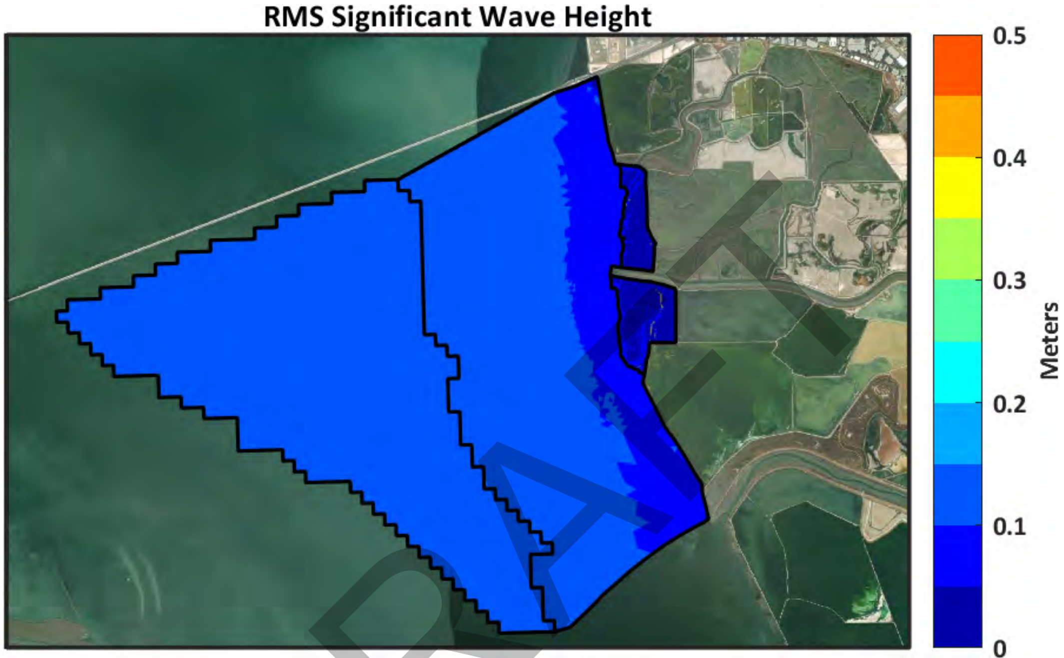


Figure 4.1-8
RMS Significant Wave Height Near the Eden Landing Placement Area for Summer

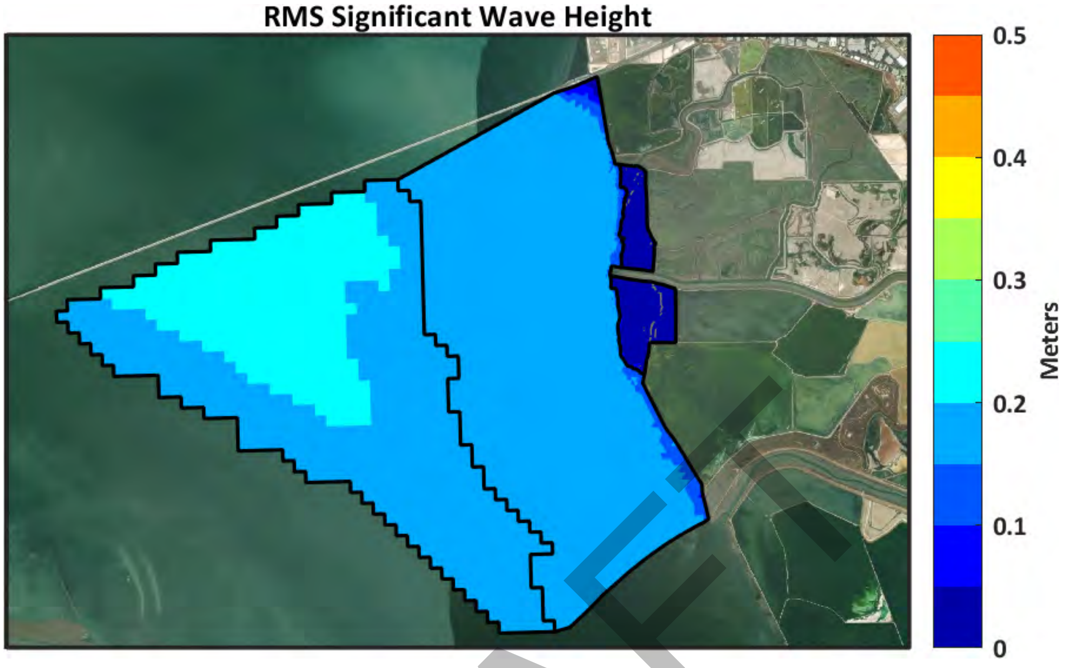


Figure 4.1-9
RMS Bottom Orbital Velocity Near the Eden Landing Placement Area for Winter

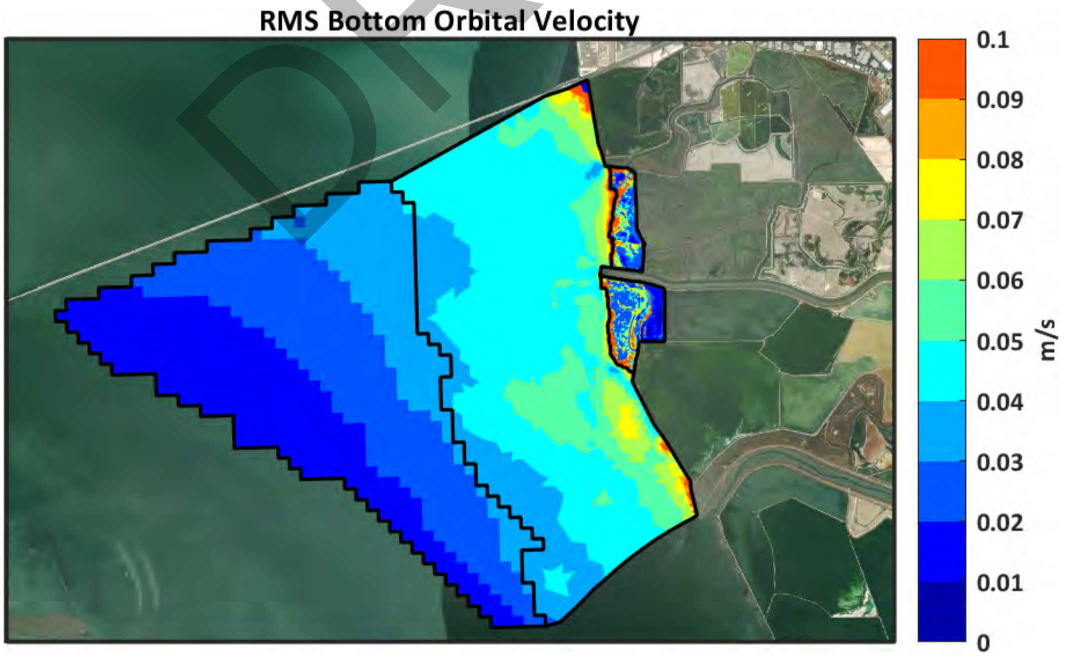


Figure 4.1-10
RMS Bottom Orbital Velocity Near the Eden Landing Placement Area for Summer

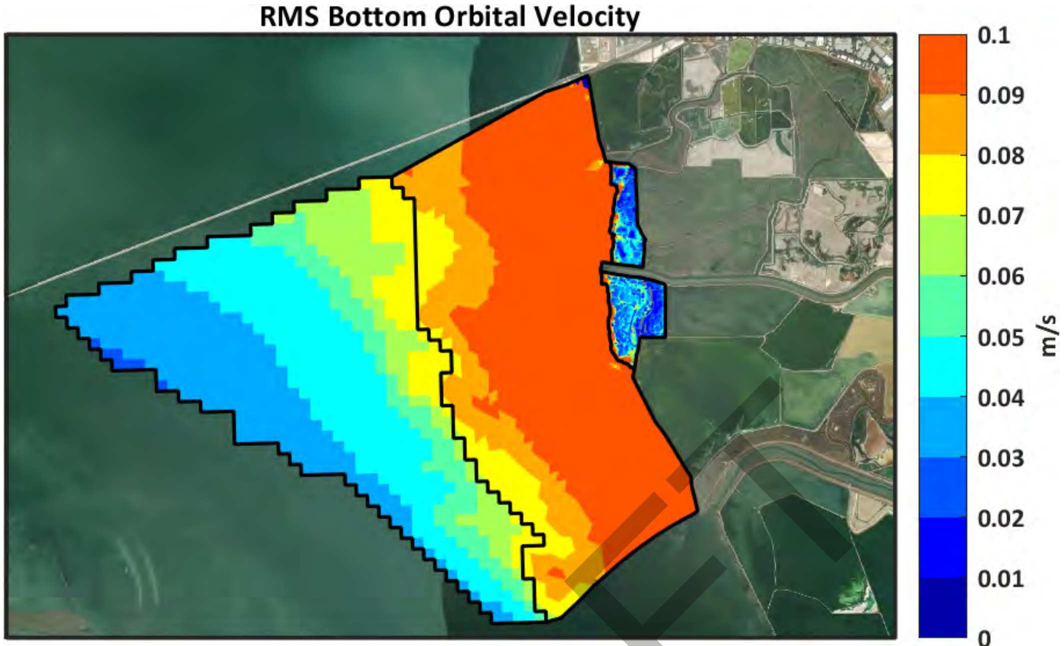


Figure 4.1-11
RMS Bed Shear Stress Near the Eden Landing Placement Area for Winter

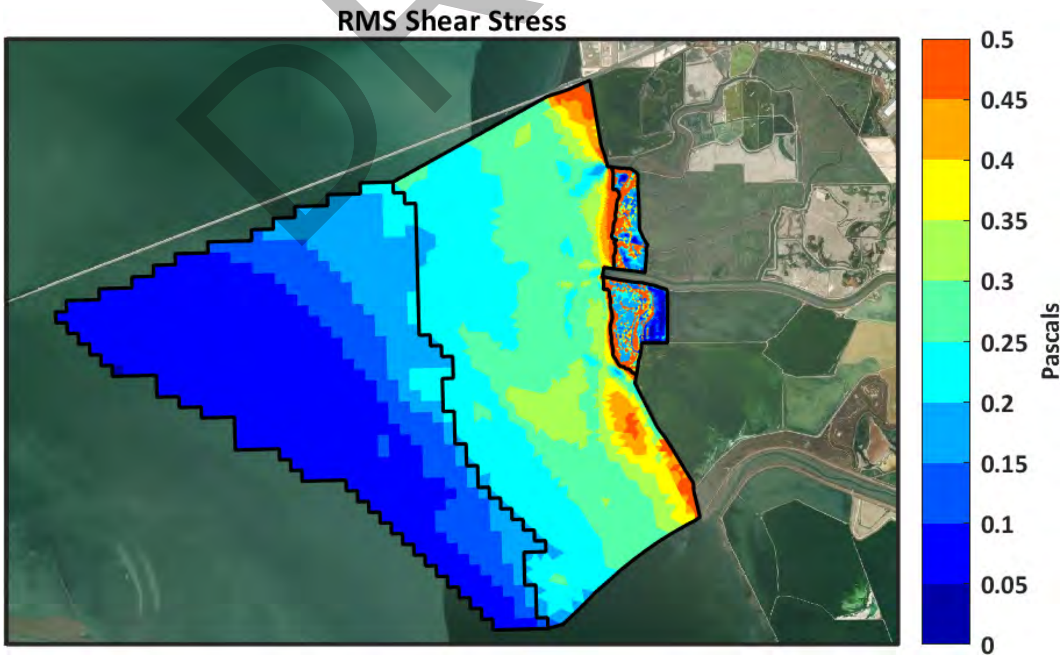
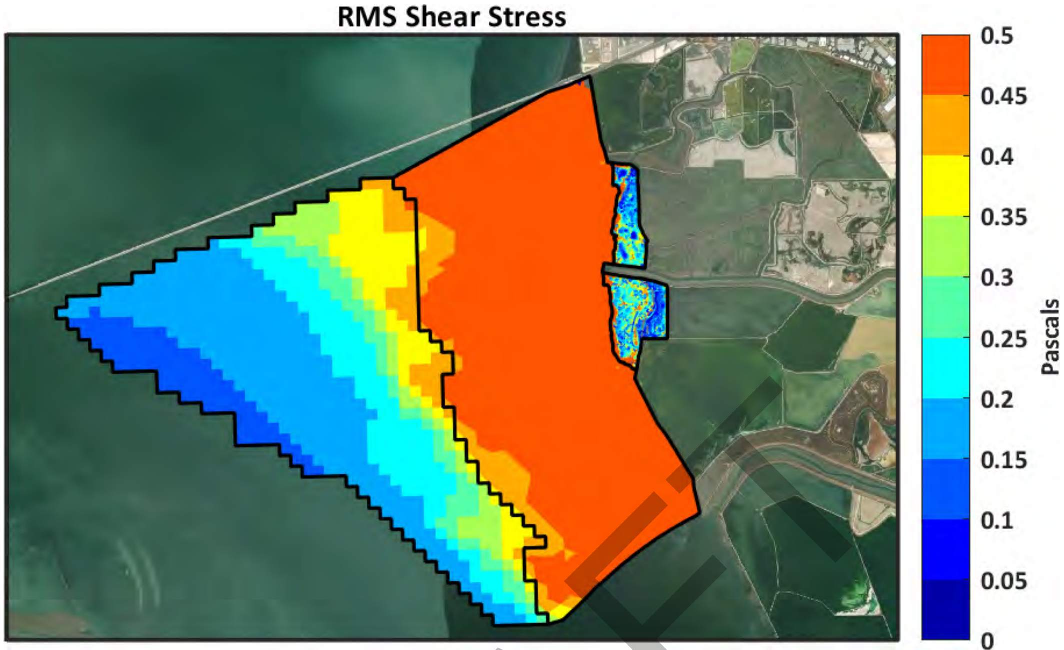


Figure 4.1-12
RMS Bed Shear Stress Near the Eden Landing Placement Area for Summer



4.1.3 *Comparison of Summer Versus Winter and Emeryville Versus Eden Landing*

Significant wave height, bottom orbital velocity, and bed shear stress were higher during the summer period than during the winter period at both Emeryville and Eden Landing. The larger waves and higher bed shear stress result from the seasonally stronger winds in late-spring and early-summer than during the winter. This does not suggest that winter storms will not act to resuspend sediment, simply that on average the waves and the potential for sediment resuspension were larger during the summer period evaluated.

The bottom orbital velocity and bed shear stress that act to resuspend sediment were the lowest on the western side of the placement grids and highest on the eastern side, at both Emeryville and Eden Landing. This results from the shallowing of the placement grids from the western to the eastern side and the increasing effect of wind waves as the water depth gets lower. The bed shear stress was further evaluated based on a 0.2-Pa cutoff. The threshold of 0.2 Pa was based on the critical shear stress of the flocculated sediment class being 0.15 Pa and the critical shear stress of the sand being 0.19 Pa. At Emeryville, the RMS bed shear stress was greater than the 0.2-Pa threshold over much of the placement grid. However, at Eden Landing the RMS bed shear stress was only greater than this threshold toward the eastern side of the placement grid. Since the RMS is a type of averaging, this does not mean the western side of the Eden Landing placement grid will not have wave-induced resuspension of the dredged material. Rather, it means the eastern side of the placement grid should have much more sediment resuspension and potential for dispersal away from the placement location than the western side of the placement grid.

4.2 Time-Averaged Currents

Residual (time-averaged) currents are the average current speed and direction over a specified time interval. Predicted residual currents were calculated over the summer and winter simulation periods to provide insight into how the average currents may affect dispersal of the dredged material following placement. Although the residual currents provide information on how time-averaged current direction may impact sediment dispersal, sediment dispersal results from a combination of the timing and magnitude of wind-wave resuspension, tidal-current transport, and transport in the residual current direction. As such, residual currents provide additional information but do not necessarily fully predict the net direction of sediment dispersal.

Predicted residual currents were calculated by time-averaging the predicted depth-averaged velocity over the length of the simulation period. The exact start and end times of the averaging periods were selected to coincide with similar phases of the tidal cycle. Depth-averaged residual currents are presented as spatial vector (arrow) maps of the time-averaged circulation near the Emeryville and Eden Landing placement grids. The length of the arrow represents the relative speed of the depth-averaged residual current, and the direction the arrows point is the direction the current is flowing toward. On the maps, depth-averaged residual currents with a speed greater than 0.2 ft/s are plotted as a wider line. This allows for the maps to be easily interpretable without a few longer arrows obscuring other arrows. Time-averaged water depth is shown as the background colors on the maps.

4.2.1 Emeryville

During the summer simulation period, the predicted depth-averaged residual current between the Emeryville placement sites and Emeryville Crescent Marsh was a counterclockwise circulation cell, which was directed toward the south along the western (deeper) side of the Emeryville placement grid and directed toward the north on the eastern (shallower) side along Emeryville Crescent Marsh (Figures 4.2-1 and 4.2-2). The southward depth-averaged residual currents on the western side of the placement grid may act to transport sediment south away from the placement grid and Emeryville Crescent Marsh and toward Oakland Harbor. The northward depth-averaged residual currents on the western side of the placement grid may act to transport sediment away from Emeryville Crescent Marsh.

During the winter simulation period, the predicted depth-averaged residual current was directed toward the south over a large portion of the Emeryville placement grid (Figures 4.2-3 and 4.2-4). Depth-averaged residual current speeds were low on the eastern (shallower) side of the placement grid and shoreward of the placement grid, where the counterclockwise circulation cell was less pronounced than during the summer period. The southward depth-averaged residual currents were larger during the winter simulation period than during the summer. The depth-averaged residual currents east (shoreward) of the Emeryville placement grid were larger during the summer simulation period than during the winter.

Figure 4.2-1
Depth-Averaged Residual Currents near the Emeryville Placement Grid During the Summer Simulation Period

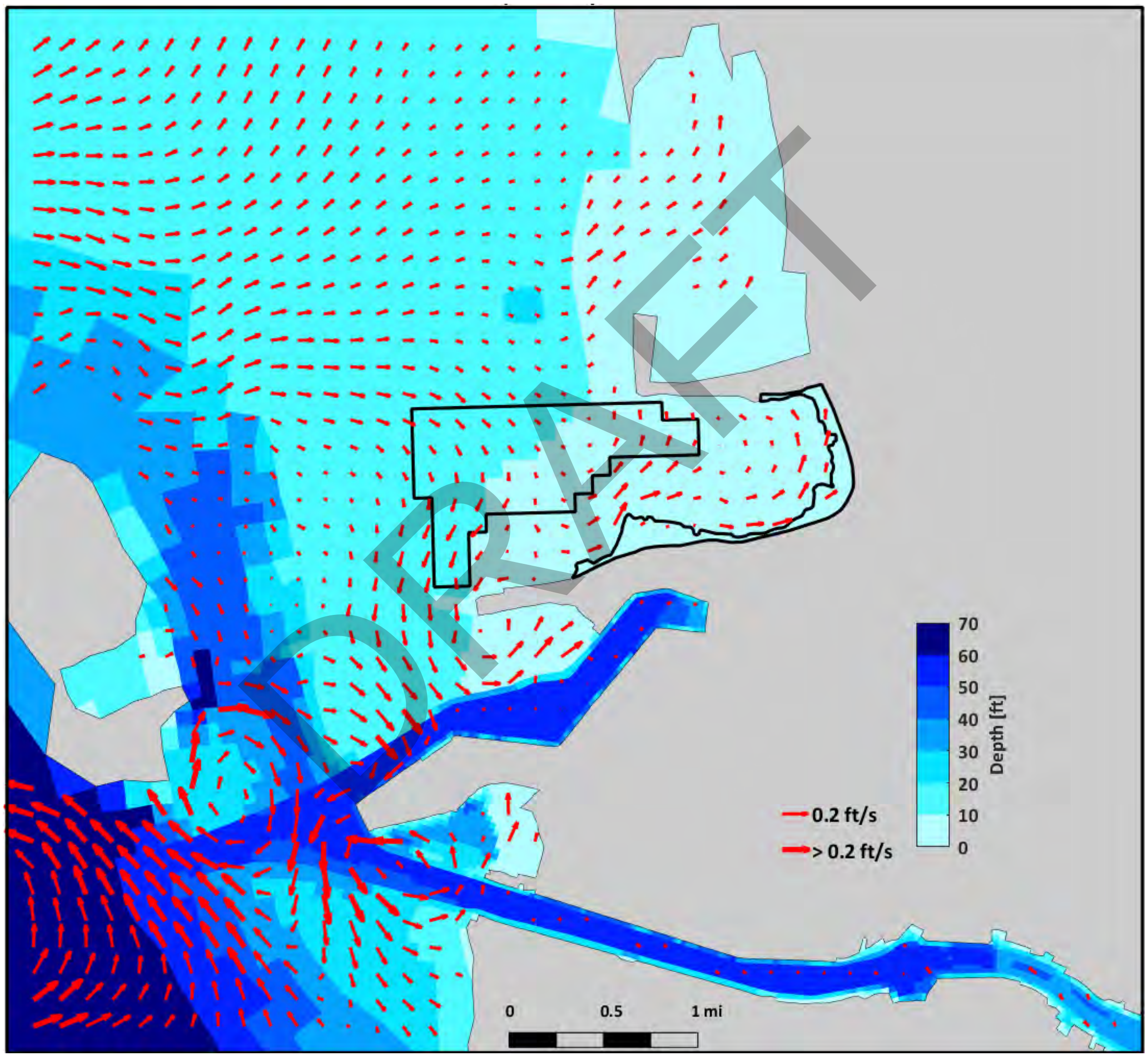


Figure 4.2-2
Depth-Averaged Residual Currents Zoomed in on the Emeryville Placement Grid and Emeryville Crescent Marsh During the Summer Simulation Period

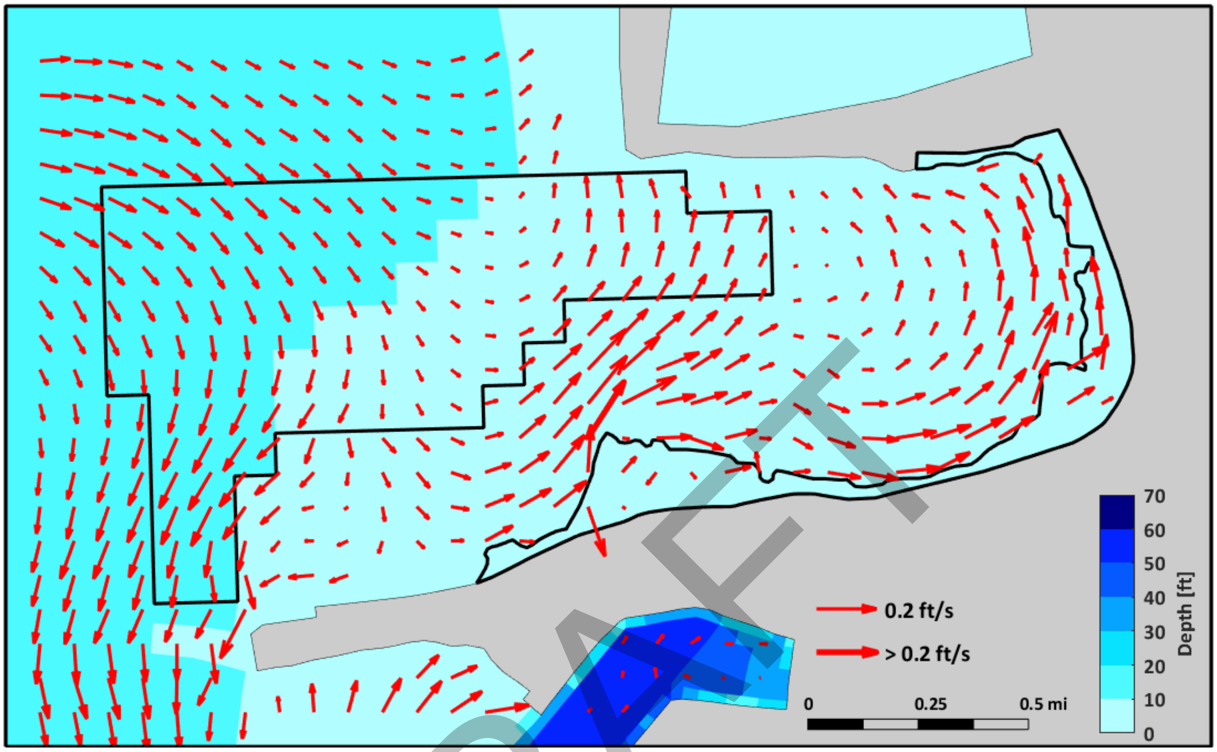


Figure 4.2-3
Depth-Averaged Residual Currents near the Emeryville Placement Grid During the Winter Simulation Period

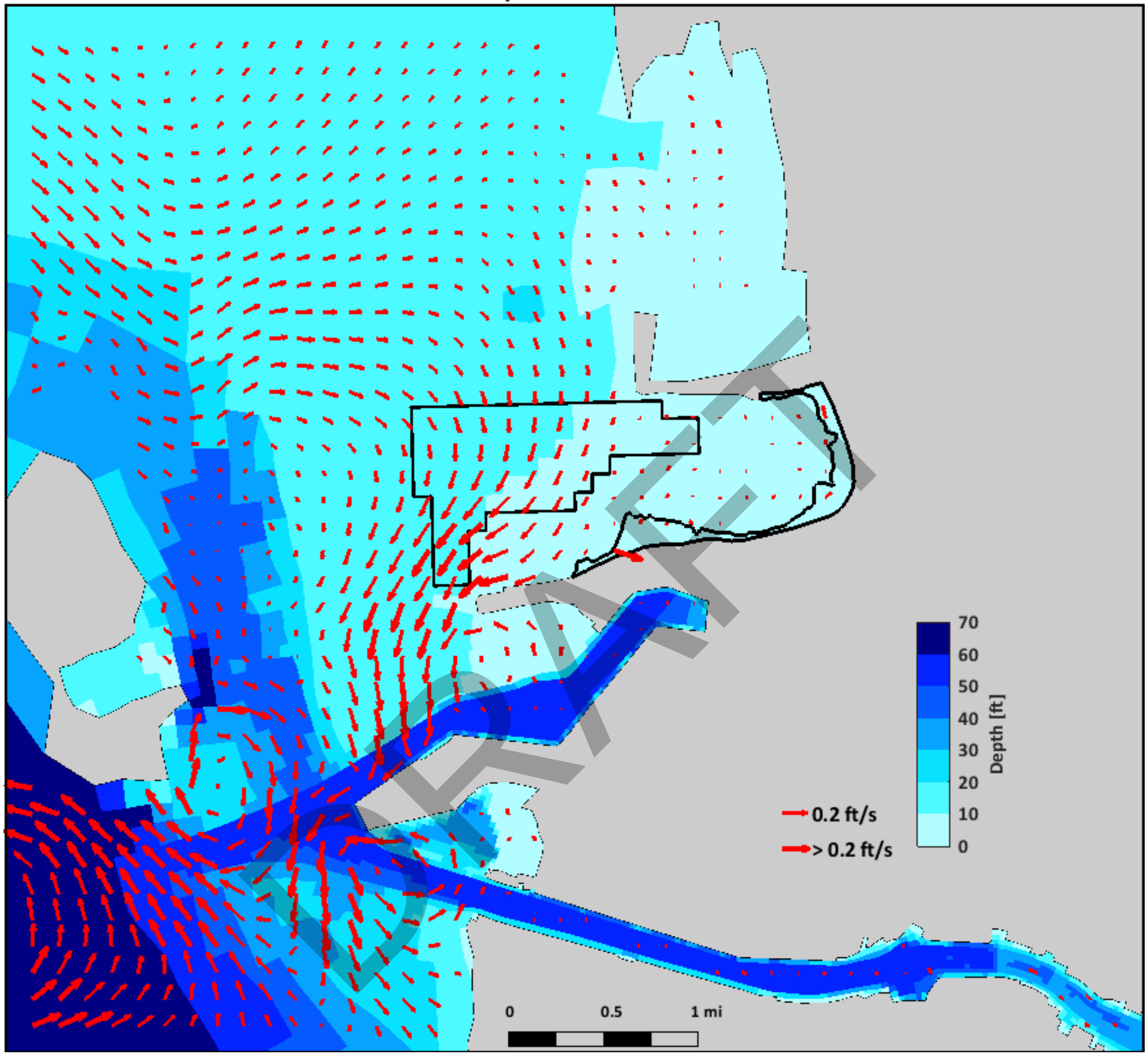
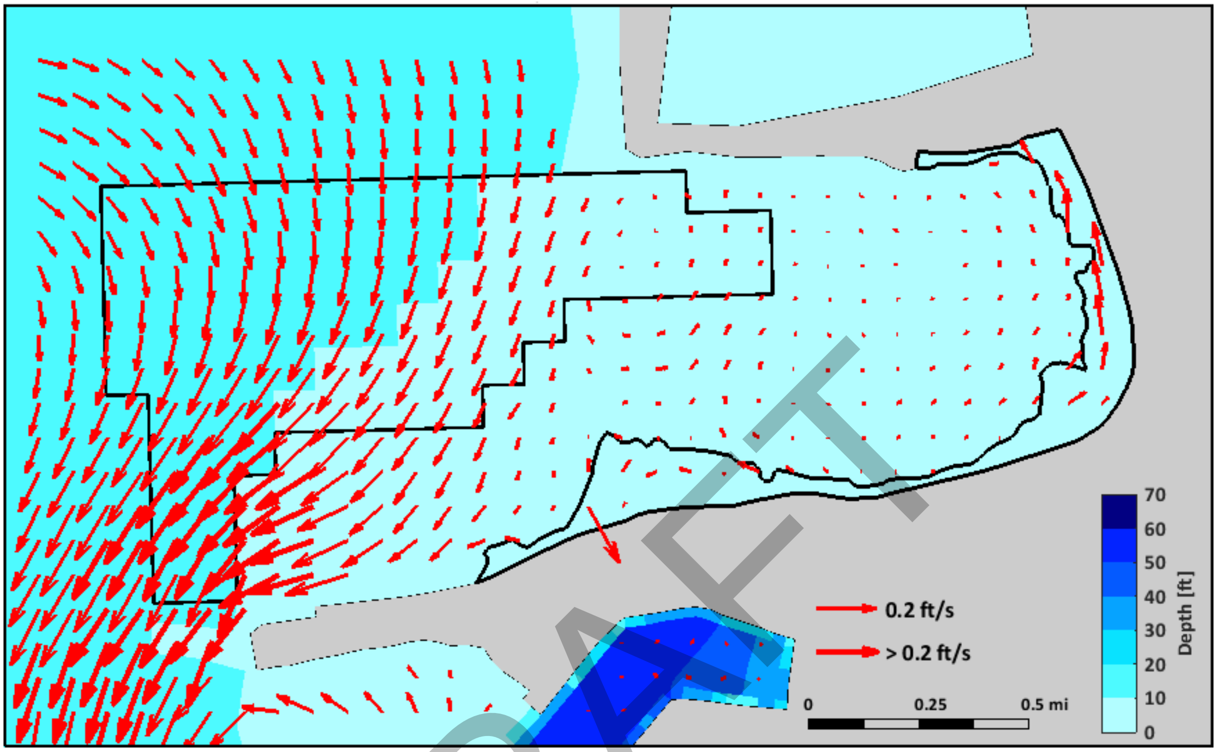


Figure 4.2-4
Depth-Averaged Residual Currents Zoomed in on the Emeryville Placement Grid and Emeryville Crescent Marsh During the Winter Simulation Period



4.2.2 Eden Landing

During the summer simulation period, the predicted depth-averaged residual current was directed toward the north over the northeast portion of the Eden Landing placement grid, where the dredged material placement footprints were located in the sediment transport model scenarios (Figures 4.2-5 and 4.2-6). Depth-averaged residual currents were also directed toward the north between the placement grid and Eden Landing Marsh. West of the dredged material placement grid, a complex pattern of depth-averaged residual circulation was predicted. This pattern includes generally southward directed depth-averaged residual currents in the main channel of South San Francisco Bay and a clockwise rotating depth-averaged residual current south of Redwood City Harbor. Depth-averaged residual currents just north of the placement grid were very low. This area of very low predicted depth-averaged residual currents near San Mateo Bridge is consistent with the findings of Walters et al. (1985) that "horizontal [tidal] residual flows south of San Mateo Bridge appear to be extremely weak and are not measurable." A location of very low residual currents in the middle of South Bay suggests that residual currents in the South Bay may be more complex than interpreted from previous observational data (e.g., Walters et al. 1985; Lacy et al. 1996). The northward predicted depth-averaged residual currents also compare favorably with Gostic (2017), who used sediment transport modeling to predict northward net sediment fluxes on the eastern shoal of South Bay during wet and dry years (see Figure 4.10 in Gostic 2017).

During the winter simulation period, the predicted depth-averaged residual current pattern was very similar to that of the summer simulation period (Figures 4.2-7 and 4.2-8). However, the depth-averaged residual currents were larger during the winter simulation period than during the summer. This increase in the speed of the depth-averaged residual currents is shown by the lengthening of the arrows from the summer simulation period (Figures 4.2-5 and 4.2-6) to the winter simulation period (Figures 4.2-7 and 4.2-8). Similar to the summer period, the depth-averaged residual currents in the main channel of South San Francisco Bay were generally directed southward, with northward directed currents on the eastern side of the South Bay between the placement grid and Eden Landing Marsh and very low depth-averaged residual currents just north of the placement grid.

Figure 4.2-5
Depth-Averaged Residual Currents near the Eden Landing Placement Grid During the Summer Simulation Period

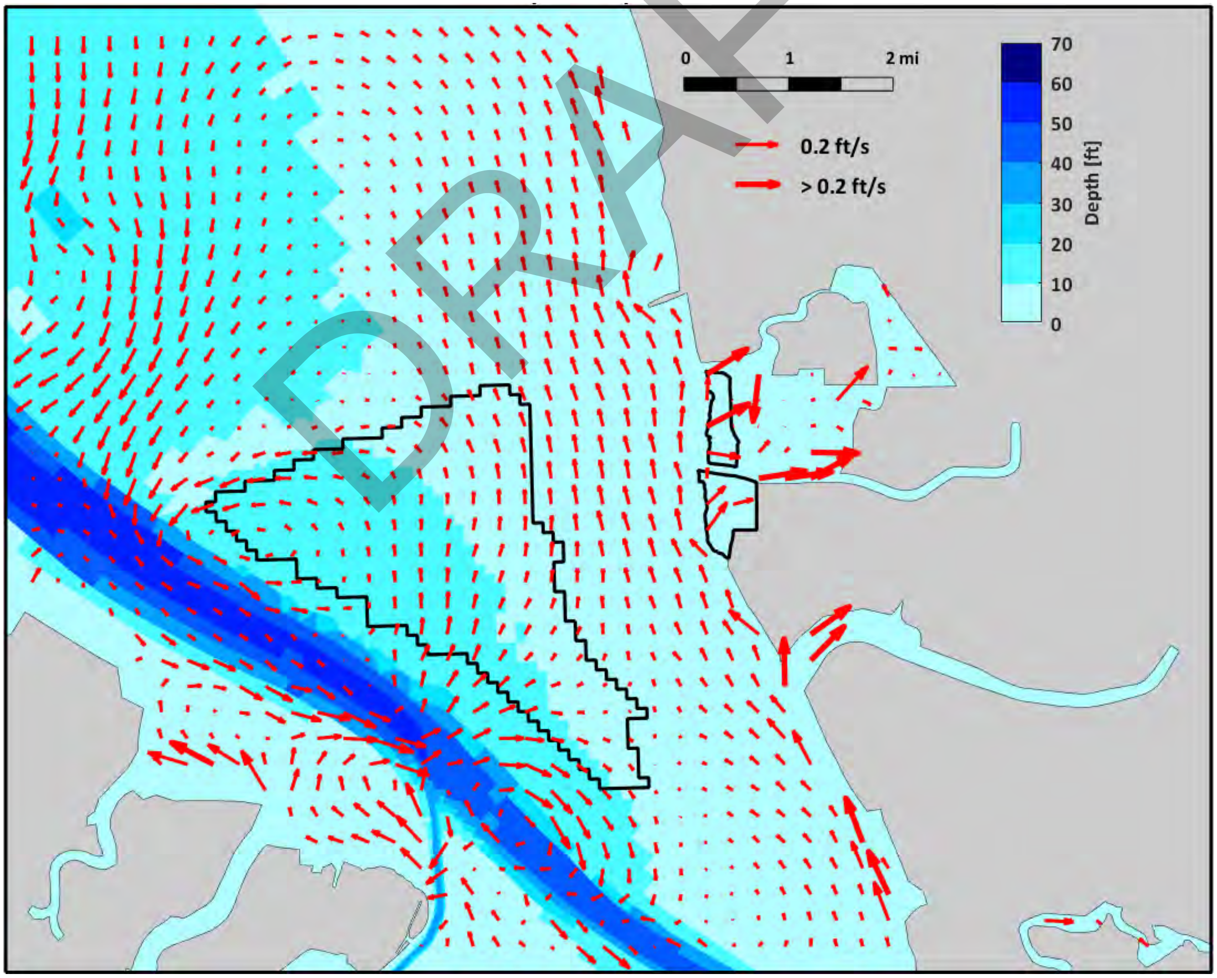


Figure 4.2-6
Depth-Averaged Residual Currents Zoomed in on the Eden Landing Placement Grid and Eden Landing Marsh During the Summer Simulation Period

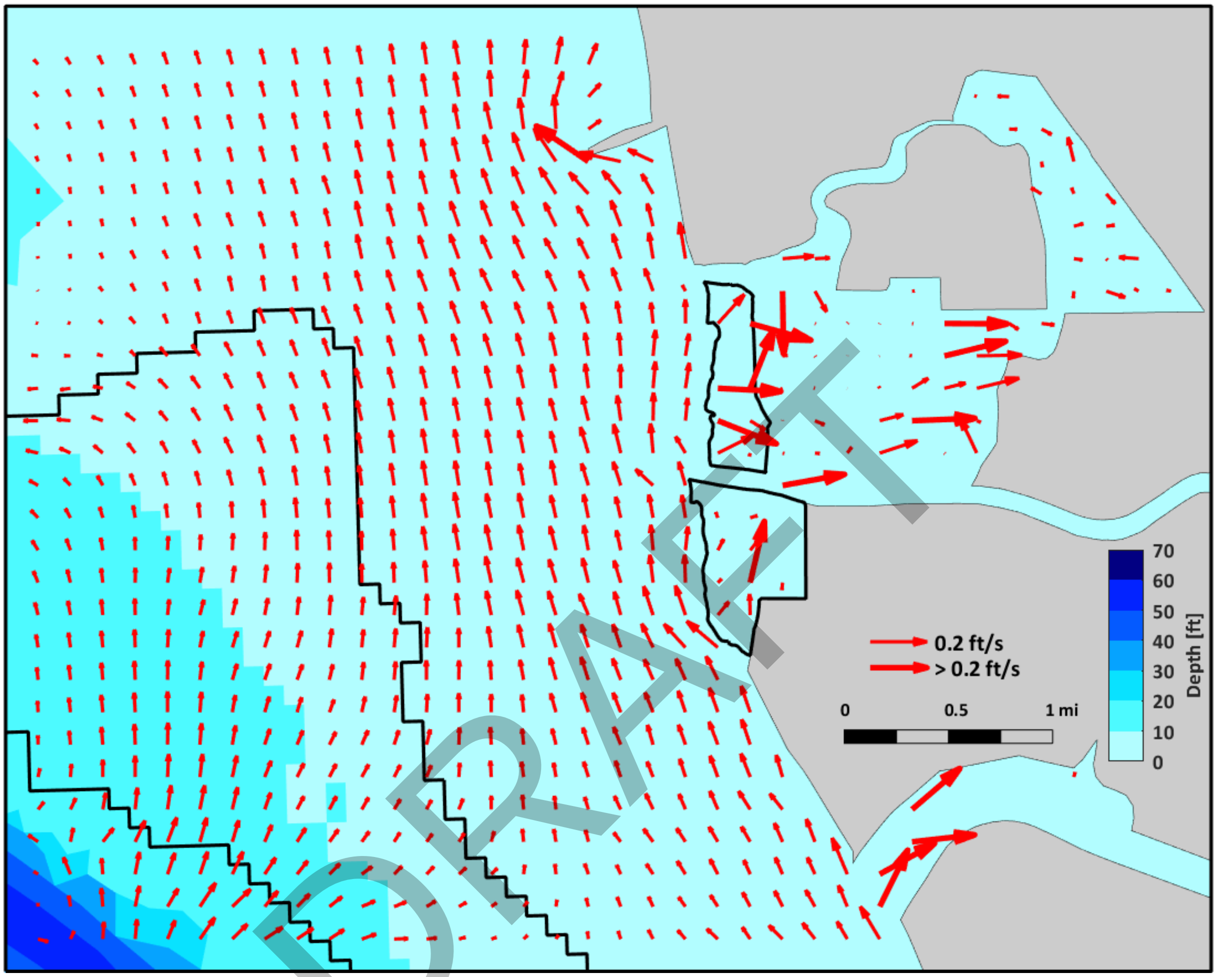


Figure 4.2-7
Depth-Averaged Residual Currents near the Eden Landing Placement Grid During the Winter Simulation Period

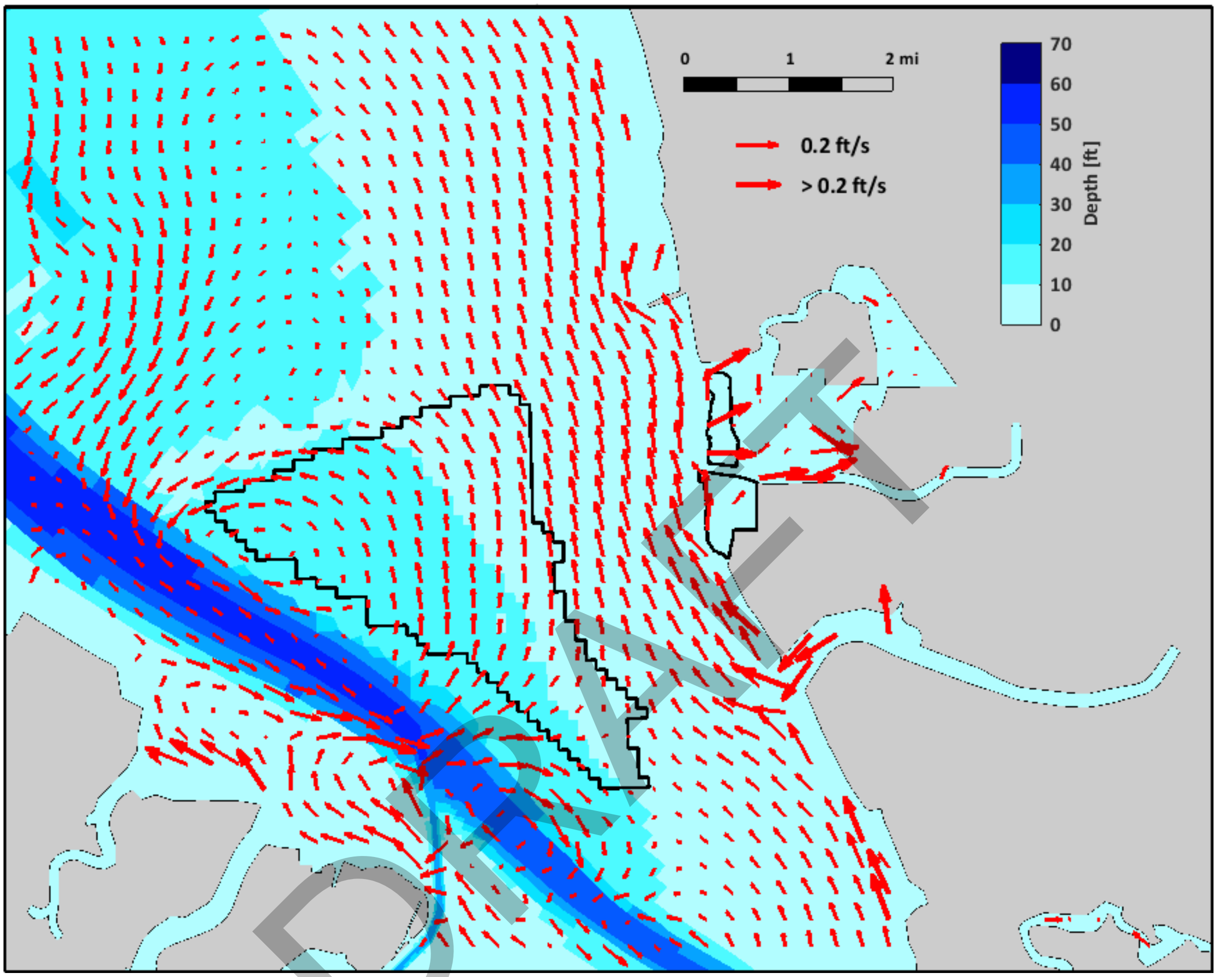
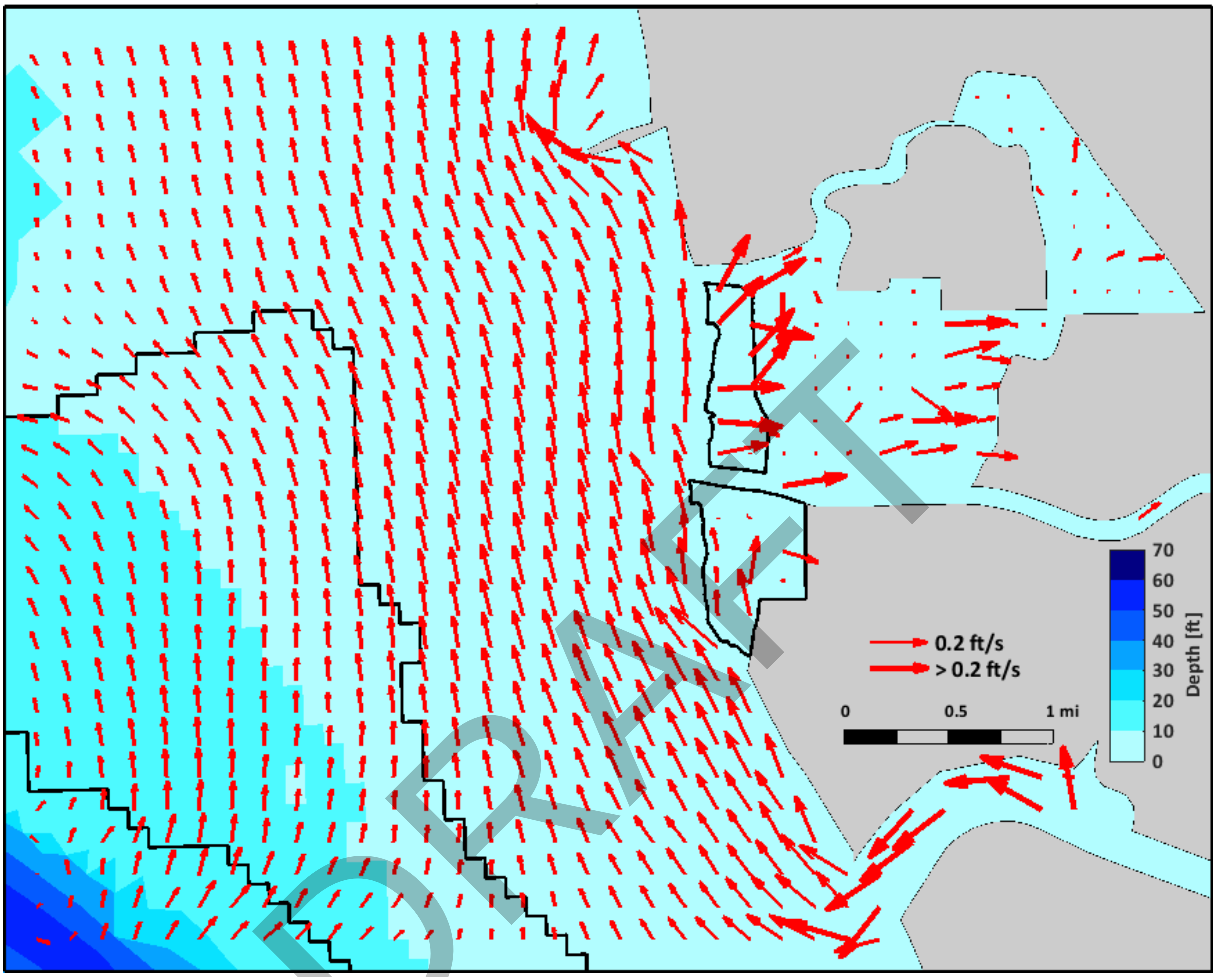


Figure 4.2-8
Depth-Averaged Residual Currents Zoomed in on the Eden Landing Placement Grid and Eden Landing Marsh During the Winter Simulation Period



5 Evaluation of Dredged Material Placement Scenarios

The 12 dredged material placement scenarios were analyzed to determine the predicted amount of dredged material dispersed to specific locations or retained in the placement footprint at the end of the simulations. Sections 5.1 and 5.2 focus on the first six scenarios used to evaluate the Emeryville and Eden Landing placement sites. These six scenarios were developed to evaluate three different placement strategies at each site and provide additional information to inform the selection of the most suitable site for the 1122 pilot study. The results from each of these six scenarios are presented, and then the similarities and differences between the placements at Emeryville and Eden Landing are summarized. Section 5.3 presents the results of the additional six scenarios developed to refine the placement strategy and placement volume at Eden Landing. Section 5.4 compares the set of scenarios focused on the shallow/east placement location at Eden Landing.

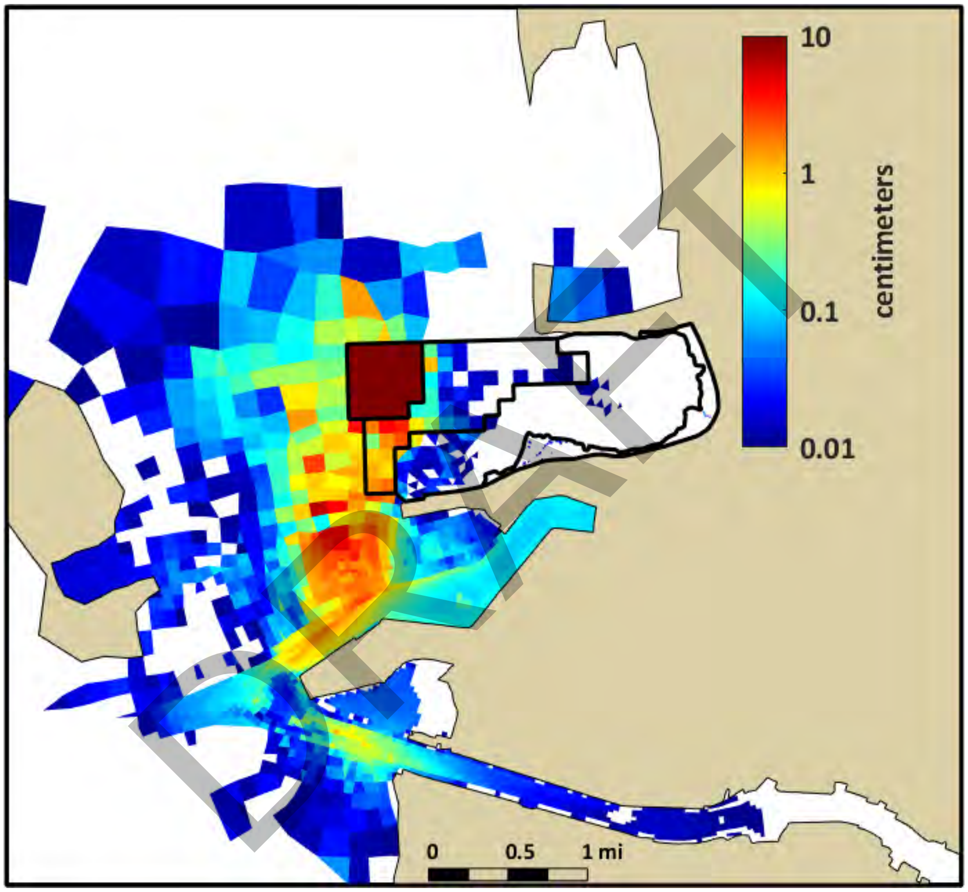
The Emeryville and Eden Landing regions shown on Figures 3.4-1, 3.4-2, and 3.4-3 were used to evaluate the predicted fate of the dredged material at the end of the simulations. The amount of dredged material in the regions are presented as the percentage of the placement sediment mass in each region and as the volume of dredged material in each region. The percentage is presented as the percentage of sediment mass because the sediment transport model simulates the erosion, deposition, and transport of sediment mass. This is the same approach used previously for evaluating the dispersal of dredged material south of Dumbarton Bridge (Bever and MacWilliams 2014). The volume of dredged material in each region was calculated by multiplying the percentage of sediment mass in each region by the total volume of dredged material used in each scenario.

5.1 Initial Emeryville and Eden Landing Scenario Results

5.1.1 Emeryville Deep

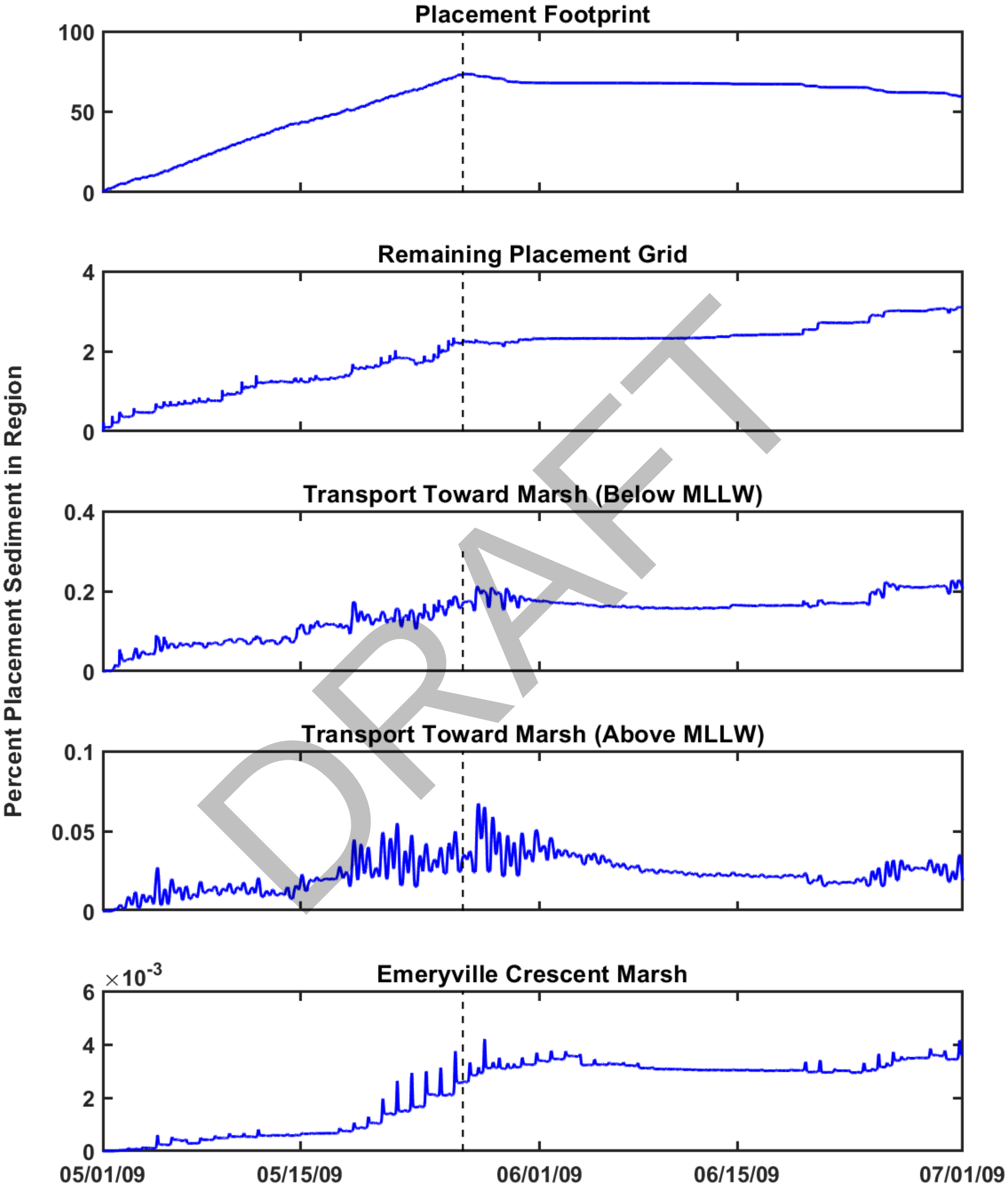
The Emeryville Deep scenario included the placement of 100,000 yd^3 of dredged material on the western side of the placement grid. The scenario assumed a total of 72 placements over a period of 26 days, as described in Section 3.3.1.1. At the end of the 2-month simulation, some of the dredged material was predicted to be dispersed away from the placement footprint (Figure 5.1-1), but 60% of the placed dredged material was predicted to remain inside the placement footprint (Figures 5.1-2 and 5.1-3; Tables 5.1-1 and 5.1-2). The model predicted that dredged material that was transported out of the initial placement footprint was predominately deposited toward the west and south of the placement footprint (Figure 5.1-1). Predicted thickness of the dredged material remaining in the placement footprint ranged from 13 to 26 cm, with up to 0.05 cm of dredged material deposition in Emeryville Crescent Marsh (Table 5.1-3). The percentage of the total amount of dredged material in the placement footprint increased until the placements were completed and then was predicted to slowly decrease as the dredged material was resuspended (Figure 5.1-2). Much of the dredged material deposited on Emeryville Crescent Marsh was predicted to be transported onto the marsh during the second half of May, when the tidal higher high water level was relatively high and the placements were still occurring. About 3% of the placed dredged material was predicted to be transported into Oakland Harbor, and 34% was predicted to be dispersed to areas deeper than MLLW at the end of the 2-month simulation.

Figure 5.1-1
Predicted Thickness of Dredged Material at the End of the 2-Month Simulation: Scenario 1 Emeryville Deep



Note:
Note the log scale of the color range.

Figure 5.1-2
Predicted Percentage of Dredged Sediment Mass in Each Region During the 2-Month Simulation: Scenario 1 Emeryville Deep



Note:
Vertical dashed line denotes the end of the dredged material placements for this scenario.

Figure 5.1-3
Predicted Percentage of Dredged Sediment Mass in Each Region at the End of the 2-Month Simulation: Scenario 1 Emeryville Deep

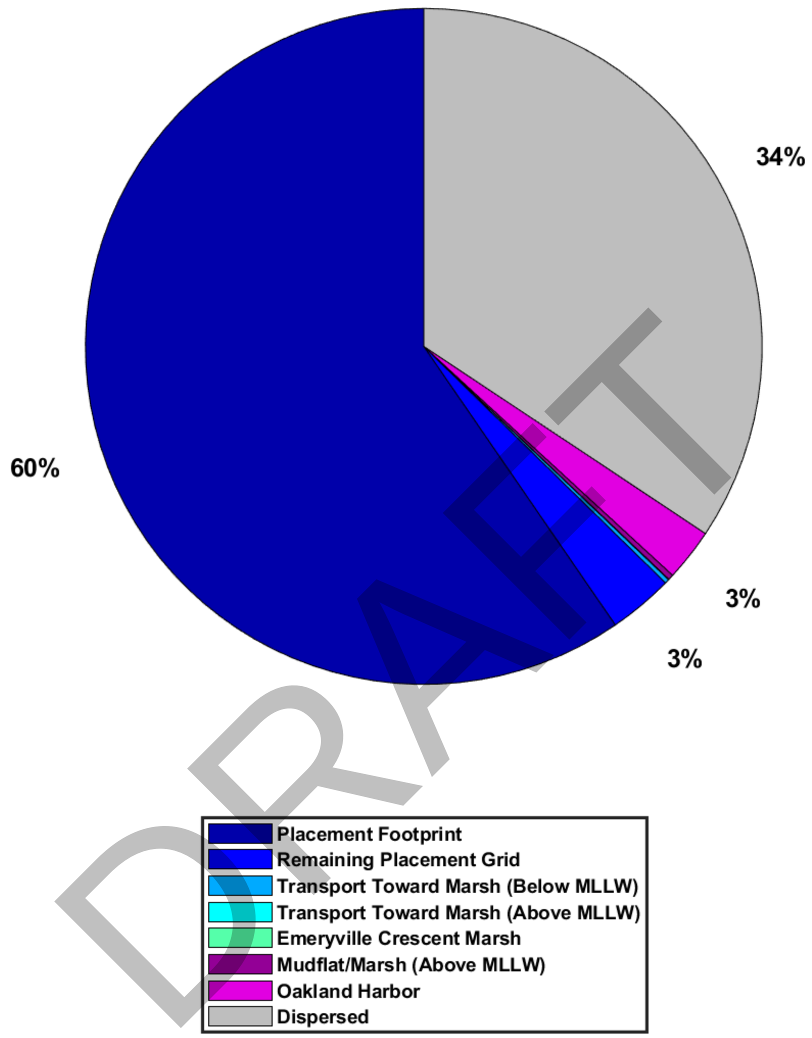


Table 5.1-1
Percentage of Placement Sediment Mass in Each Region at the End of the Three Emeryville Scenarios

Scenario Number	Scenario Name	Placement Footprint	Remaining Placement Grid	Transport Toward Marsh (Below MLLW)	Transport Toward Marsh (Above MLLW)	Emeryville Crescent Marsh	Mudflat/Marsh (Above MLLW)	Oakland Harbor	Dispersed
1	Emeryville Deep	60	3	0.2	<0.1	<0.1	0.3	3	34
2	Emeryville Middle	68	7	1	<0.1	<0.1	0.2	1	22
3	Emeryville Shallow/East	75	6	3	0.1	<0.1	0.2	0.7	15

Note:
Percentages may not round to 100% because of rounding of the values.

Table 5.1-2
Volume of Placement Sediment in Cubic Yards in Each Region at the End of the Three Emeryville Scenarios

Scenario Number	Scenario Name	Placement Footprint	Remaining Placement Grid	Transport Toward Marsh (Below MLLW)	Transport Toward Marsh (Above MLLW)	Emeryville Crescent Marsh	Mudflat/Marsh (Above MLLW)	Oakland Harbor	Dispersed
1	Emeryville Deep	60,000	3,000	200	<100	<100	300	3,000	34,000
2	Emeryville Middle	68,000	7,000	1,000	<100	<100	200	1,000	22,000
3	Emeryville Shallow/East	75,000	6,000	3,000	100	<100	200	700	15,000

Notes:
Sediment volume in each region was calculated by multiplying the percentage in each region shown in Table 5.1-1 by the total placement volume show on Table 3.3-1.
Sediment volume may not sum to the total volume of dredged material because of rounding of the percentages in each region.

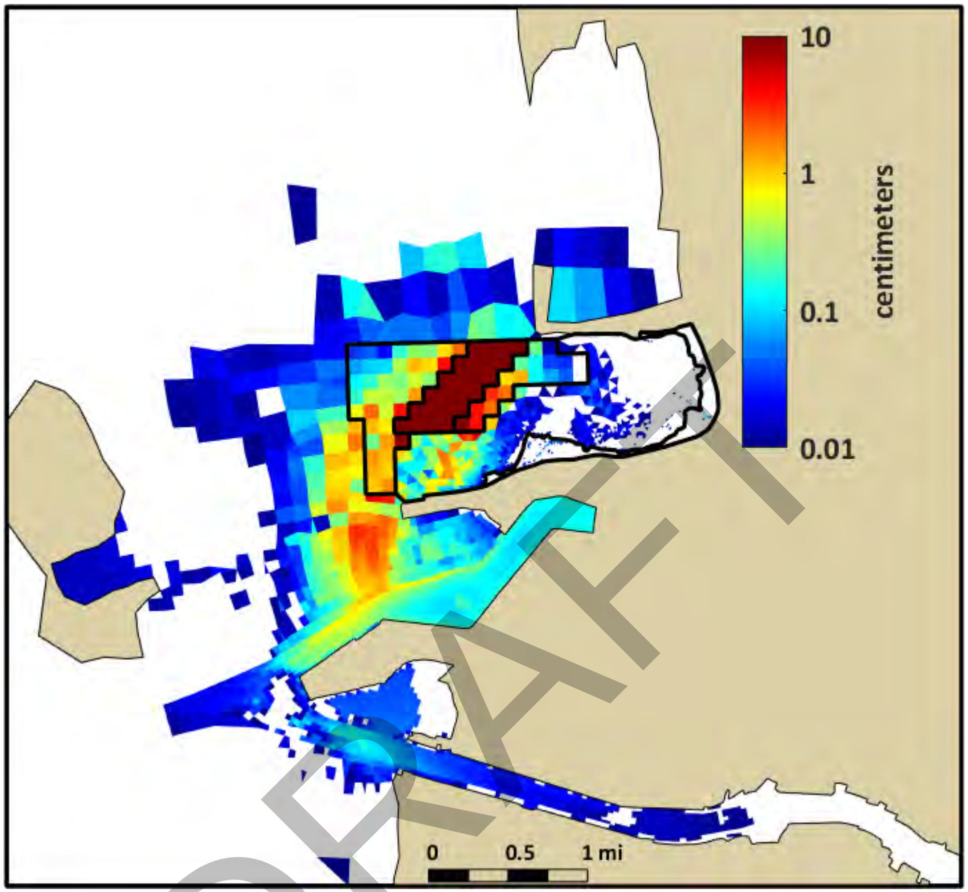
Table 5.1-3
Minimum (Top Number) and Maximum (Bottom Number) Predicted Dredged Material Deposition Thickness in Centimeters in Each Region at the End of the Three Emeryville Scenarios

Scenario Number	Scenario Name	Placement Footprint	Remaining Placement Grid	Transport Toward Marsh (Below MLLW)	Transport Toward Marsh (Above MLLW)	Emeryville Crescent Marsh	Mudflat/Marsh (Above MLLW)	Oakland Harbor	Dispersed
1	Emeryville Deep	13 26	<0.01 4	<0.01 1	<0.01 0.03	<0.01 0.05	<0.01 0.01	<0.01 2	<0.01 6
2	Emeryville Middle	12 30	<0.01 10	<0.01 5	<0.01 0.3	<0.01 0.1	<0.01 0.01	<0.01 0.8	<0.01 4
3	Emeryville Shallow/East	40 56	<0.01 12	<0.01 9	<0.01 0.1	<0.01 0.2	<0.01 0.1	<0.01 0.1	<0.01 11

5.1.2 *Emeryville Middle*

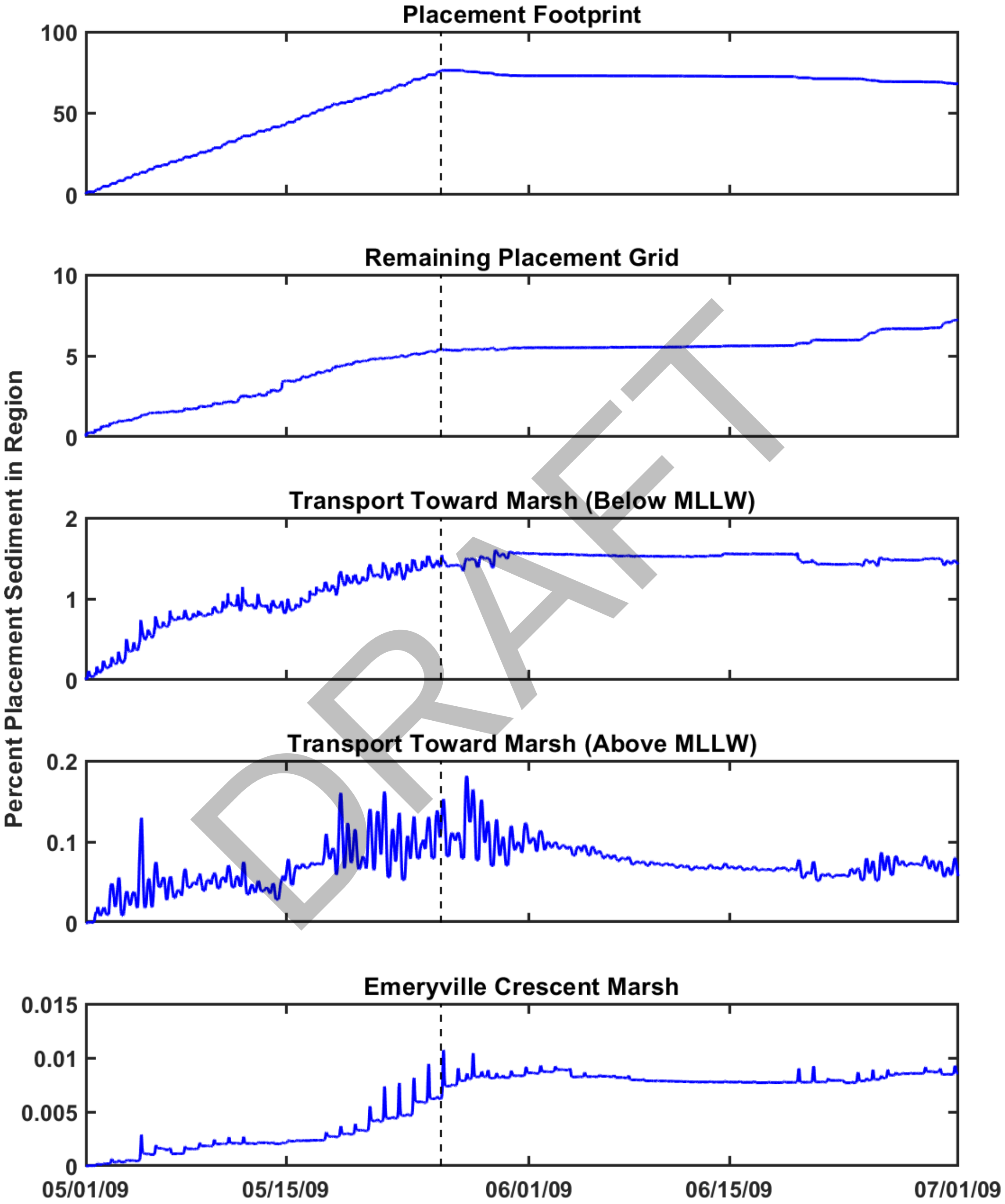
The Emeryville Middle scenario included the placement of 100,000 yd^3 of dredged material near the middle of the placement grid. The scenario assumed a total of 87 placements over a period of 25 days, as described in Section 3.3.1.2. At the end of the 2-month simulation, some of the dredged material was predicted to be dispersed away from the placement footprint (Figure 5.1-4), but 68% of the placed dredged material was predicted to remain inside the placement footprint (Figures 5.1-5 and 5.1-6; Tables 5.1-1 and 5.1-2). The model predicted that dredged material that was transported out of the initial placement footprint was predominately deposited toward the west and south of the placement footprint (Figure 5.1-4). Predicted thickness of the dredged material remaining in the placement footprint ranged from 12 to 30 cm, with up to 0.1 cm of dredged material deposition in Emeryville Crescent Marsh (Table 5.1-3). The percentage of the total amount of dredged material in the placement footprint increased until the placements were completed and then was predicted to slowly decrease as the dredged material was resuspended (Figure 5.1-5). Much of the dredged material deposited on Emeryville Crescent Marsh was predicted to be transported onto the marsh during the second half of May, when the tidal higher high water level was relatively high and the placements were still occurring. About 1% of the placed dredged material was predicted to be transported into Oakland Harbor, and 22% was predicted to be dispersed to areas deeper than MLLW at the end of the 2-month simulation.

Figure 5.1-4
Predicted Thickness of Dredged Material at the End of the 2-Month Simulation: Scenario 2 Emeryville Middle



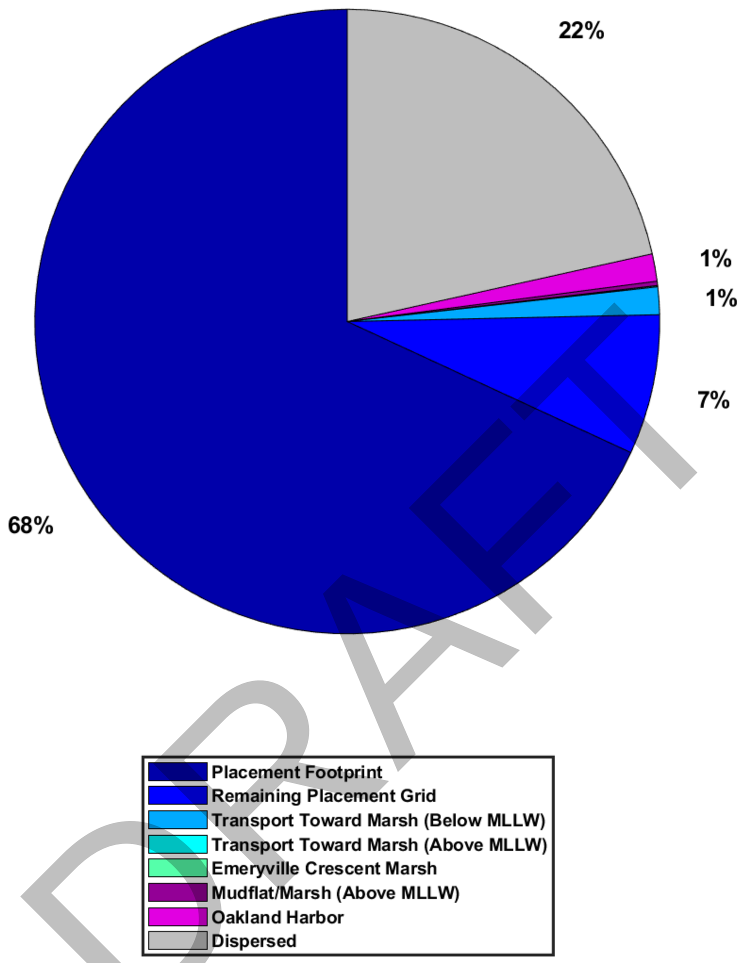
Note:
Note the log scale of the color range.

Figure 5.1-5
Predicted Percentage of Dredged Sediment Mass in Each Region During the 2-Month Simulation: Scenario 2 Emeryville Middle



Note:
Vertical dashed line denotes the end of the dredged material placements for this scenario.

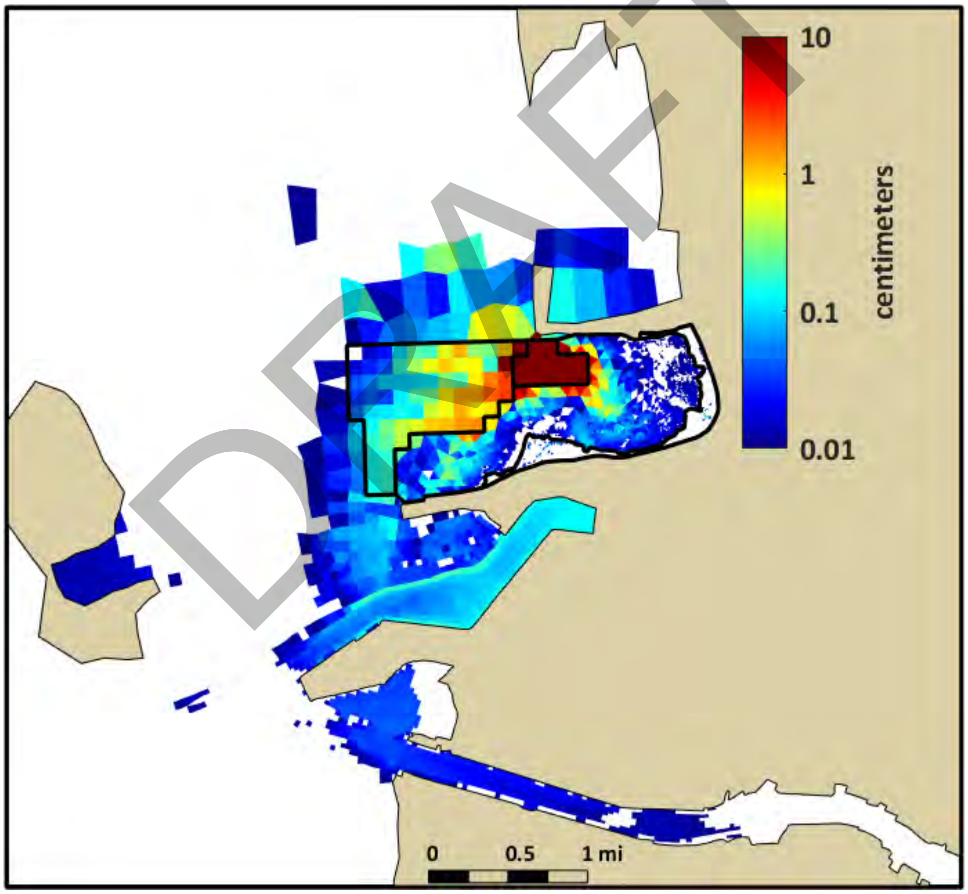
Figure 5.1-6
Predicted Percentage of Dredged Sediment Mass in Each Region at the End of the 2-Month Simulation: Scenario 2 Emeryville Middle



5.1.3 Emeryville Shallow/East

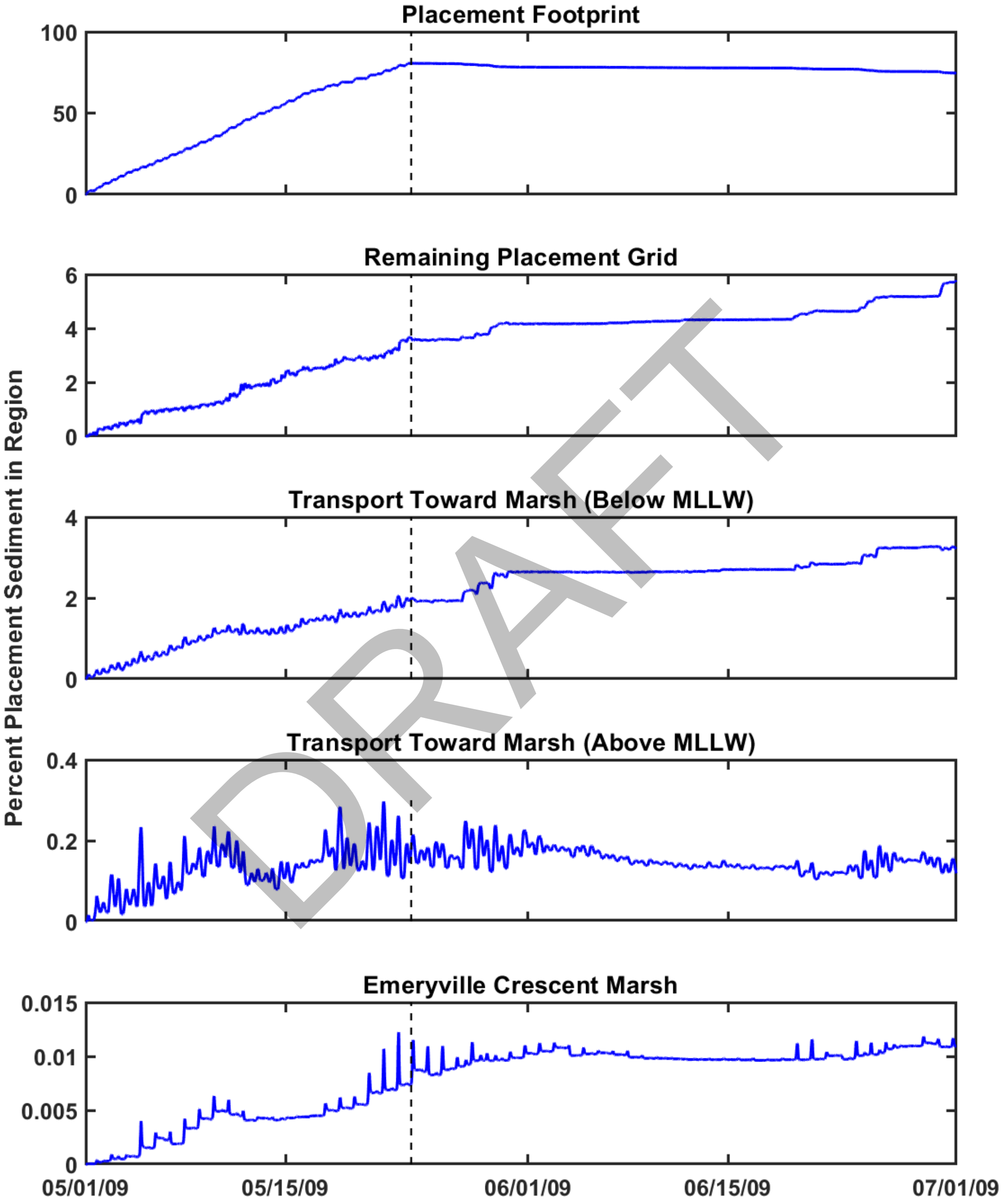
The Emeryville Shallow/East scenario included the placement of 100,000 yd^3 of dredged material on the eastern side of the placement grid. The scenario assumed a total of 112 placements over a period of 23 days, as described in Section 3.3.1.3. At the end of the 2-month simulation, some of the dredged material was predicted to be dispersed away from the placement footprint (Figure 5.1-7), but 75% of the placed dredged material was predicted to remain inside the placement footprint (Figures 5.1-8 and 5.1-9; Tables 5.1-1 and 5.1-2). The model predicted that dredged material that was transported out of the initial placement footprint was predominately deposited toward the west and south of the placement footprint, but with more deposition toward Emeryville Crescent Marsh than in the Emeryville Deep and Emeryville Middle scenarios (Figure 5.1-7). Predicted thickness of the dredged material remaining in the placement footprint ranged from 40 to 56 cm, with up to 0.2 cm of dredged material deposition in Emeryville Crescent Marsh (Table 5.1-3). The percentage of the total amount of dredged material in the placement footprint increased until the placements were completed and then was predicted to slowly decrease as the dredged material was resuspended (Figure 5.1-8). Much of the dredged material deposited on Emeryville Crescent Marsh was predicted to be transported onto the marsh during two periods in May, when the tidal higher high water level was relatively high and the placements were still occurring. About 0.7% of the placed dredged material was predicted to be transported into Oakland Harbor, and 15% was predicted to be dispersed to areas deeper than MLLW at the end of the 2-month simulation.

Figure 5.1-7
Predicted Thickness of Dredged Material at the End of the 2-Month Simulation: Scenario 3 Emeryville Shallow/East



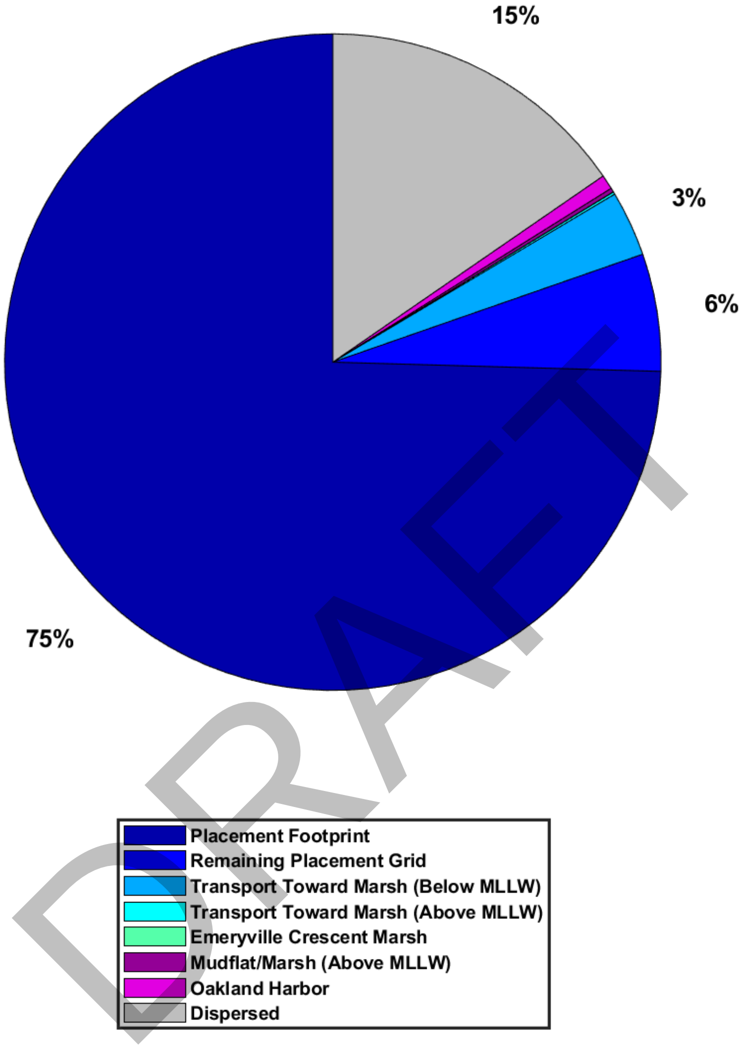
Note:
Note the log scale of the color range.

Figure 5.1-8
Predicted Percentage of Dredged Sediment Mass in Each Region During the 2-Month Simulation: Scenario 3 Emeryville Shallow/East



Note:
Vertical dashed line denotes the end of the dredged material placements for this scenario.

Figure 5.1-9
Predicted Percentage of Dredged Sediment Mass in Each Region at the End of the 2-Month Simulation: Scenario 3 Emeryville Shallow/East



5.1.4 Eden Landing Deep

The Eden Landing Deep scenario included the placement of 100,000 yd^3 of dredged material along the eastern side of the placement grid. The scenario assumed a total of 72 placements over a period of 25 days, as described in Section 3.3.1.4. At the end of the 2-month simulation, much of the dredged material was predicted to be dispersed away from the placement footprint (Figure 5.1-10), but 23% of the placed dredged material was predicted to remain inside the placement footprint (Figures 5.1-11 and 5.1-12; Tables 5.1-4 and 5.1-5). The model predicted that dredged material that was transported out of the initial placement footprint was deposited around the placement footprint, with a skewing of the deposition toward the southeast of the placement footprint (Figure 5.1-12).

Predicted thickness of the dredged material remaining in the placement footprint ranged from 5 to 19 cm, with up to 0.4 cm of dredged material deposition in Eden Landing Marsh (Table 5.1-6). The percentage of the total amount of dredged material in the placement footprint increased until the placements were completed and then was predicted to decrease as the dredged material was resuspended (Figure 5.1-11).

At the end of the 2-month simulation period, less than 0.1% of the placed dredged material was predicted to be deposited in Eden Landing Marsh (Figure 3.4-2), and 0.5% was predicted to be deposited in other regions of the Eden Landing complex (Table 5.1-4). Much of the dredged material deposited on Eden Landing Marsh was predicted to be transported onto the marsh during the second half of May and June, during spring tide when the tidal higher high water levels were relatively high. Although only a small portion of the placed dredged material was predicted to reach Eden Landing Marsh within the 2-month simulation period, some of the placed sediment was predicted to be transported toward the marsh. The model predicted that 2% of the placed dredged material was transported towards Eden Landing but was still below MLLW, while an additional 2% of the placed dredged material was predicted to be transported towards the marsh and was already deposited at elevations above MLLW. An additional 1% was predicted to be transported to other areas above MLLW on the eastern side of the South Bay.

About 0.2% of the dredged material was predicted to be transported into Redwood City Harbor, and 0.1% was transported into the Alameda FCC. About 21% of the placed dredged material was predicted to be dispersed within the South Bay below MLLW, 2% dispersed north of Dumbarton Bridge, and 4% dispersed north of the Bay Bridge.

Table 5.1-4
Percentage of Placement Sediment Mass in Each Region at the End of the Simulation for the Scenarios Focused on Eden Landing

	Scenario	Placement Footprint	Remaining Placement Grid	North of Placement Footprint	Toward Marsh (Below MLLW)	Toward Marsh (Above MLLW)	Eden Landing Marsh	Remaining Eden Landing	Old Alameda Creek	South Bay Mudflat/Marsh (East)	South Bay Mudflat/Marsh (West)	Alameda FCC	Redwood City Harbor	Dispersed South Bay	Dispersed South of Dumbarton	Dispersed North of Bay Bridge
4	Eden Landing Deep 100k yd^3	23	39	3	3	2	<0.1	0.5	<0.1	1	1	0.1	0.2	21	2	4
5	Eden Landing Middle 100k yd^3	41	27	2	5	3	<0.1	0.5	0.1	1	0.7	0.1	0.2	16	2	3
6	Eden Landing Shallow/East 100k yd^3	20	22	1	22	6	0.1	1	0.2	2	0.8	0.3	0.2	18	2	4
7	Eden Landing Shallow/East 50k yd^3	18	22	1	23	6	0.1	1	0.2	2	0.9	0.3	0.2	18	2	5
8	Eden Landing Shallow/East 75k yd^3	17	23	1	22	7	0.1	1	0.2	2	0.9	0.3	0.2	18	2	4
9	Eden Landing Shallow/East Winter 100k yd^3	32	22	3	15	2	<0.1	0.3	<0.1	1	0.5	<0.1	<0.1	14	1	9
10	Eden Landing Oakland Sediment 100k yd^3	27	22	1	23	5	0.1	0.8	0.2	1	0.6	0.2	0.1	15	2	3
11	Eden Landing: Expanded East 100k yd^3	34	16	2	18	5	0.1	0.9	0.2	2	0.8	0.3	0.2	17	2	4
12	Eden Landing: Expanded East 125k yd^3	33	14	2	18	6	0.1	0.9	0.2	2	0.8	0.3	0.2	17	2	4

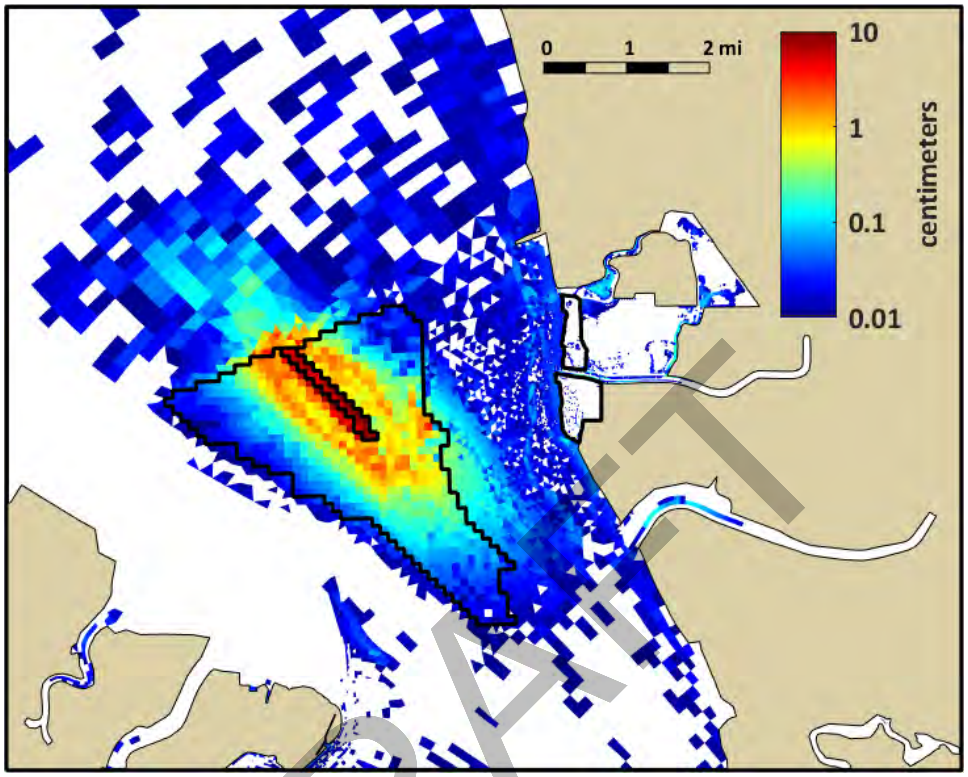
Table 5.1-5
Volume of Placement Sediment in Cubic Yards in Each Region at the End of the Simulation for the Scenarios Focused on Eden Landing

	Scenario	Placement Footprint	Remaining Placement Grid	North of Placement Footprint	Toward Marsh (Below MLLW)	Toward Marsh (Above MLLW)	Eden Landing Marsh	Remaining Eden Landing	Old Alameda Creek	South Bay Mudflat/Marsh (East)	South Bay Mudflat/Marsh (West)	Alameda FCC	Redwood City Harbor	Dispersed South Bay	Dispersed South of Dumbarton	Dispersed North of Bay Bridge
4	Eden Landing Deep 100k yd^3	23,000	39,000	3,000	3,000	2,000	<100	500	<100	1,000	1,000	100	200	21,000	2,000	4,000
5	Eden Landing Middle 100k yd^3	41,000	27,000	2,000	5,000	3,000	<100	500	100	1,000	700	100	200	16,000	2,000	3,000
6	Eden Landing Shallow/East 100k yd^3	20,000	22,000	1,000	22,000	6,000	100	1,000	200	2,000	800	300	200	18,000	2,000	4,000
7	Eden Landing Shallow/East 50k yd^3	9,000	11,000	500	11,500	3,000	50	500	100	1,000	450	150	100	9,000	1,000	2,500
8	Eden Landing Shallow/East 75k yd^3	12,750	17,250	750	16,500	5,250	75	750	150	1,500	675	225	150	13,500	1,500	3,000
9	Eden Landing Shallow/East Winter 100k yd^3	32,000	22,000	3,000	15,000	2,000	<100	300	<100	1,000	500	<100	<100	14,000	1,000	9,000
10	Eden Landing Oakland Sediment 100k yd^3	27,000	22,000	1,000	23,000	5,000	100	800	200	1,000	600	200	100	15,000	2,000	3,000
11	Eden Landing: Expanded East 100k yd^3	34,000	16,000	2,000	18,000	5,000	100	900	200	2,000	800	300	200	17,000	2,000	4,000
12	Eden Landing: Expanded East 125k yd^3	41,250	17,500	2,500	22,500	7,500	125	1,125	250	2,500	1,000	375	250	21,250	2,500	5,000

Table 5.1-6
Minimum (Top Number) and Maximum (Bottom Number) Predicted Dredged Material Deposition Thickness in Centimeters in Each Region at the End of the Simulation for the Scenarios Focused on Eden Landing

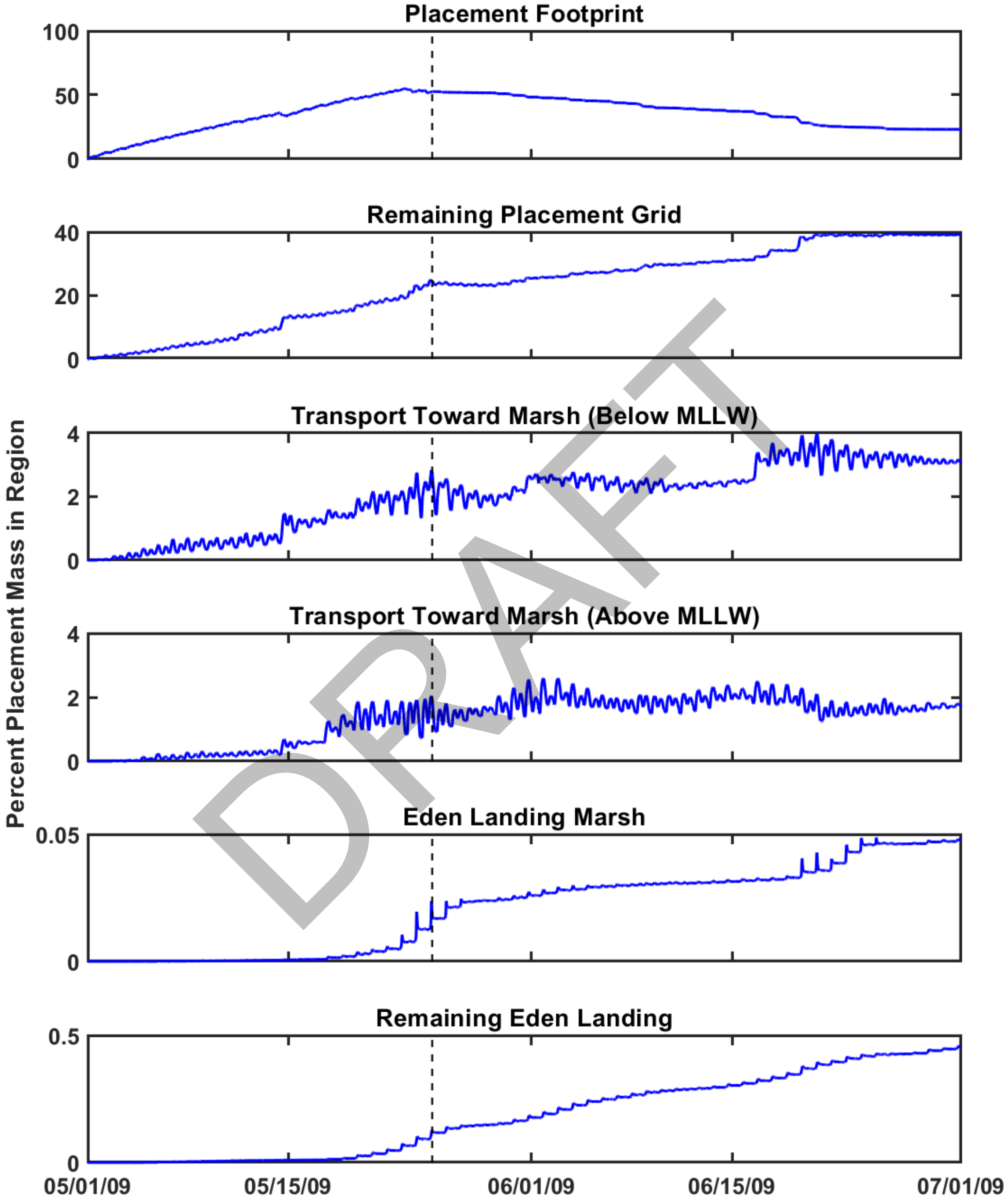
	Scenario	Placement Footprint	Remaining Placement Grid	North of Placement Footprint	Toward Marsh (Below MLLW)	Toward Marsh (Above MLLW)	Eden Landing Marsh	Remaining Eden Landing	Old Alameda Creek	South Bay Mudflat/ Marsh (East)	South Bay Mudflat/ Marsh (West)	Alameda FCC	Redwood City Harbor	Dispersed South Bay	Dispersed South of Dumbarton	Dispersed North of Bay Bridge
4	Eden Landing Deep 100k yd^3	5 19	<0.01 8	<0.01 5	<0.01 0.4	<0.01 0.1	<0.01 0.4	<0.01 0.3	<0.01 0.3	<0.01 0.1	<0.01 0.07	<0.01 0.2	<0.01 0.07	<0.01 2	<0.01 0.1	<0.01 <0.01
5	Eden Landing Middle 100k yd^3	5 21	<0.01 4	<0.01 1	<0.01 0.9	<0.01 0.3	<0.01 0.5	<0.01 0.4	<0.01 0.3	<0.01 0.2	<0.01 0.05	<0.01 0.2	<0.01 0.05	<0.01 0.1	<0.01 0.08	<0.01 <0.01
6	Eden Landing Shallow/East 100k yd^3	0.8 17	<0.01 8	<0.01 0.8	<0.01 7	<0.01 2	<0.01 1	<0.01 0.7	<0.01 0.7	<0.01 0.3	<0.01 0.05	<0.01 0.3	<0.01 0.05	<0.01 0.09	<0.01 0.09	<0.01 <0.01
7	Eden Landing Shallow/East 50k yd^3	0.3 12	<0.01 3	<0.01 0.5	<0.01 6	<0.01 0.7	<0.01 0.6	<0.01 0.4	<0.01 0.3	<0.01 0.1	<0.01 0.03	<0.01 0.2	<0.01 0.03	<0.01 0.05	<0.01 0.06	<0.01 <0.01
8	Eden Landing Shallow/East 75k yd^3	0.6 12	<0.01 5	<0.01 0.6	<0.01 7	<0.01 2	<0.01 0.9	<0.01 0.6	<0.01 0.5	<0.01 0.2	<0.01 0.04	<0.01 0.3	<0.01 0.04	<0.01 0.06	<0.01 0.08	<0.01 <0.01
9	Eden Landing Shallow/East Winter 100k yd^3	5 20	<0.01 7	<0.01 2	<0.01 9	<0.01 0.2	<0.01 0.08	<0.01 0.2	<0.01 0.1	<0.01 0.06	<0.01 0.03	<0.01 <0.01	<0.01 0.03	<0.01 0.08	<0.01 0.03	<0.01 <0.01
10	Eden Landing Oakland Sediment 100k yd^3	1 17	<0.01 8	<0.01 1	<0.01 7	<0.01 1	<0.01 0.9	<0.01 0.6	<0.01 0.6	<0.01 0.3	<0.01 0.04	<0.01 0.2	<0.01 0.04	<0.01 0.07	<0.01 0.07	<0.01 <0.01
11	Eden Landing: Expanded East 100k yd^3	0.2 15	<0.01 4	<0.01 0.8	<0.01 7	<0.01 1	<0.01 0.9	<0.01 0.6	<0.01 0.6	<0.01 0.3	<0.01 0.05	<0.01 0.3	<0.01 0.05	<0.01 0.08	<0.01 0.09	<0.01 <0.01
12	Eden Landing: Expanded East 125k yd^3	0.5 19	<0.01 5	<0.01 1	<0.01 7	<0.01 2	<0.01 1	<0.01 0.8	<0.01 0.7	<0.01 0.3	<0.01 0.06	<0.01 0.4	<0.01 0.06	<0.01 0.1	<0.01 0.1	<0.01 <0.01

Figure 5.1-10
Predicted Thickness of Dredged Material at the End of the 2-Month Simulation: Scenario 4 Eden Landing Deep



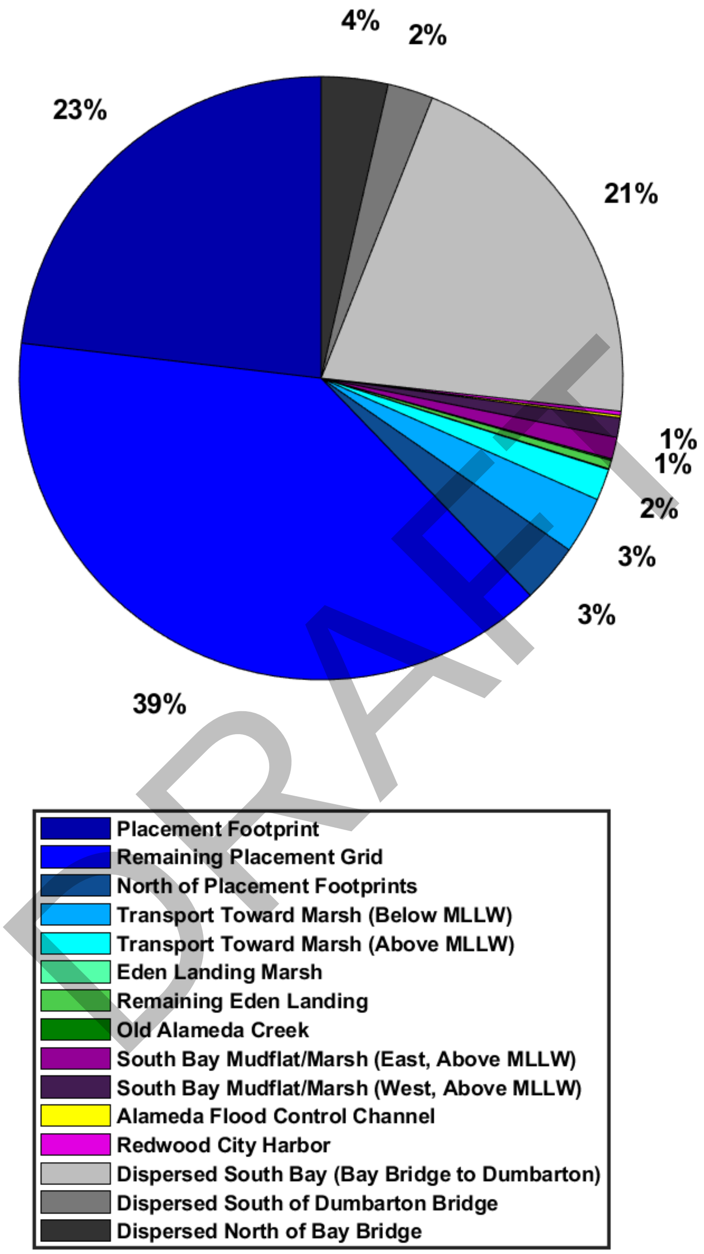
Note:
Note the log scale of the color range.

Figure 5.1-11
Predicted Percentage of Dredged Sediment Mass in Each Region During the 2-Month Simulation: Scenario 4 Eden Landing Deep



Note:
Vertical dashed line denotes the end of the dredged material placements for this scenario.

Figure 5.1-12
Predicted Percentage of Dredged Sediment Mass in Each Region at the End of the 2-Month Simulation: Scenario 4 Eden Landing Deep



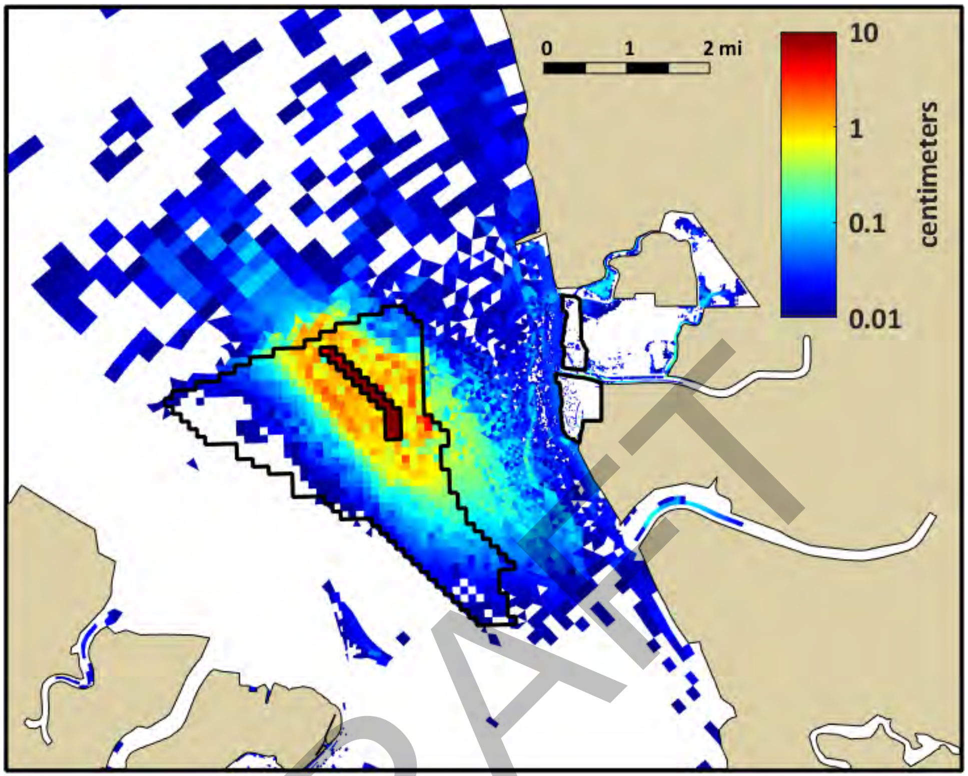
5.1.5 Eden Landing Middle

The Eden Landing Middle scenario included the placement of 100,000 yd^3 of dredged material along the eastern side of the placement grid. The scenario assumed a total of 87 placements over a period of 23 days, as described in Section 3.3.1.5. At the end of the 2-month simulation, more than half of the dredged material was predicted to be dispersed away from the placement footprint (Figure 5.1-13), but 41% of the placed dredged material was predicted to remain inside the placement footprint (Figures 5.1-14 and 5.1-15; Tables 5.1-4 and 5.1-5). The model predicted that dredged material that was transported out of the initial placement footprint was deposited around the placement footprint, with a skewing of the deposition toward the southeast of the placement footprint (Figure 5.1-13). Predicted thickness of the dredged material remaining in the placement footprint ranged from 5 to 21 cm, with up to 0.5 cm of dredged material deposition in Eden Landing Marsh (Table 5.1-6). The percentage of the total amount of dredged material in the placement footprint increased until the placements were completed and then was predicted to decrease as the dredged material was resuspended (Figure 5.1-14).

At the end of the 2-month simulation period, less than 0.1% of the placed dredged material was predicted to be deposited in Eden Landing Marsh (Figure 3.4-2), and 0.5% was predicted to be deposited in other regions of the Eden Landing complex (Table 5.1-4). Much of the dredged material deposited on Eden Landing Marsh was predicted to be transported onto the marsh during the second half of May and June, during spring tide when the tidal higher high water levels were relatively high. Although only a small portion of the placed dredged material was predicted to reach Eden Landing Marsh within the 2-month simulation period, some of the placed sediment was predicted to be transported toward the marsh. The model predicted that 5% of the placed dredged material was transported towards Eden Landing Marsh but was still below MLLW, while an additional 3% of the placed dredged material was predicted to be transported towards the marsh and was already deposited at elevations above MLLW. An additional 1% was predicted to be transported to other areas above MLLW on the eastern side of the South Bay.

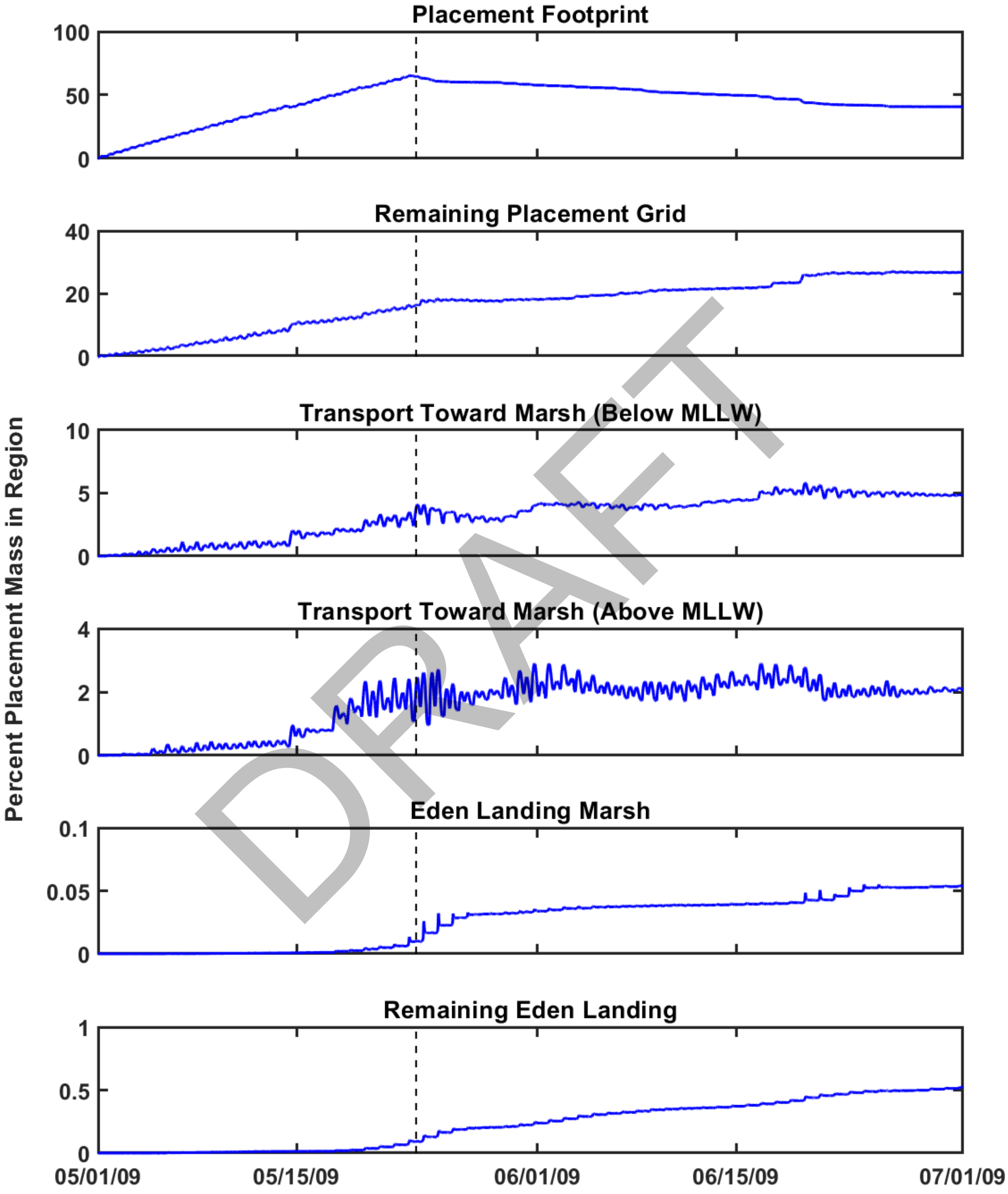
About 0.2% of the dredged material was predicted to be transported into Redwood City Harbor, and 0.1% was transported into the Alameda FCC. About 16% of the placed dredged material was predicted to be dispersed within the South Bay below MLLW, 2% dispersed north of Dumbarton Bridge, and 3% dispersed north of the Bay Bridge.

Figure 5.1-13
Predicted Thickness of Dredged Material at the End of the 2-Month Simulation: Scenario 5 Eden Landing Middle



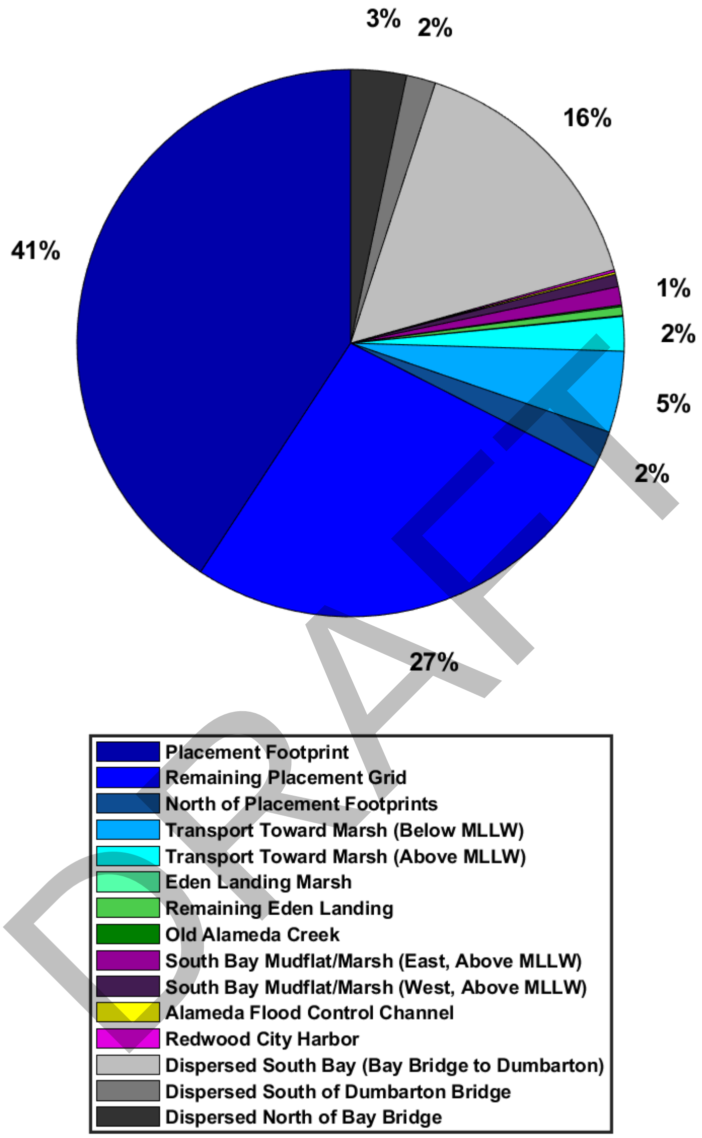
Note:
Note the log scale of the color range.

Figure 5.1-14
Predicted Percentage of Dredged Sediment Mass in Each Region During the 2-Month Simulation: Scenario 5 Eden Landing Middle



Note:
Vertical dashed line denotes the end of the dredged material placements for this scenario.

Figure 5.1-15
Predicted Percentage of Dredged Sediment Mass in Each Region at the End of the 2-Month Simulation: Scenario 5 Eden Landing Middle



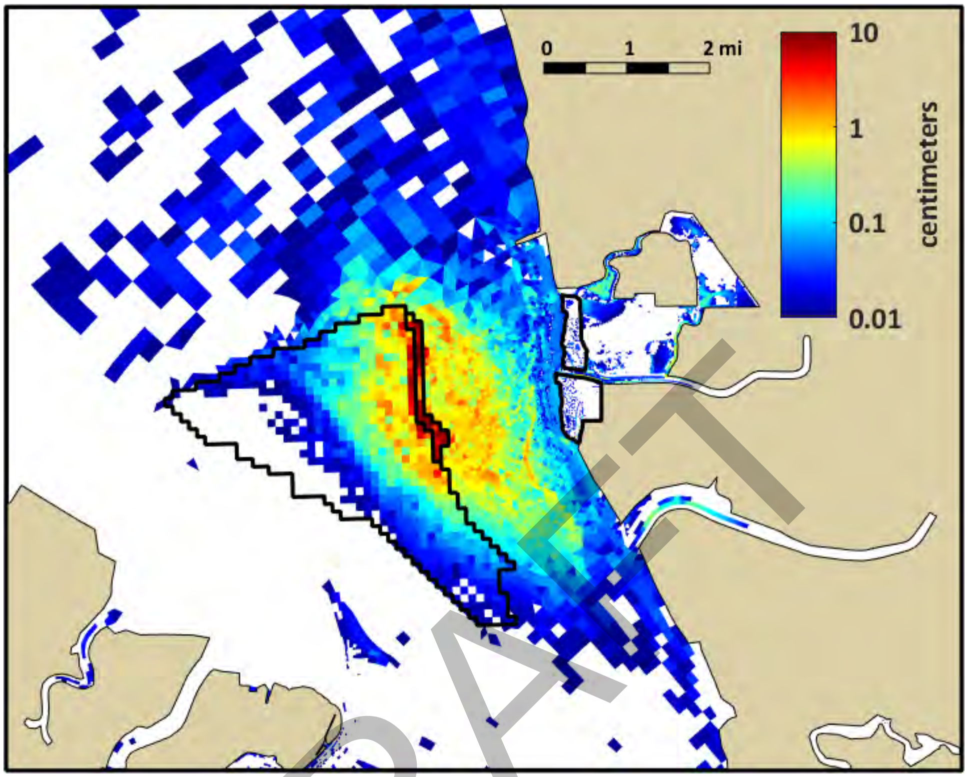
5.1.6 Eden Landing Shallow/East

The Eden Landing Shallow/East scenario included the placement of 100,000 yd^3 of dredged material along the eastern side of the placement grid. The scenario assumed a total of 112 placements over a period of 25 days, as described in Section 3.3.1.6. At the end of the 2-month simulation period, much of the dredged material was predicted to be dispersed away from the placement footprint (Figure 5.1-16), but 20% of the placed dredged material was predicted to remain inside the placement footprint (Figures 5.1-17 and 5.1-18; Tables 5.1-4 and 5.1-5). The model predicted that dredged material that was transported out of the initial placement footprint was deposited around the placement footprint, with a skewing of the deposition toward the east and south of the placement footprint (Figure 5.1-16). Predicted thickness of the dredged material remaining in the placement footprint ranged from 0.8 to 17 cm, with up to 1 cm of dredged material deposition in Eden Landing Marsh (Table 5.1-6). The percentage of the total amount of dredged material in the placement footprint increased until the placements were completed and then was predicted to decrease as the dredged material was resuspended (Figure 5.1-17).

At the end of the 2-month simulation period, 0.1% of the placed dredged material was predicted to be deposited in Eden Landing Marsh (Figure 3.4-2), and 1% was predicted to be deposited in other regions of the Eden Landing complex (Table 5.1-4). Much of the dredged material deposited on Eden Landing Marsh was predicted to be transported onto the marsh during the second half of May and June, during spring tide when the tidal higher high water levels were relatively high. Although only a small portion of the placed dredged material was predicted to reach Eden Landing Marsh within the 2-month simulation period, a relatively large amount of the placed sediment was predicted to be transported toward the marsh. The model predicted that 22% of the placed dredged material was transported towards Eden Landing Marsh but was still below MLLW, while an additional 6% of the placed dredged material was predicted to be transported towards the marsh and was already deposited at elevations above MLLW. An additional 2% was predicted to be transported to other areas above MLLW on the eastern side of the South Bay.

About 0.2% of the dredged material was predicted to be transported into Redwood City Harbor, and 0.3% was transported into the Alameda FCC. About 18% of the placed dredged material was predicted to be dispersed within the South Bay below MLLW, 2% dispersed north of Dumbarton Bridge, and 4% dispersed north of the Bay Bridge.

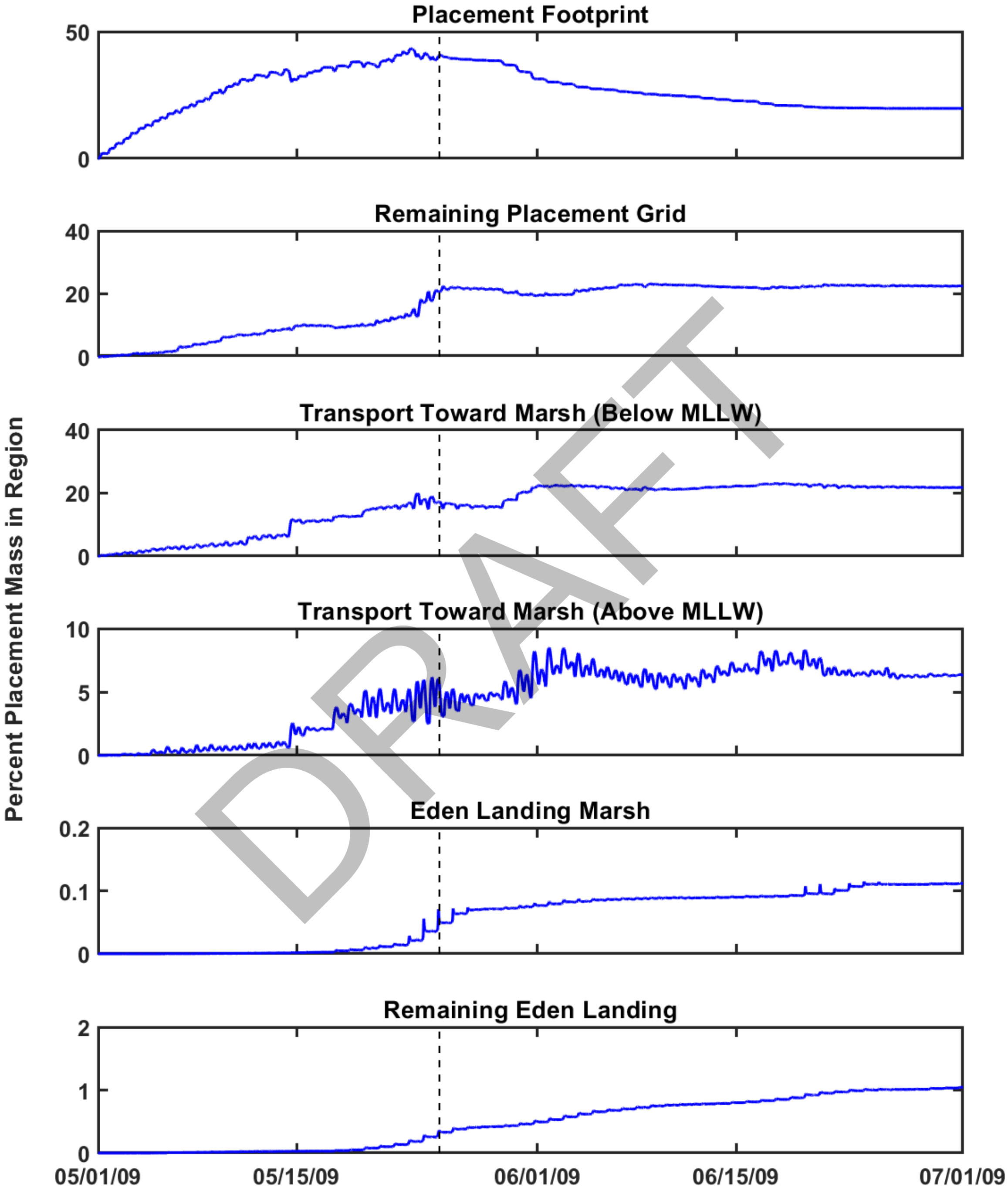
Figure 5.1-16
Predicted Thickness of Dredged Material at the End of the 2-Month Simulation: Scenario 6 Eden Landing Shallow/East



Note:
Note the log scale of the color range.

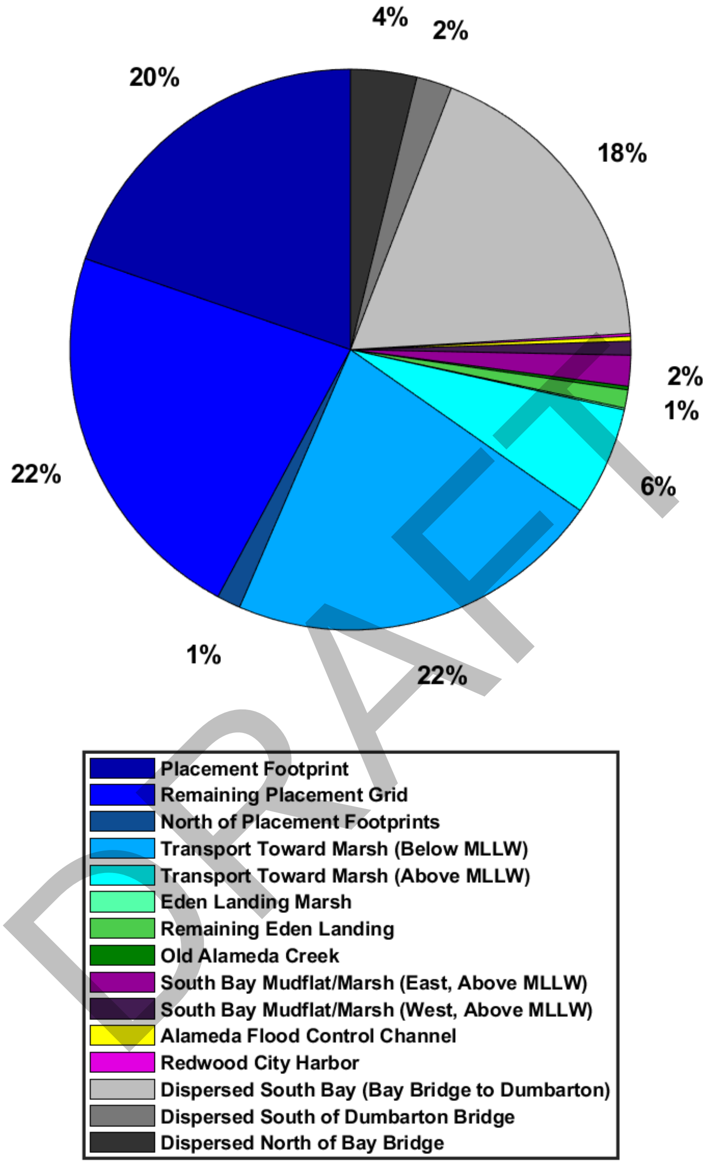
Figure 5.1-17

Predicted Percentage of Dredged Sediment Mass in Each Region During the 2-Month Simulation: Scenario 6 Eden Landing Shallow/East



Note:
Vertical dashed line denotes the end of the dredged material placements for this scenario.

Figure 5.1-18
Predicted Percentage of Dredged Sediment Mass in Each Region at the End of the 2-Month Simulation: Scenario 6 Eden Landing Shallow/East



5.2 Comparison of Emeryville and Eden Landing

The depositional pattern of the placed dredged material at the end of the 2-month simulation periods was similar for the Emeryville Deep, Middle, and Shallow/East scenarios (Figure 5.2-1). Deposition was highest in and around the placement footprint and skewed toward the west and south. The Deep and Middle scenarios resulted in little deposition of dredged material east of the placement footprints toward Emeryville Crescent Marsh. The Shallow/East scenario resulted in the most predicted deposition toward Emeryville Crescent Marsh. Residual currents directed south from the deep placement footprint may have resulted in some southward sediment transport away from the target marsh and toward Oakland Harbor from the deep placement footprint (Figure 4.2-2). Residual currents directed north from the shallow/east placement footprint may have resulted in some northward sediment transport away from the target marsh from the shallow/east placement footprint. Generally southward residual currents over the middle placement location may have resulted in some sediment transport directed toward Oakland Harbor or toward the far western side of Emeryville Crescent Marsh from the middle placement footprint.

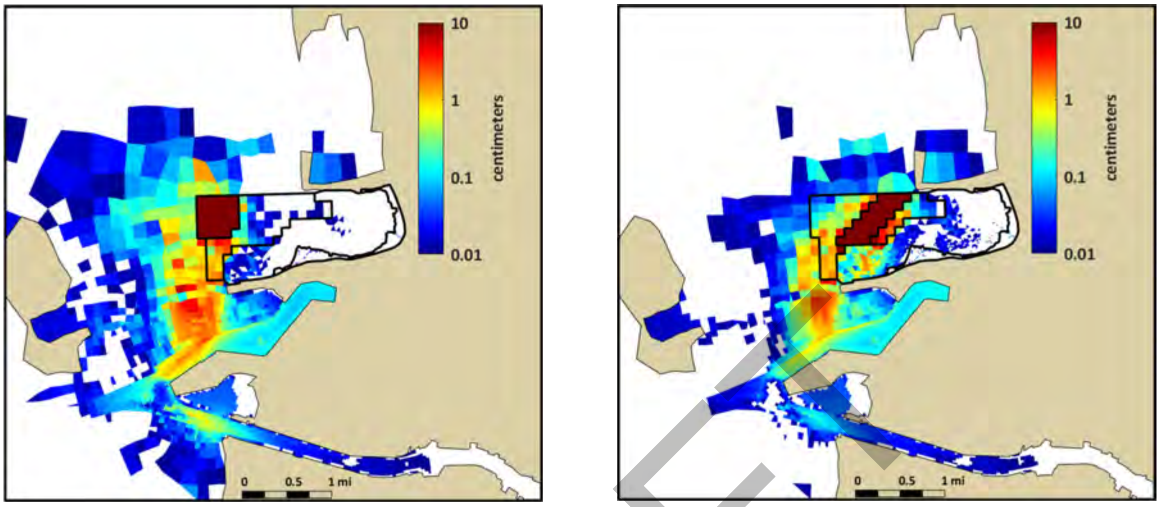
The depositional pattern of the placed dredged material at the end of the 2-month simulation periods was also similar for the Eden Landing Deep, Middle, and Shallow/East scenarios (Figure 5.2-2). Deposition was highest in and around the placement footprint and skewed toward the southeast. The Deep and Middle scenarios resulted in little deposition of dredged material east of the placement footprints toward Eden Landing Marsh. The Shallow/East scenario had much more predicted eastward deposition toward Eden Landing Marsh than the Deep and Middle scenarios. Northward directed currents over the Eden Landing placement footprints and between the placement grid and Eden Landing Marsh may have resulted in some northward sediment transport from each of the placement footprints (Figure 4.2-6).

At both the Emeryville and Eden Landing placement locations, the highest percentage of the dredged material was transported toward, and supplied to, the respective marshes in the Shallow/East scenarios (Figures 5.2-3 through 5.2-7; Tables 5.1-1 and 5.1-4). The Deep scenarios resulted in the most dredged material being transported back into the federal navigation channels. This was most obvious in the Emeryville Deep scenario, where 3% of the dredged material was predicted to be transported back into Oakland Harbor in the 2-month simulation period (Figure 5.2-7). The Deep scenarios also resulted in the largest percentage of dredged material being dispersed away from any of the other analysis regions (Tables 5.1-1 and 5.1-4).

A lower percentage of the dredged material was predicted to remain in the placement footprints in the Eden Landing scenarios than the scenarios with dredged material placements at Emeryville (Figures 5.2-7 and 5.2-8). This indicates more predicted dispersal from the Eden Landing placement footprints than the Emeryville footprints. For the Emeryville Shallow/East scenario, 75% of the dredged material was predicted to remain in the placement footprint at the end of the simulation, compared to 20% remaining in the placement footprint for the Eden Landing Shallow/East scenario. The Eden Landing scenarios also had more predicted deposition in the target marsh and on other mudflats and marshes—that is, above MLLW outside Eden Landing Marsh or Emeryville Crescent Marsh (Tables 5.1-1 and 5.1-4). The Emeryville scenarios had relatively little predicted deposition on other mudflats and marshes. For the Emeryville Shallow/East scenario, less than 0.1% of the dredged material was predicted to deposit in Emeryville Crescent Marsh and 0.1% was predicted to deposit above MLLW bayward of the marsh at the end of the simulation. For the Eden Landing Shallow/East scenario, 0.1% of the dredged material was predicted to deposit in the Whale's Tail portion of Eden Landing Marsh and 6% was predicted to deposit above MLLW bayward of the marsh at the end of the simulation. The Eden Landing placement location was also predicted to supply dredged material to the other portion of the Eden Landing complex, not simply the Whale's Tail portion of Eden Landing. For the Eden Landing Shallow/East scenario, 1% of the dredged material was predicted to deposit in the remaining portion of Eden Landing.

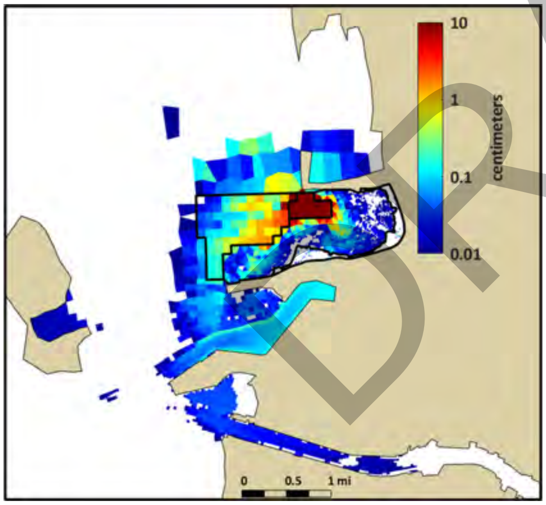
These findings suggest the Eden Landing placement location may be more suitable than the Emeryville placement location for the natural transport of dredged material away from the initial placement footprint and toward the marsh and to other mudflats/marshes. The findings also demonstrate that placements toward the shallower (eastern) side of the placement grids are more effective at getting transport toward the marshes and mudflats than placements in deeper water further toward the west of the placement grids. Because of these findings, the six additional scenarios described in Sections 5.3 and 5.4 focus on how modifications to the Eden Landing Shallow/East scenario would affect the predicted dispersal of dredged material.

Figure 5.2-1
Predicted Thickness of Dredged Material at the End of the 2-Month Simulations for the Initial Three Emeryville Scenarios



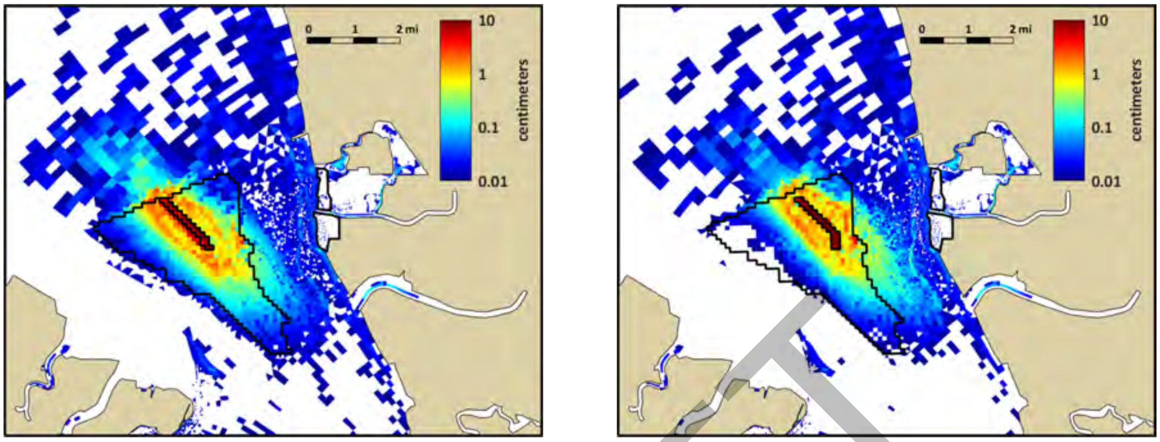
Emeryville Deep

Emeryville Middle



Emeryville Shallow/East

Figure 5.2-2
Predicted Thickness of Dredged Material at the End of the 2-Month Simulations for the Initial Three Eden Landing Scenarios


Eden Landing Deep

Eden Landing Middle

Eden Landing Shallow/East

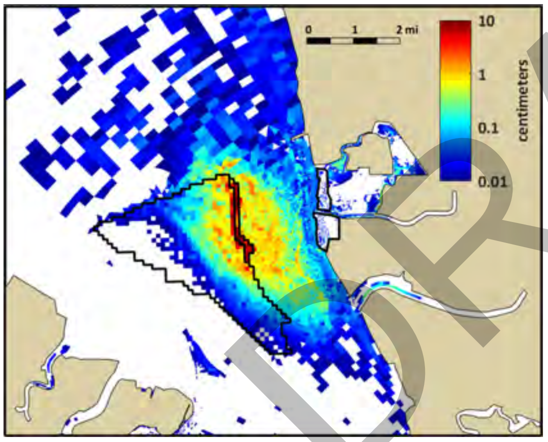
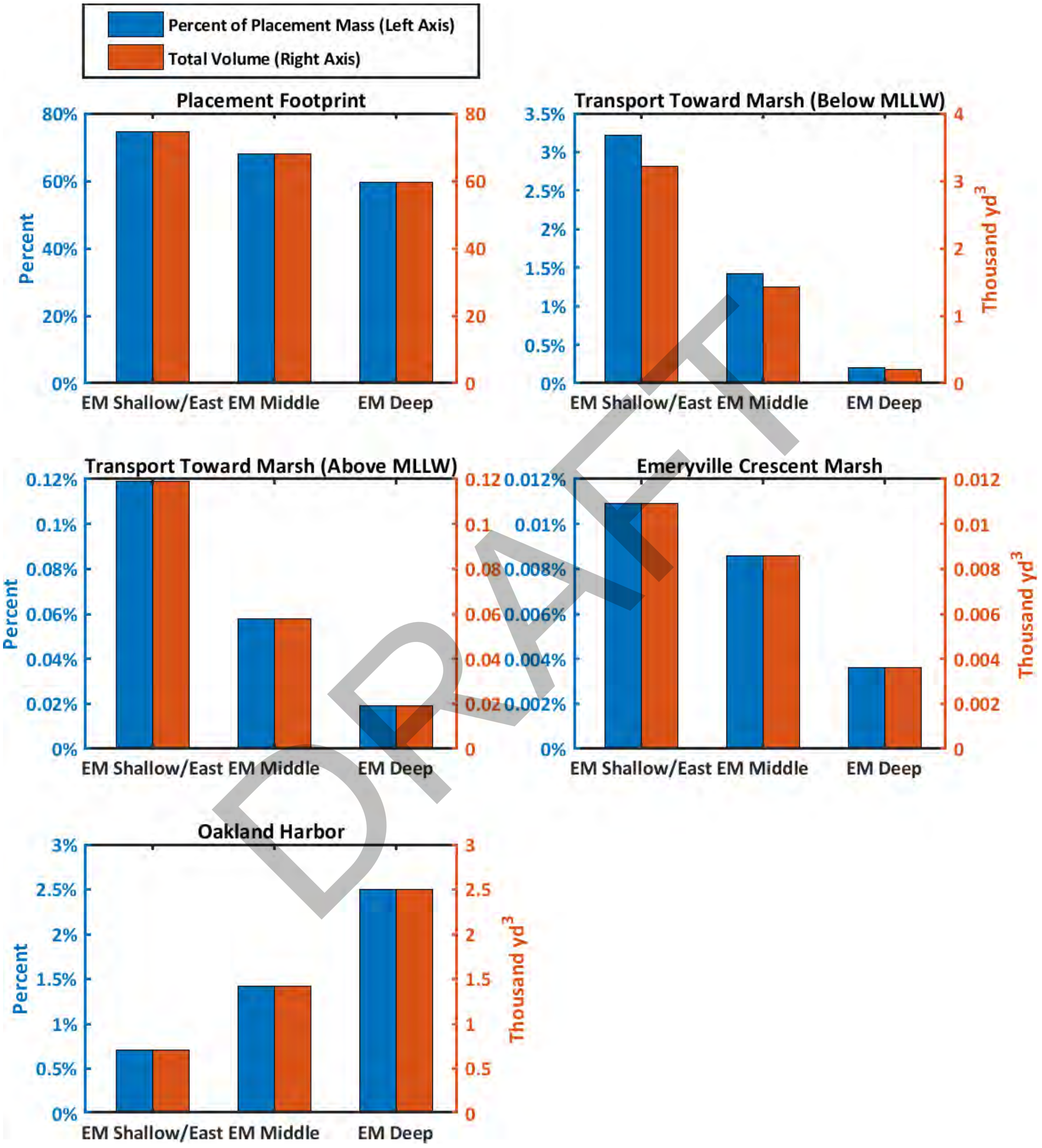


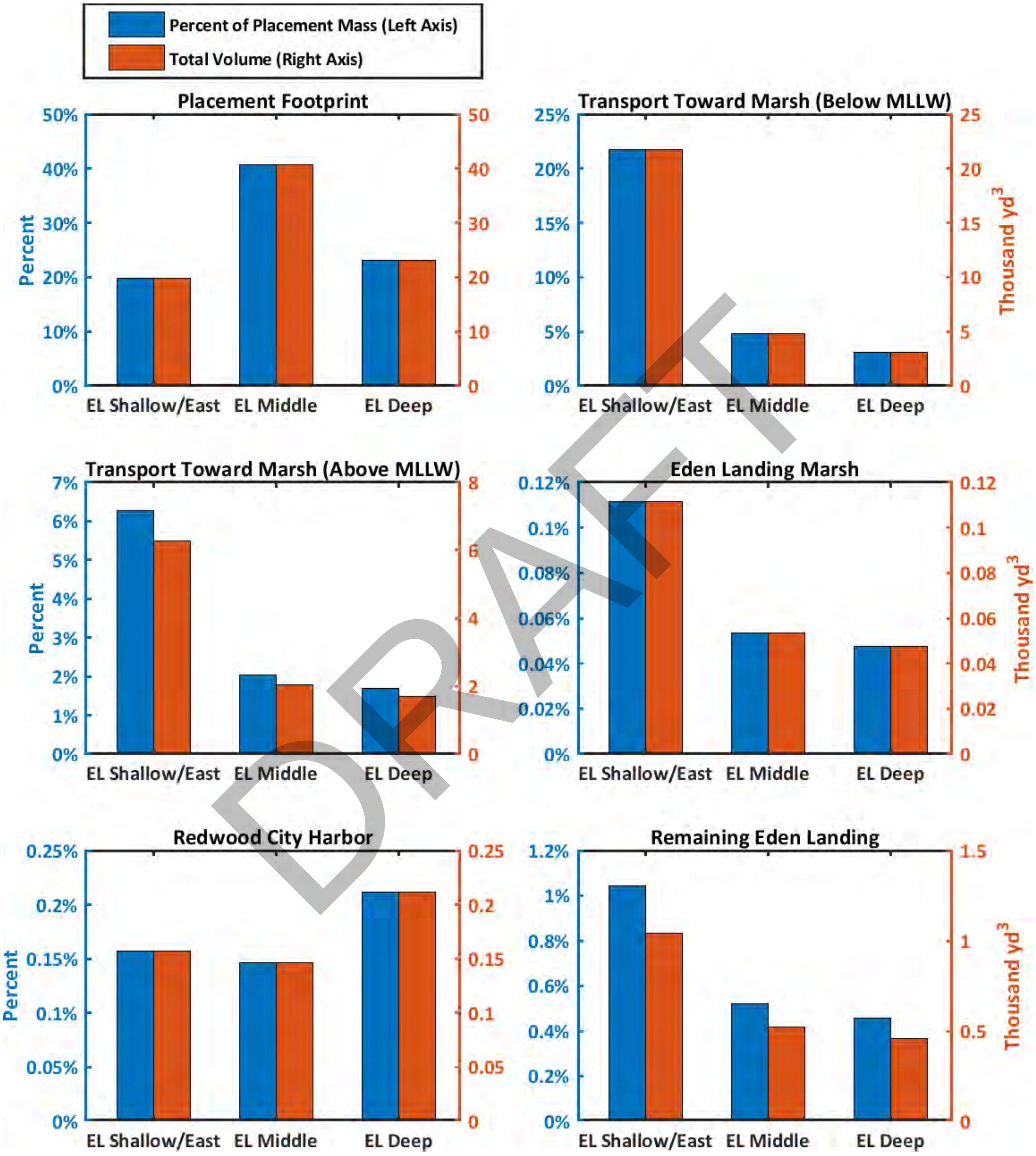
Figure 5.2-3
Predicted Percentage of Dredged Sediment Mass and Dredged Material Volume in Each Region at the End of the 2-Month Simulations for the Initial Three Emeryville Scenarios



Note:
EM: Emeryville

Figure 5.2-4

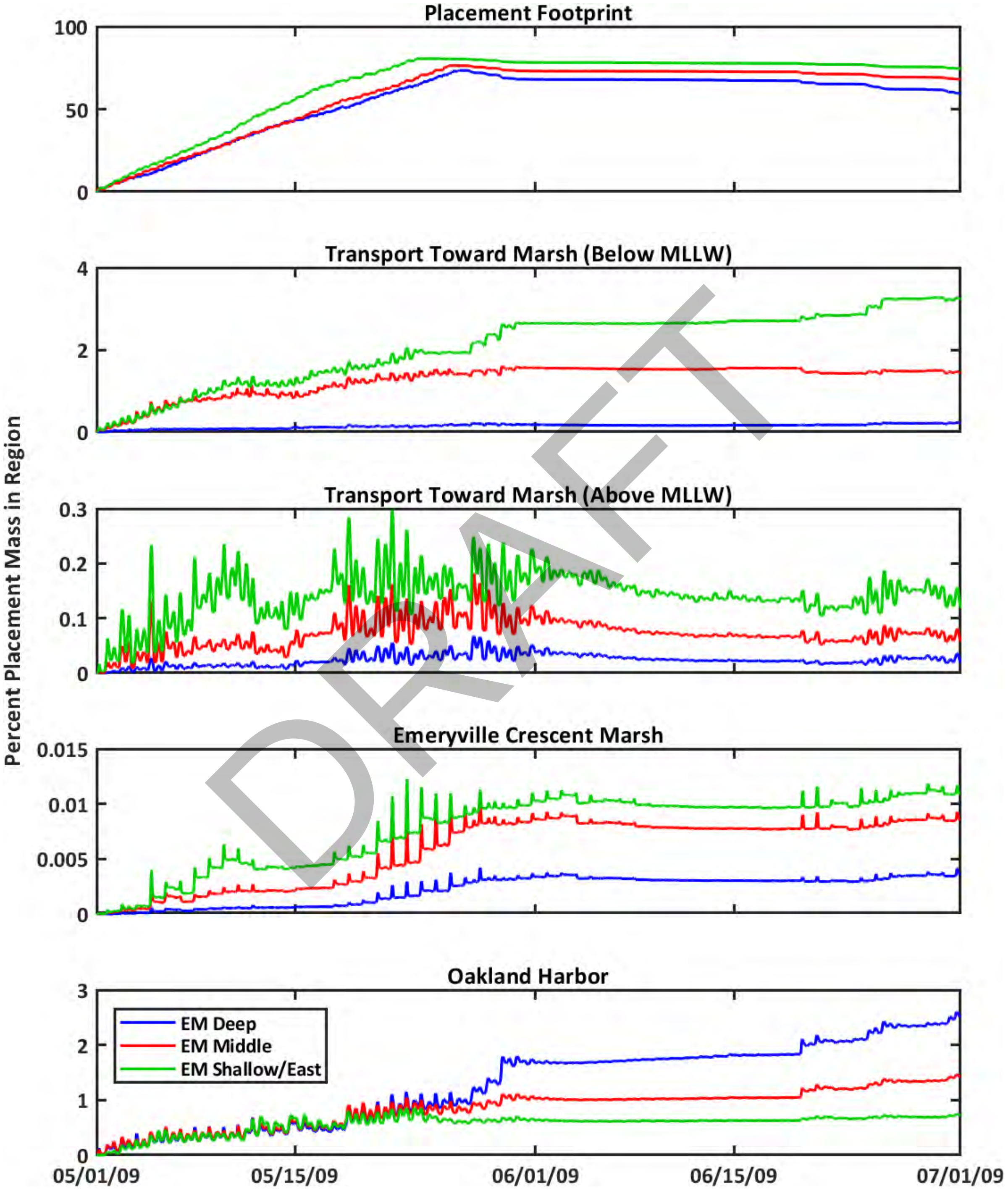
Predicted Percentage of Dredged Sediment Mass and Dredged Material Volume in Each Region at the End of the 2-Month Simulations for the Initial Three Eden Landing Scenarios



Note:
EL: Eden Landing

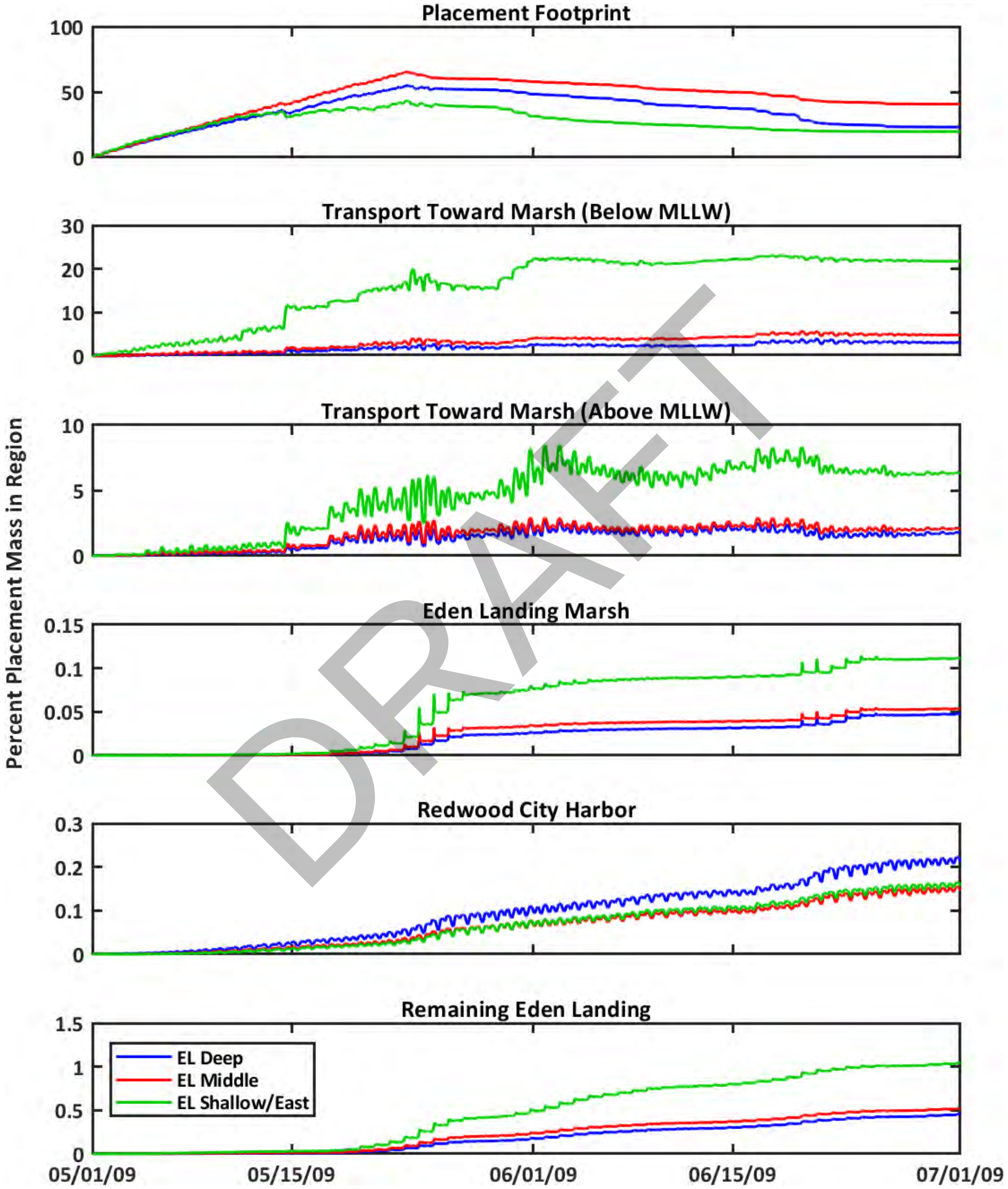
Figure 5.2-5

Predicted Percentage of Dredged Sediment Mass in Each Region During of the 2-Month Simulations for the Initial Three Emeryville Scenarios



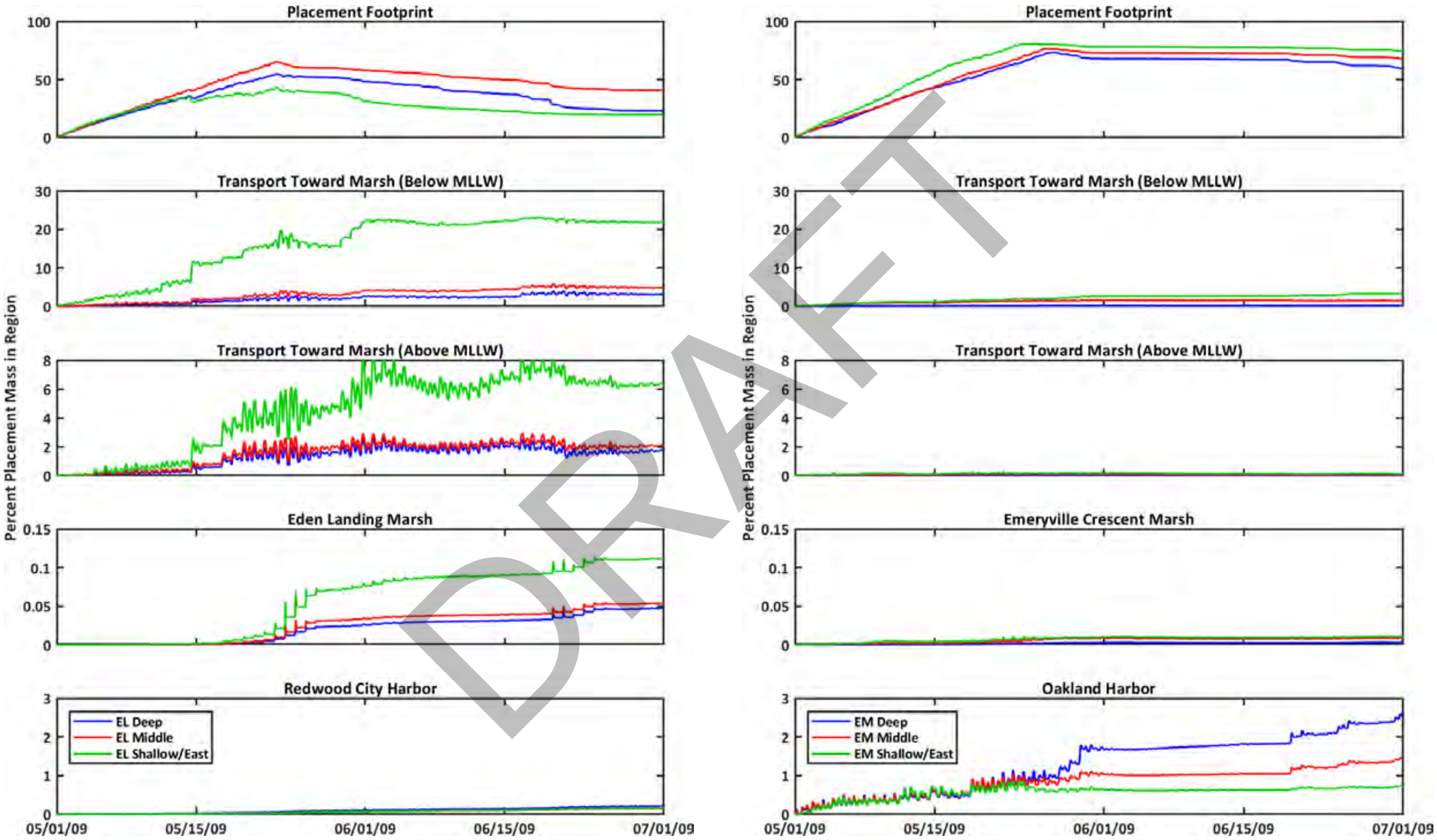
Note:
EM: Emeryville

Figure 5.2-6
Predicted Percentage of Dredged Sediment Mass in Each Region During the 2-Month Simulations for the Initial Three Eden Landing Scenarios



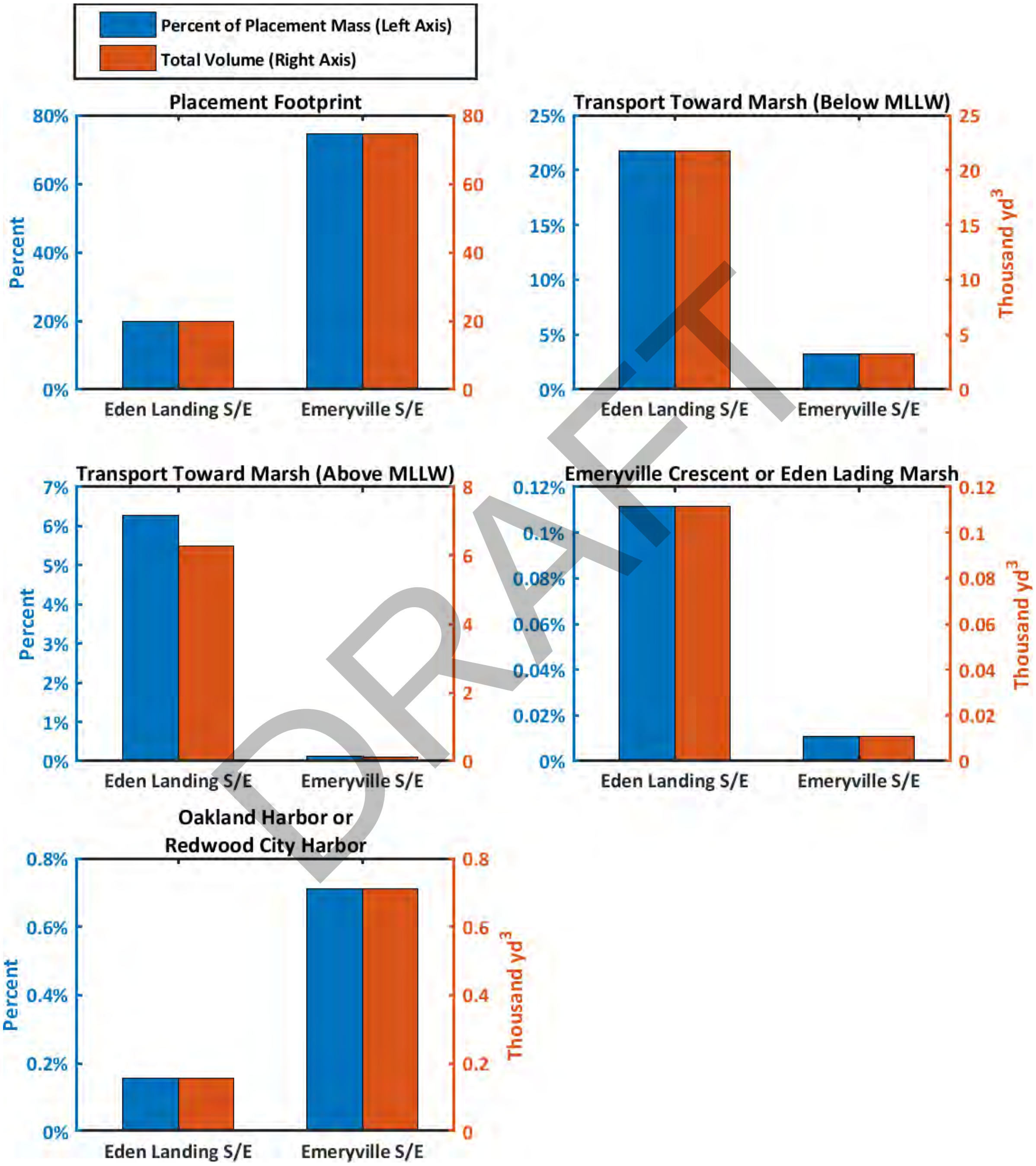
Note:
EL: Eden Landing

Figure 5.2-7
Predicted Percentage of Dredged Sediment Mass in Each Region During the 2-Month Simulations for the Initial Three Emeryville Scenarios (Left) and Eden Landing Scenarios (Right)



Notes:
EM: Emeryville
EL: Eden Landing

Figure 5.2-8
Predicted Percentage of Dredged Sediment Mass and Dredged Material Volume in Each Region at the End of the 2-Month Simulations for the Eden Landing and Emeryville Shallow/East Scenarios



Note:
S/E: Shallow/East scenario

5.3 Results of Six Additional Eden Landing Scenarios

The second set of six scenarios focused on Eden Landing were conducted to refine the placement strategy and placement volume at Eden Landing. These scenarios evaluated the amount of placed dredged material (50,000 yd^3 and 75,000 yd^3), conducting the placements in the winter, using Oakland Harbor sediment at the Eden Landing placement location, using a larger placement footprint, and using a larger placement footprint combined with a larger placement volume (125,000 yd^3).

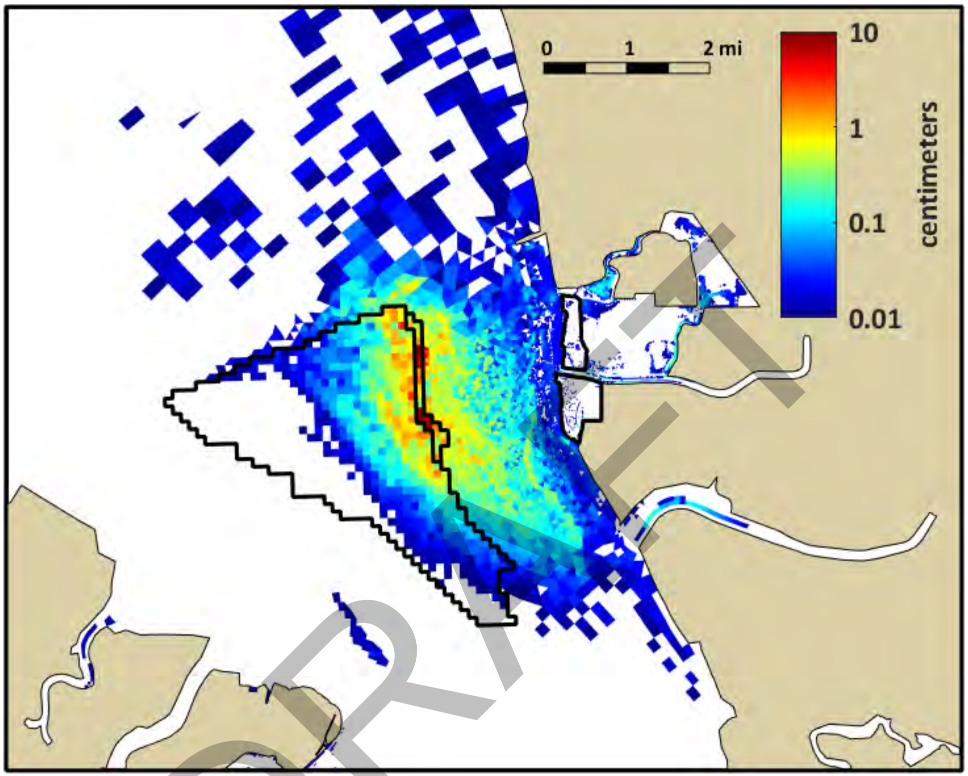
5.3.1 Eden Landing Shallow/East 50,000 yd^3 of Dredged Material

The Eden Landing Shallow/East 50,000 yd^3 of Dredged Material scenario included the placement of 50,000 yd^3 of dredged material along the eastern side of the placement grid. The scenario assumed a total of 56 placements over a period of 13 days, as described in Section 3.3.2.1. At the end of the 2-month simulation period, much of the dredged material was predicted to be dispersed away from the placement footprint (Figure 5.3-1), but 18% of the placed dredged material was predicted to remain inside the placement footprint (Figures 5.3-2 and 5.3-3; Tables 5.1-4 and 5.1-5). The model predicted that dredged material that was transported out of the initial placement footprint was deposited around the placement footprint, with a skewing of the deposition toward the east and south of the placement footprint (Figure 5.3-1). Predicted thickness of the dredged material remaining in the placement footprint ranged from 0.3 to 12 cm, with up to 0.6 cm of dredged material deposition in Eden Landing Marsh (Table 5.1-6). The percentage of the total amount of dredged material in the placement footprint increased until the placements were completed and then was predicted to decrease as the dredged material was resuspended (Figure 5.3-2).

At the end of the 2-month simulation period, 0.1% of the placed dredged material was predicted to be deposited in Eden Landing Marsh (Figure 3.4-2), and 1% was predicted to be deposited in other regions of the Eden Landing complex (Table 5.1-4). Much of the dredged material deposited on Eden Landing Marsh was predicted to be transported onto the marsh during the second half of May and June, during spring tide when the tidal higher high water levels were relatively high. Although only a small portion of the placed dredged material was predicted to reach Eden Landing Marsh within the 2-month simulation period, a relatively large amount of the placed sediment was predicted to be transported toward the marsh. The model predicted that 23% of the placed dredged material was transported towards Eden Landing Marsh but was still below MLLW, while an additional 6% of the placed dredged material was predicted to be transported towards the marsh and was already deposited at elevations above MLLW. An additional 2% was predicted to be transported to other areas above MLLW on the eastern side of the South Bay.

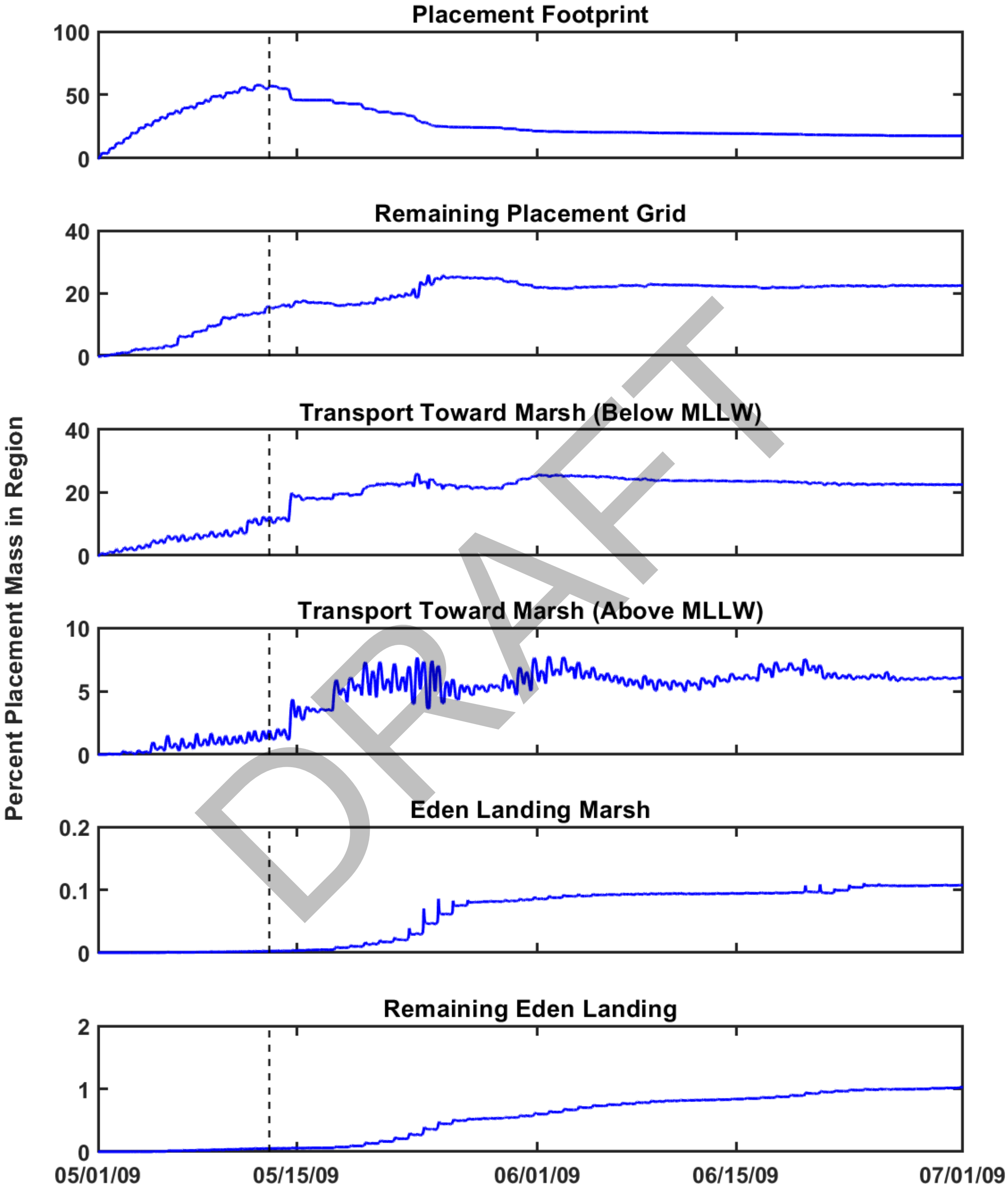
About 0.2% of the dredged material was predicted to be transported into Redwood City Harbor, and 0.3% was transported into the Alameda FCC. About 18% of the placed dredged material was predicted to be dispersed within the South Bay below MLLW, 2% dispersed north of Dumbarton Bridge, and 5% dispersed north of the Bay Bridge.

Figure 5.3-1
Predicted Thickness of Dredged Material at the End of the 2-Month Simulation: Scenario 7 Eden Landing Shallow/East 50,000 yd^3 of Dredged Material



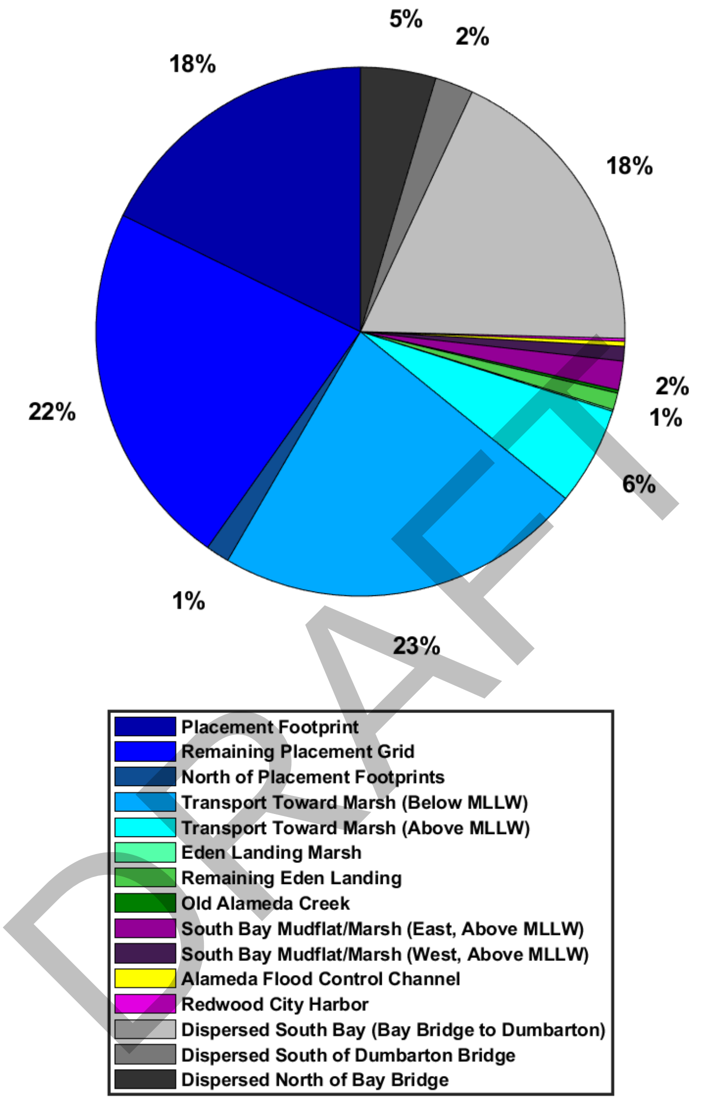
Note:
Note the log scale of the color range.

Figure 5.3-2
Predicted Percentage of Dredged Sediment Mass in Each Region During the 2-Month Simulation: Scenario 7 Eden Landing Shallow/East 50,000 yd^3 of Dredged Material



Note: Vertical dashed line denotes the end of the dredged material placements for this scenario.

Figure 5.3-3
Predicted Percentage of Dredged Sediment Mass in Each Region at the End of the 2-Month Simulation: Scenario 7 Eden Landing Shallow/East 50,000 yd^3 of Dredged Material



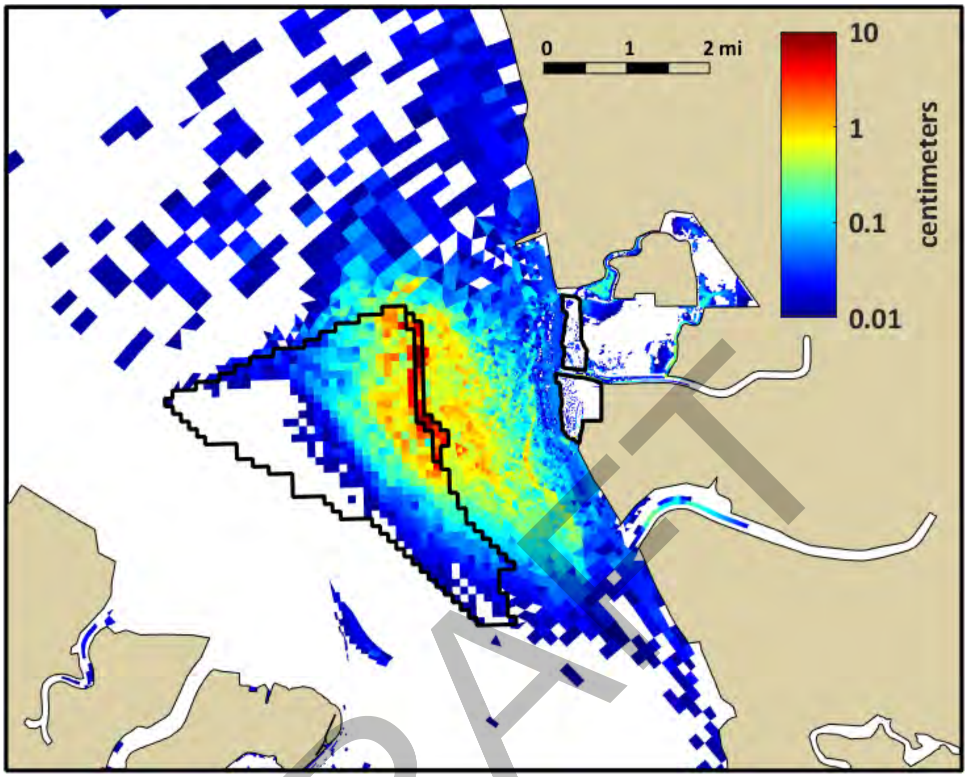
5.3.2 Eden Landing Shallow/East 75,000 yd^3 of Dredged Material

The Eden Landing Shallow/East 75,000 yd^3 of Dredged Material scenario included the placement of 75,000 yd^3 of dredged material along the eastern side of the placement grid. The scenario assumed a total of 84 placements over a period of 21 days, as described in Section 3.3.2.2. At the end of the 2-month simulation period, much of the dredged material was predicted to be dispersed away from the placement footprint (Figure 5.3-4), but 17% of the placed dredged material was predicted to remain inside the placement footprint (Figures 5.3-5 and 5.3-6; Tables 5.1-4 and 5.1-5). The model predicted that dredged material that was transported out of the initial placement footprint was deposited around the placement footprint, with a skewing of the deposition toward the east and south of the placement footprint (Figure 5.3-4). Predicted thickness of the dredged material remaining in the placement footprint ranged from 0.6 to 12 cm, with up to 0.9 cm of dredged material deposition in Eden Landing Marsh (Table 5.1-6). The percentage of the total amount of dredged material in the placement footprint increased until the placements were completed and then was predicted to decrease as the dredged material was resuspended (Figure 5.3-5).

At the end of the 2-month simulation period, 0.1% of the placed dredged material was predicted to be deposited in Eden Landing Marsh (Figure 3.4-2), and 1% was predicted to be deposited in other regions of the Eden Landing complex (Table 5.1-4). Much of the dredged material deposited on Eden Landing Marsh was predicted to be transported onto the marsh during the second half of May and June, during spring tide when the tidal higher high water levels were relatively high. Although only a small portion of the placed dredged material was predicted to reach Eden Landing Marsh within the 2-month simulation period, a relatively large amount of the placed sediment was predicted to be transported toward the marsh. The model predicted that 22% of the placed dredged material was transported towards Eden Landing Marsh but was still below MLLW, while an additional 7% of the placed dredged material was predicted to be transported towards the marsh and was already deposited at elevations above MLLW. An additional 2% was predicted to be transported to other areas above MLLW on the eastern side of the South Bay.

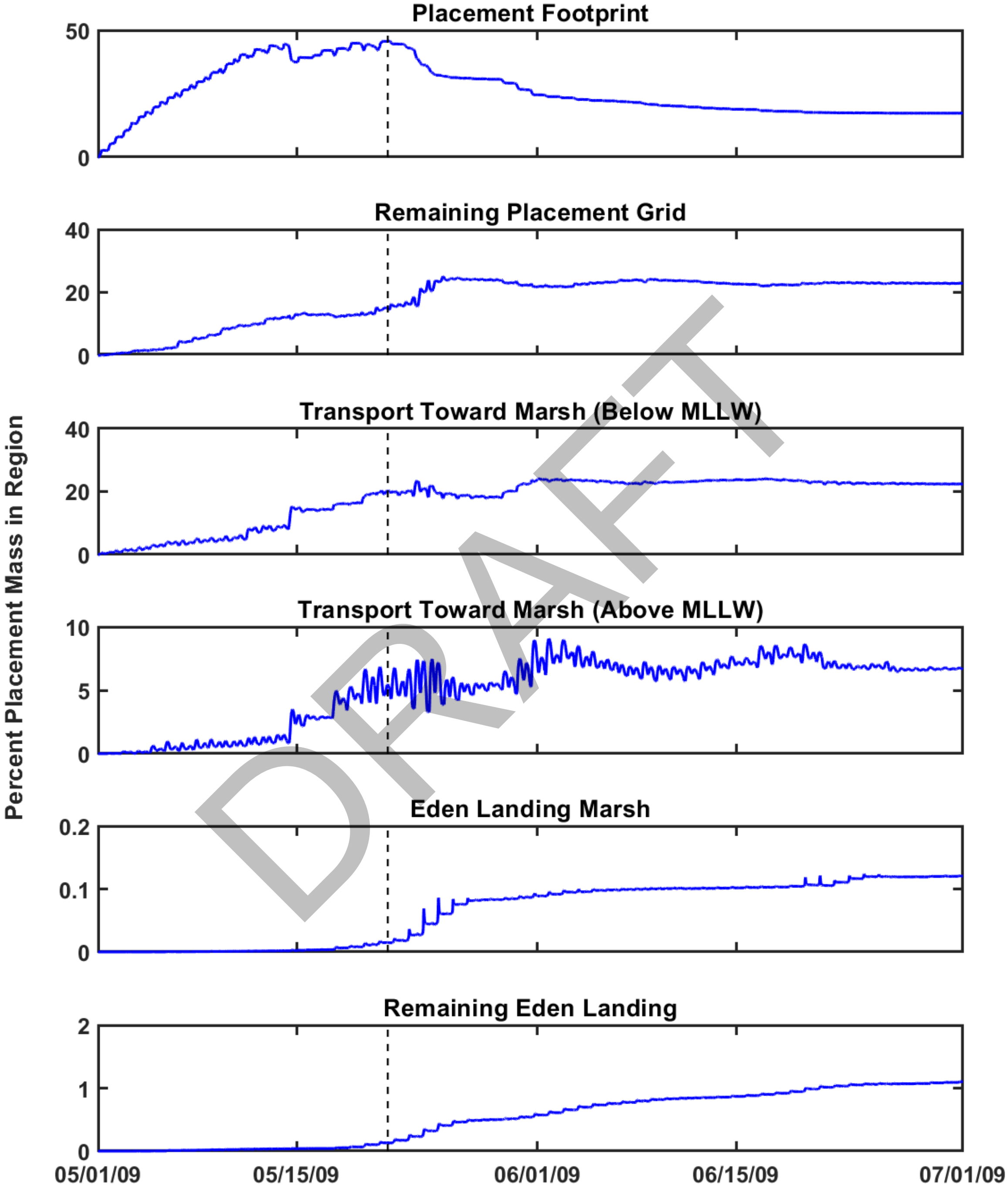
About 0.2% of the dredged material was predicted to be transported into Redwood City Harbor, and 0.3% was transported into the Alameda FCC. About 18% of the placed dredged material was predicted to be dispersed within the South Bay below MLLW, 2% dispersed north of Dumbarton Bridge, and 4% dispersed north of the Bay Bridge.

Figure 5.3-4
Predicted Thickness of Dredged Material at the End of the 2-Month Simulation: Scenario 8 Eden Landing Shallow/East 75,000 yd^3 of Dredged Material



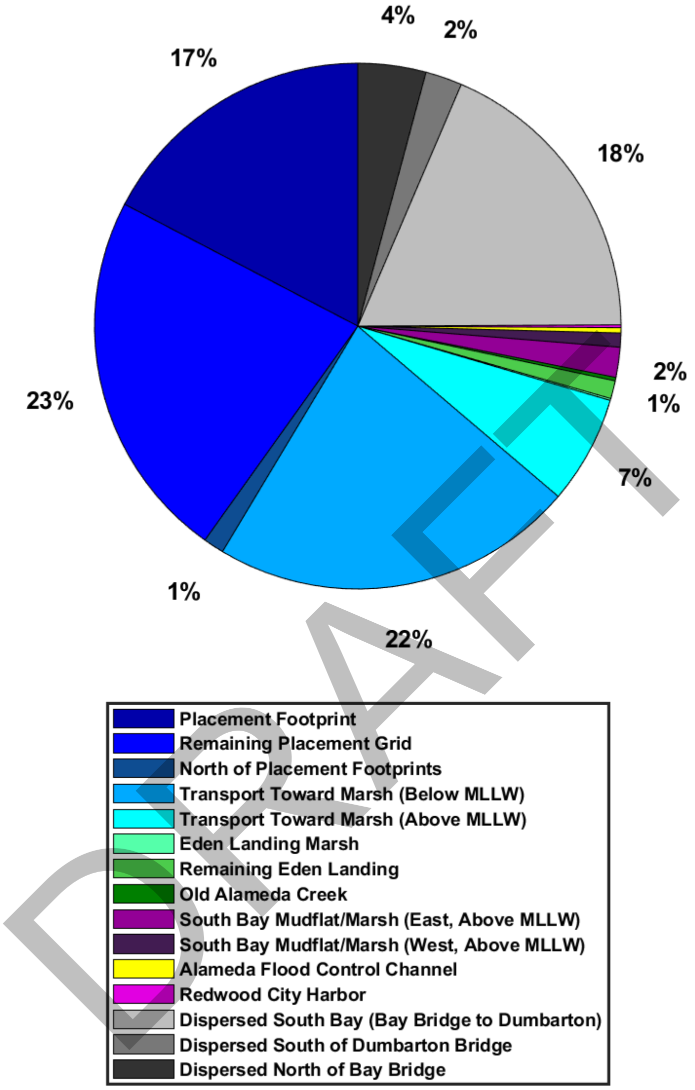
Note:
Note the log scale of the color range.

Figure 5.3-5
Predicted Percentage of Dredged Sediment Mass in Each Region During the 2-Month Simulation: Scenario 8 Eden Landing Shallow/East 75,000 yd^3 of Dredged Material



Note:
Vertical dashed line denotes the end of the dredged material placements for this scenario.

Figure 5.3-6
Predicted Percentage of Dredged Sediment Mass in Each Region at the End of the 2-Month Simulation: Scenario 8 Eden Landing Shallow/East 75,000 yd^3 of Dredged Material



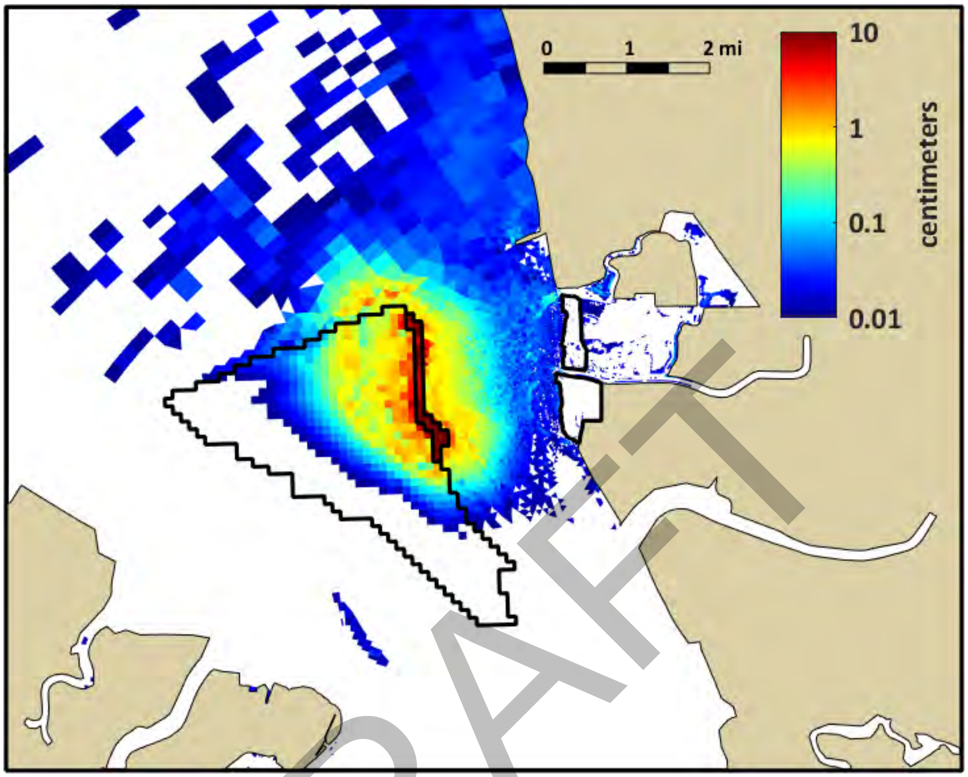
5.3.3 Eden Landing Shallow/East Winter

The Eden Landing Shallow/East Winter scenario included the placement of 100,000 yd^3 of dredged material along the eastern side of the placement grid and spanned 3 months, compared to the 2-month duration of the other 11 scenarios. The scenario assumed a total of 112 placements over a period of 18 days, as described in Section 3.3.2.3. At the end of the 3-month simulation period, much of the dredged material was predicted to be dispersed away from the placement footprint (Figure 5.3-7), but 32% of the placed dredged material was predicted to remain inside the placement footprint (Figures 5.3-8 and 5.3-9; Tables 5.1-4 and 5.1-5). The model predicted that dredged material that was transported out of the initial placement footprint was deposited roughly centered around the placement footprint, with the deposition skewed toward the north of the placement grid and north along the shoreline (Figure 5.3-7). Skewing of the deposition toward the north is consistent with the relatively strong northward directed predicted depth-averaged residual currents toward the eastern side of the placement grid during the winter simulation period (Figure 4.2-7). Predicted thickness of the dredged material remaining in the placement footprint ranged from 5 to 20 cm, with up to 0.08 cm of dredged material deposition in Eden Landing Marsh (Table 5.1-6). The percentage of the total amount of dredged material in the placement footprint increased until the placements were completed and then was predicted to decrease as the dredged material was resuspended (Figure 5.3-8).

At the end of the 3-month simulation period, less than 0.1% of the placed dredged material was predicted to be deposited in Eden Landing Marsh (Figure 3.4-2), and 0.3% was predicted to be deposited in other regions of the Eden Landing complex (Table 5.1-4). Much of the dredged material deposited on Eden Landing Marsh was predicted to be transported onto the marsh during discrete short-duration events. Although only a very small portion of the placed dredged material was predicted to reach Eden Landing Marsh within the 3-month simulation period, some additional placed sediment was predicted to be transported toward the marsh. The model predicted that 15% of the placed dredged material was transported towards Eden Landing Marsh but was still below MLLW, while an additional 3% of the placed dredged material was predicted to be transported towards the marsh and was already deposited at elevations above MLLW. An additional 1% was predicted to be transported to other areas above MLLW on the eastern side of the South Bay.

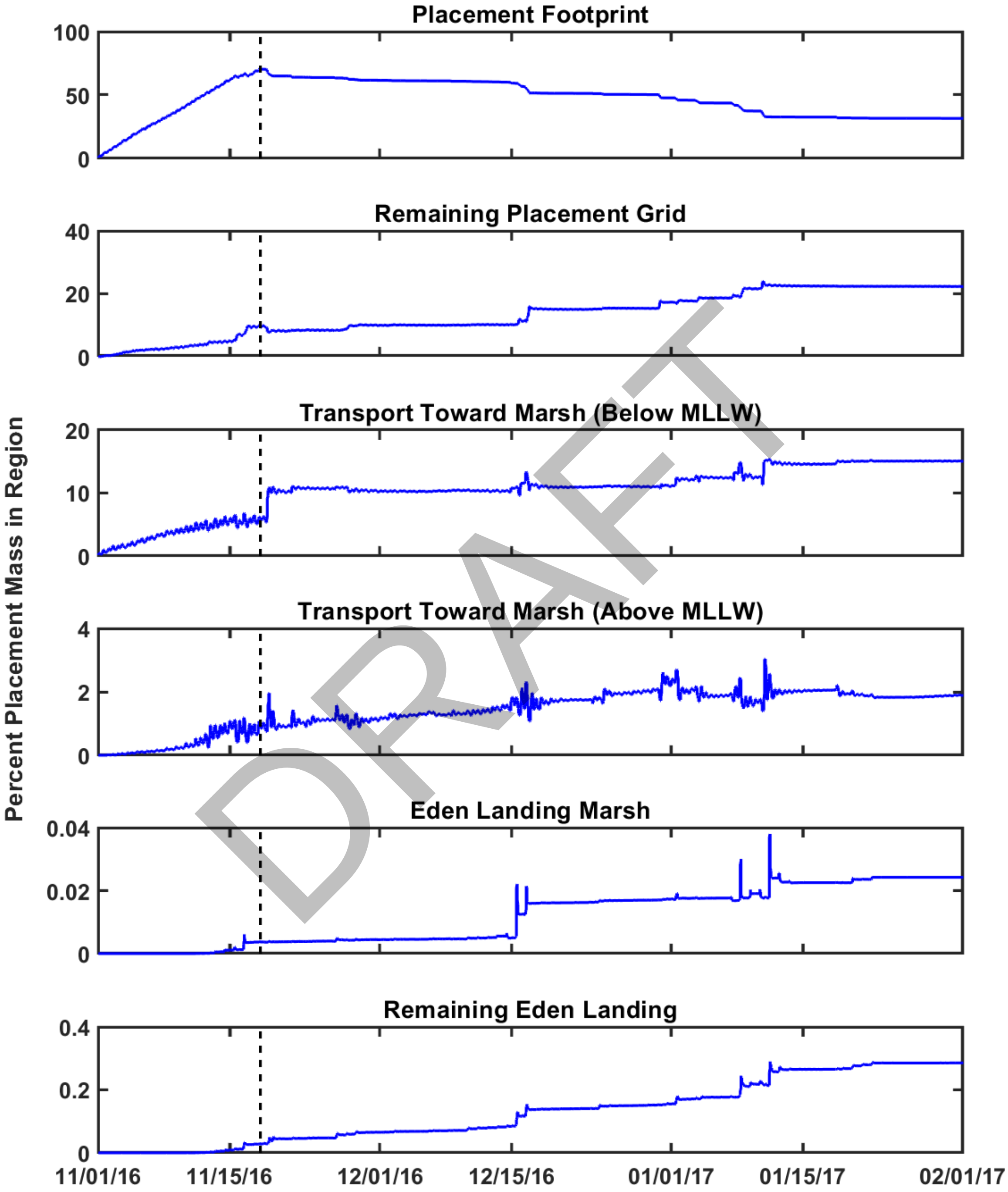
Less than 0.1% of the dredged material was predicted to be transported into Redwood City Harbor or into the Alameda FCC. About 14% of the placed dredged material was predicted to be dispersed within the South Bay below MLLW, 1% dispersed north of Dumbarton Bridge, and 9% dispersed north of the Bay Bridge.

Figure 5.3-7
Predicted Thickness of Dredged Material at the End of the 3-Month Simulation: Scenario 9 Eden Landing Shallow/East Winter



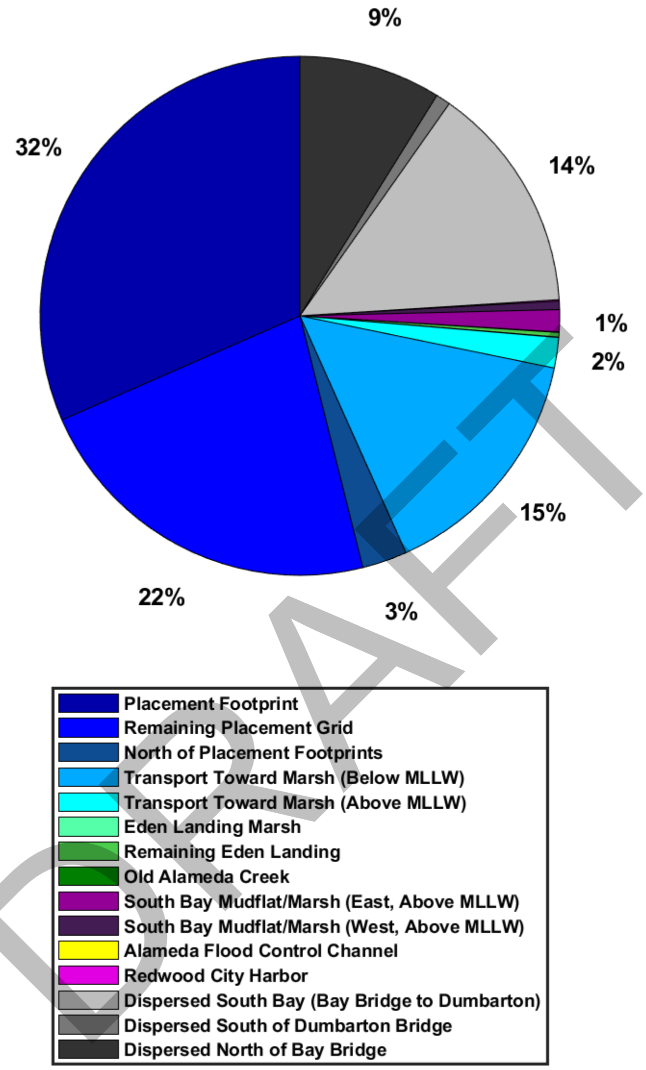
Note:
Note the log scale of the color range.

Figure 5.3-8
Predicted Percentage of Dredged Sediment Mass in Each Region During the 3-Month Simulation: Scenario 9 Eden Landing Shallow/East Winter



Note:
Vertical dashed line denotes the end of the dredged material placements for this scenario.

Figure 5.3-9
Predicted Percentage of Dredged Sediment Mass in Each Region at the End of the 3-Month Simulation: Scenario 9 Eden Landing Shallow/East Winter



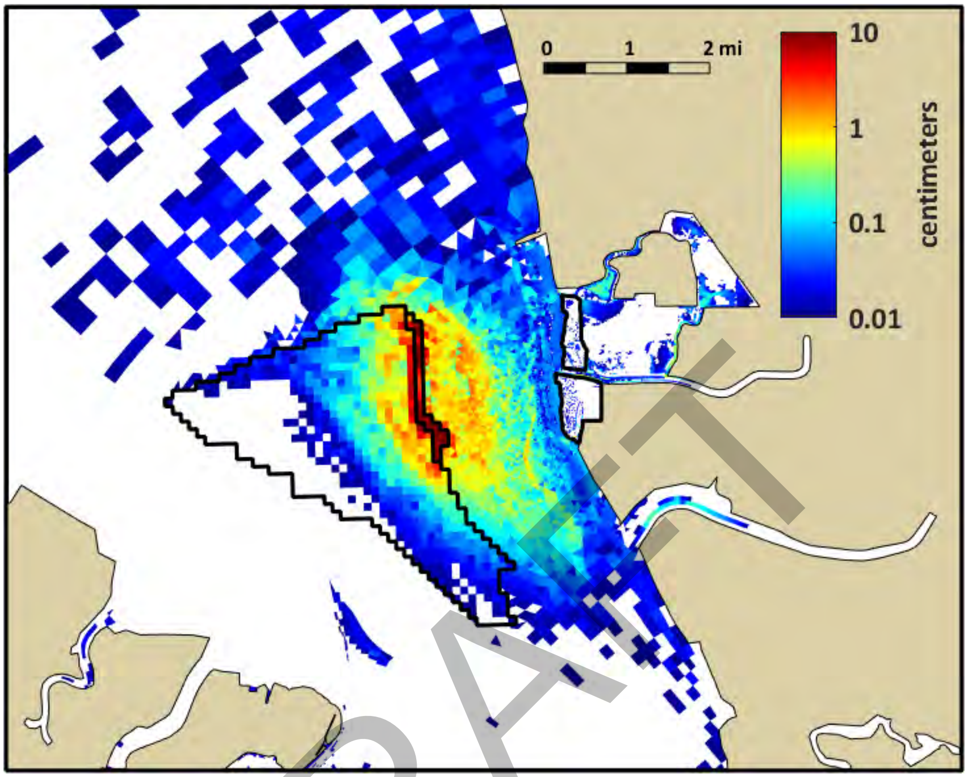
5.3.4 Eden Landing Shallow/East Oakland Harbor Sediment

The Eden Landing Shallow/East Oakland Harbor Sediment scenario included the placement of 100,000 yd^3 of dredged material along the eastern side of the placement grid. The scenario assumed a total of 112 placements over a period of 25 days, as described in Section 3.3.2.4. At the end of the 2-month simulation period, much of the dredged material was predicted to be dispersed away from the placement footprint (Figure 5.3-10), but 27% of the placed dredged material was predicted to remain inside the placement footprint (Figures 5.3-11 and 5.3-12; Tables 5.1-4 and 5.1-5). The model predicted that dredged material that was transported out of the initial placement footprint was deposited around the placement footprint, with a skewing of the deposition toward the east and south of the placement footprint (Figure 5.3-10). Predicted thickness of the dredged material remaining in the placement footprint ranged from 1 to 17 cm, with up to 0.9 cm of dredged material deposition in Eden Landing Marsh (Table 5.1-6). The percentage of the total amount of dredged material in the placement footprint increased until the placements were completed and then was predicted to decrease as the dredged material was resuspended (Figure 5.3-11).

At the end of the 2-month simulation period, 0.1% of the placed dredged material was predicted to be deposited in Eden Landing Marsh (Figure 3.4-2), and 0.8% was predicted to be deposited in other regions of the Eden Landing complex (Table 5.1-4). Much of the dredged material deposited on Eden Landing Marsh was predicted to be transported onto the marsh during the second half of May and June, during spring tide when the tidal higher high water levels were relatively high. Although only a small portion of the placed dredged material was predicted to reach Eden Landing Marsh within the 2-month simulation period, a relatively large amount of the placed sediment was predicted to be transported toward the marsh. The model predicted that 23% of the placed dredged material was transported towards Eden Landing Marsh but was still below MLLW, while an additional 5% of the placed dredged material was predicted to be transported towards the marsh and was already deposited at elevations above MLLW. An additional 1% was predicted to be transported to other areas above MLLW on the eastern side of the South Bay.

About 0.1% of the dredged material was predicted to be transported into Redwood City Harbor, and 0.2% was transported into the Alameda FCC. About 15% of the placed dredged material was predicted to be dispersed within the South Bay below MLLW, 2% dispersed north of Dumbarton Bridge, and 3% dispersed north of the Bay Bridge.

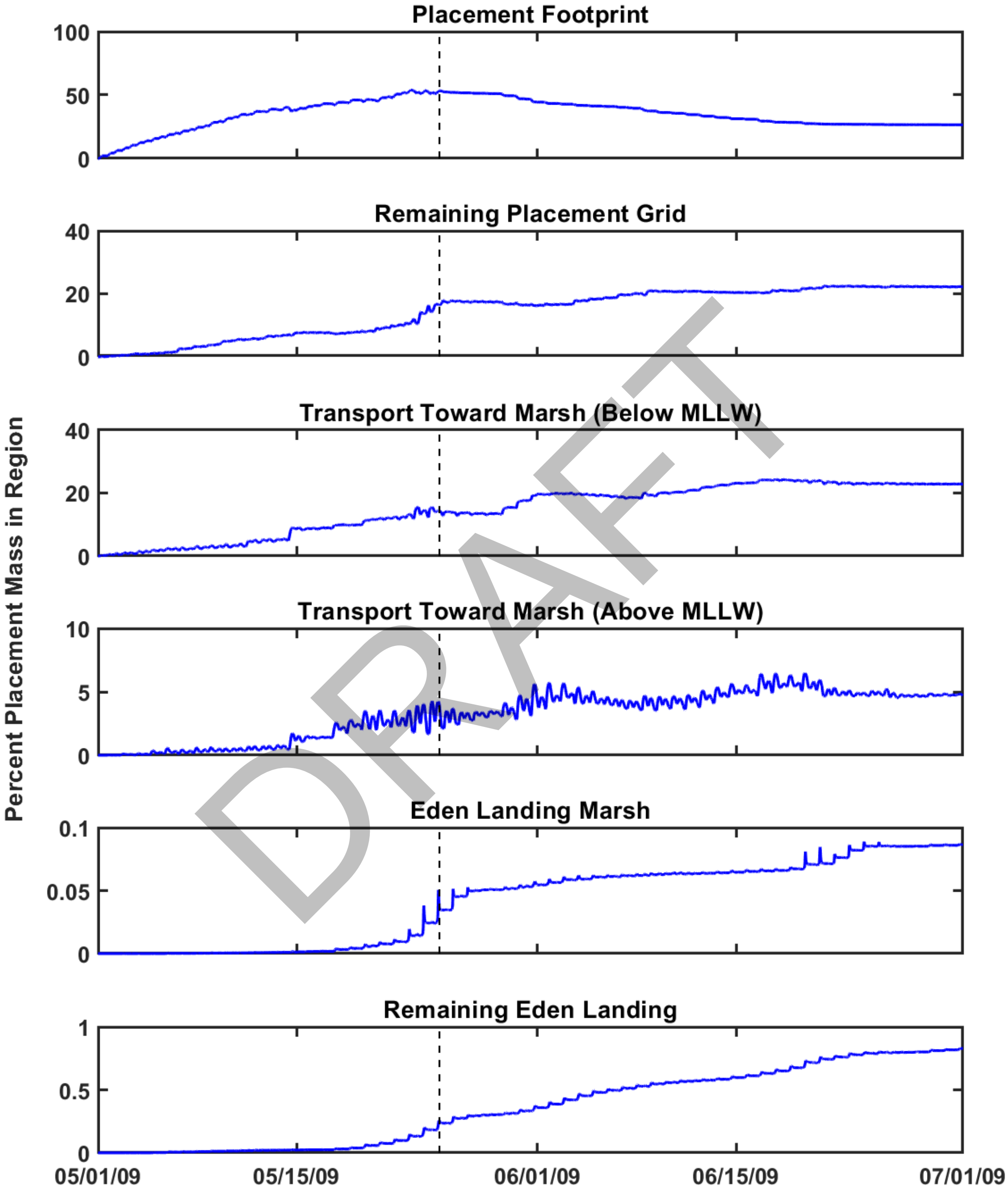
Figure 5.3-10
Predicted Thickness of Dredged Material at the End of the 2-Month Simulation: Scenario 10 Eden Landing Shallow/East Oakland Harbor Sediment



Note:
Note the log scale of the color range.

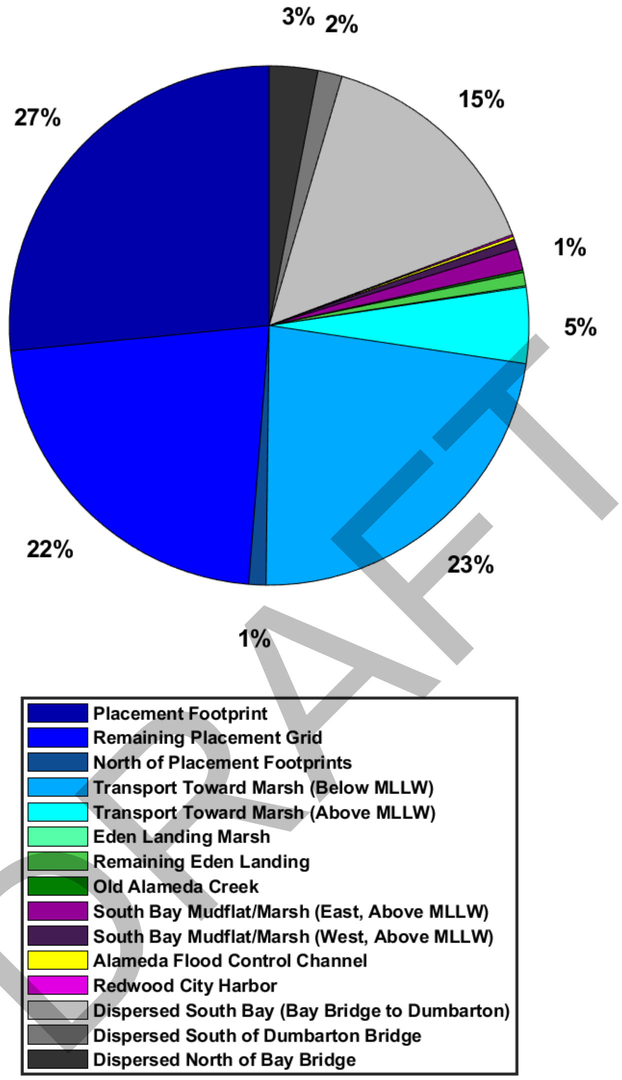
Figure 5.3-11

Predicted Percentage of Dredged Sediment Mass in Each Region During the 2-Month Simulation: Scenario 10 Eden Landing Shallow/East Oakland Harbor Sediment



Note:
Vertical dashed line denotes the end of the dredged material placements for this scenario.

Figure 5.3-12
Predicted Percentage of Dredged Sediment Mass in Each Region at the End of the 2-Month Simulation: Scenario 10 Eden Landing Shallow/East Oakland Harbor Sediment



5.3.5 Eden Landing Larger Placement Footprint

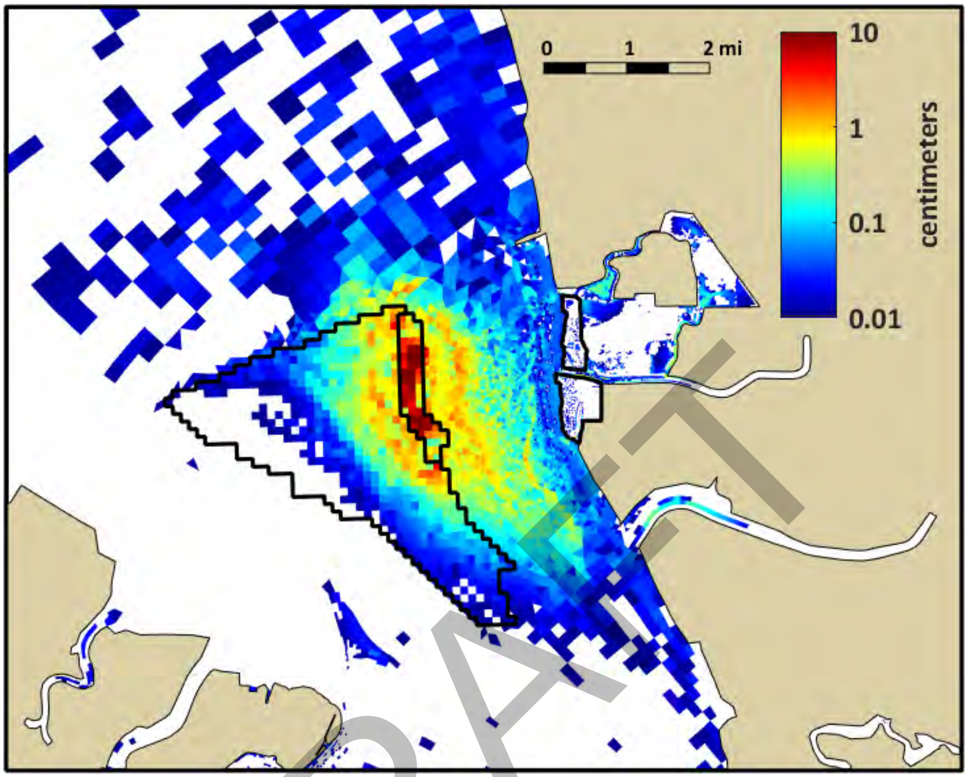
The Eden Landing Larger Placement Footprint scenario included the placement of 100,000 yd^3 of dredged material in a placement footprint near and along the eastern side of the placement grid. The scenario assumed a total of 112 placements over a period of 22 days, as described in Section 3.3.2.5. At the end of the 2-month simulation period, approximately two-thirds of the dredged material was predicted to be dispersed away from the placement footprint (Figure 5.3-13), but 34% of the placed dredged material was predicted to remain inside the placement footprint

(Figures 5.3-14 and 5.3-15; Tables 5.1-4 and 5.1-5). The model predicted that dredged material that was transported out of the initial placement footprint was deposited around the placement footprint, with a skewing of the deposition toward the southeast of the placement footprint (Figure 5.3-13). Predicted thickness of the dredged material remaining in the placement footprint ranged from 0.2 to 15 cm, with up to 0.9 cm of dredged material deposition in Eden Landing Marsh (Table 5.1-6). The percentage of the total amount of dredged material in the placement footprint increased until the placements were completed, and then was predicted to decrease as the dredged material was resuspended (Figure 5.3-14).

At the end of the 2-month simulation period, 0.1% of the placed dredged material was predicted to be deposited in Eden Landing Marsh (Figure 3.4-2), and 0.9% was predicted to be deposited in other regions of the Eden Landing complex (Table 5.1-4). Much of the dredged material deposited on Eden Landing Marsh was predicted to be transported onto the marsh during the second half of May and June, during spring tide when the tidal higher high water levels were relatively high. Although only a small portion of the placed dredged material was predicted to reach Eden Landing Marsh within the 2-month simulation period, additional placed sediment was predicted to be transported toward the marsh. The model predicted that 18% of the placed dredged material was transported towards Eden Landing Marsh but was still below MLLW, while an additional 5% of the placed dredged material was predicted to be transported towards the marsh and was already deposited at elevations above MLLW. An additional 2% was predicted to be transported to other areas above MLLW on the eastern side of the South Bay.

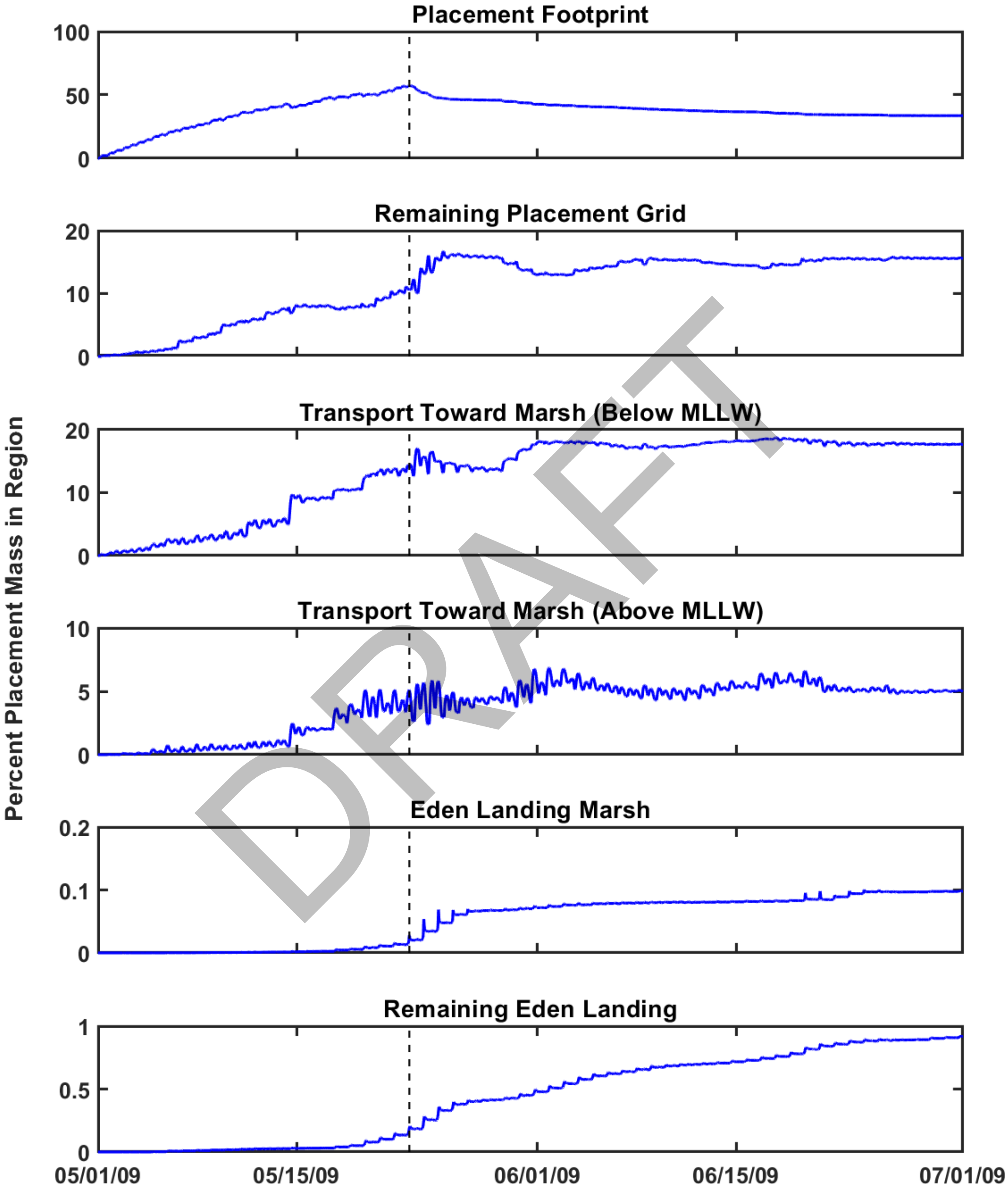
About 0.2% of the dredged material was predicted to be transported into Redwood City Harbor, and 0.3% was transported into the Alameda FCC. About 17% of the placed dredged material was predicted to be dispersed within the South Bay below MLLW, 2% dispersed north of Dumbarton Bridge, and 4% dispersed north of the Bay Bridge.

Figure 5.3-13
Predicted Thickness of Dredged Material at the End of the 2-Month Simulation: Scenario 11 Eden Landing Larger Placement Footprint



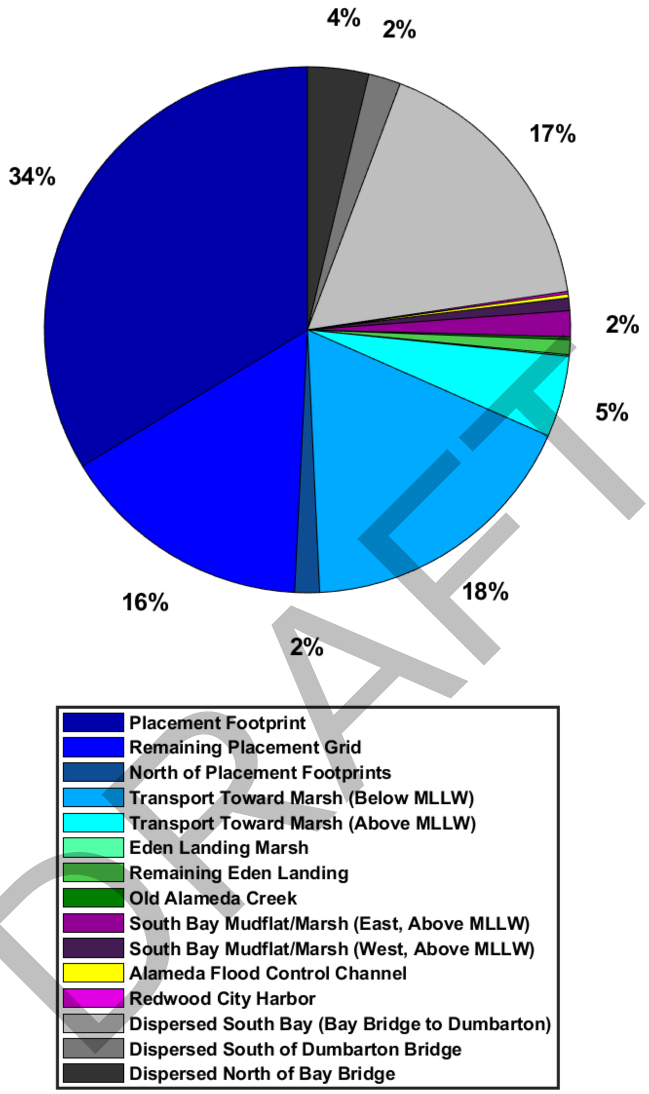
Note:
Note the log scale of the color range.

Figure 5.3-14
Predicted Percentage of Dredged Sediment Mass in Each Region During the 2-Month Simulation: Scenario 11 Eden Landing Larger Placement Footprint



Note:
Vertical dashed line denotes the end of the dredged material placements for this scenario.

Figure 5.3-15
Predicted Percentage of Dredged Sediment Mass in Each Region at the End of the 2-Month Simulation: Scenario 11 Eden Landing Larger Placement Footprint



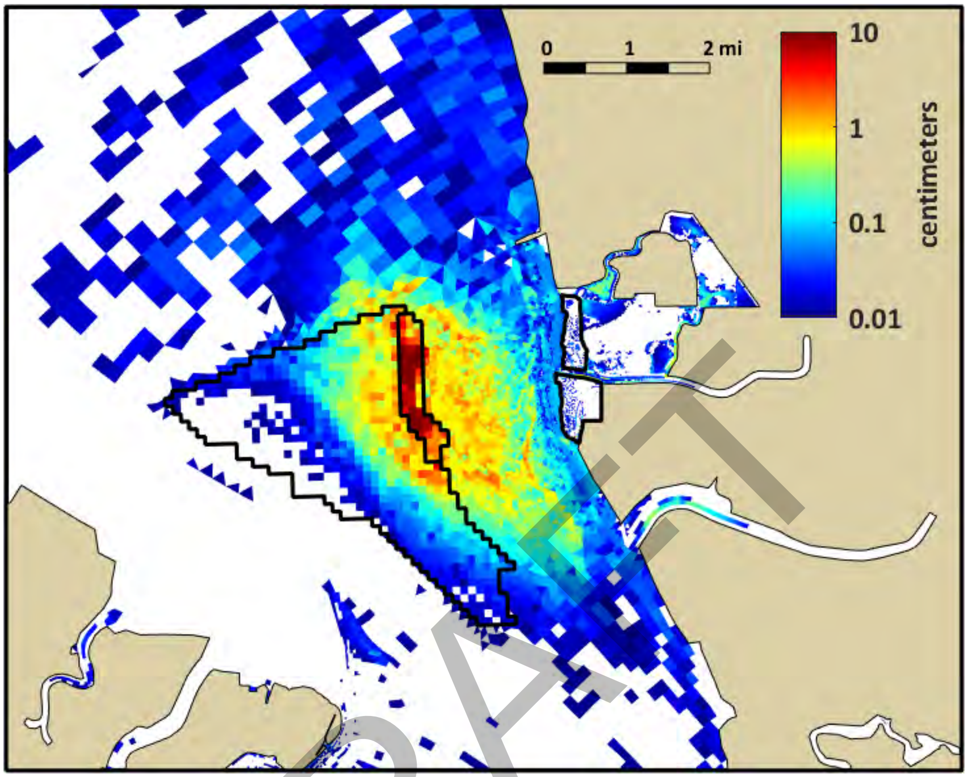
5.3.6 Eden Landing Larger Placement Footprint 125,000 yd^3

The Eden Landing Larger Placement Footprint 125,000 yd^3 scenario included the placement of 125,000 yd^3 of dredged material in a placement footprint near and along the eastern side of the placement grid. The scenario assumed a total of 139 placements over a period of 26 days, as described in Section 3.3.2.6. At the end of the 2-month simulation period, approximately two-thirds of the dredged material was predicted to be dispersed away from the placement footprint (Figure 5.3-16), but 33% of the placed dredged material was predicted to remain inside the placement footprint (Figures 5.3-17 and 5.3-18; Tables 5.1-4 and 5.1-5). The model predicted that dredged material that was transported out of the initial placement footprint was deposited around the placement footprint, with a skewing of the deposition toward the southeast of the placement footprint (Figure 5.3-16). Predicted thickness of the dredged material remaining in the placement footprint ranged from 0.5 to 19 cm, with up to 1 cm of dredged material deposition in Eden Landing Marsh (Table 5.1-6). The percentage of the total amount of dredged material in the placement footprint increased until the placements were completed and then was predicted to decrease as the dredged material was resuspended (Figure 5.3-17).

At the end of the 2-month simulation period, 0.1% of the placed dredged material was predicted to be deposited in Eden Landing Marsh (Figure 3.4-2), and 0.9% was predicted to be deposited in other regions of the Eden Landing complex (Table 5.1-4). Much of the dredged material deposited on Eden Landing Marsh was predicted to be transported onto the marsh during the second half of May and June, during spring tide when the tidal higher high water levels were relatively high. Although only a small portion of the placed dredged material was predicted to reach Eden Landing Marsh within the 2-month simulation period, additional placed sediment was predicted to be transported toward the marsh. The model predicted that 18% of the placed dredged material was transported towards Eden Landing Marsh but was still below MLLW, while an additional 6% of the placed dredged material was predicted to be transported towards the marsh and was already deposited at elevations above MLLW. An additional 2% was predicted to be transported to other areas above MLLW on the eastern side of the South Bay.

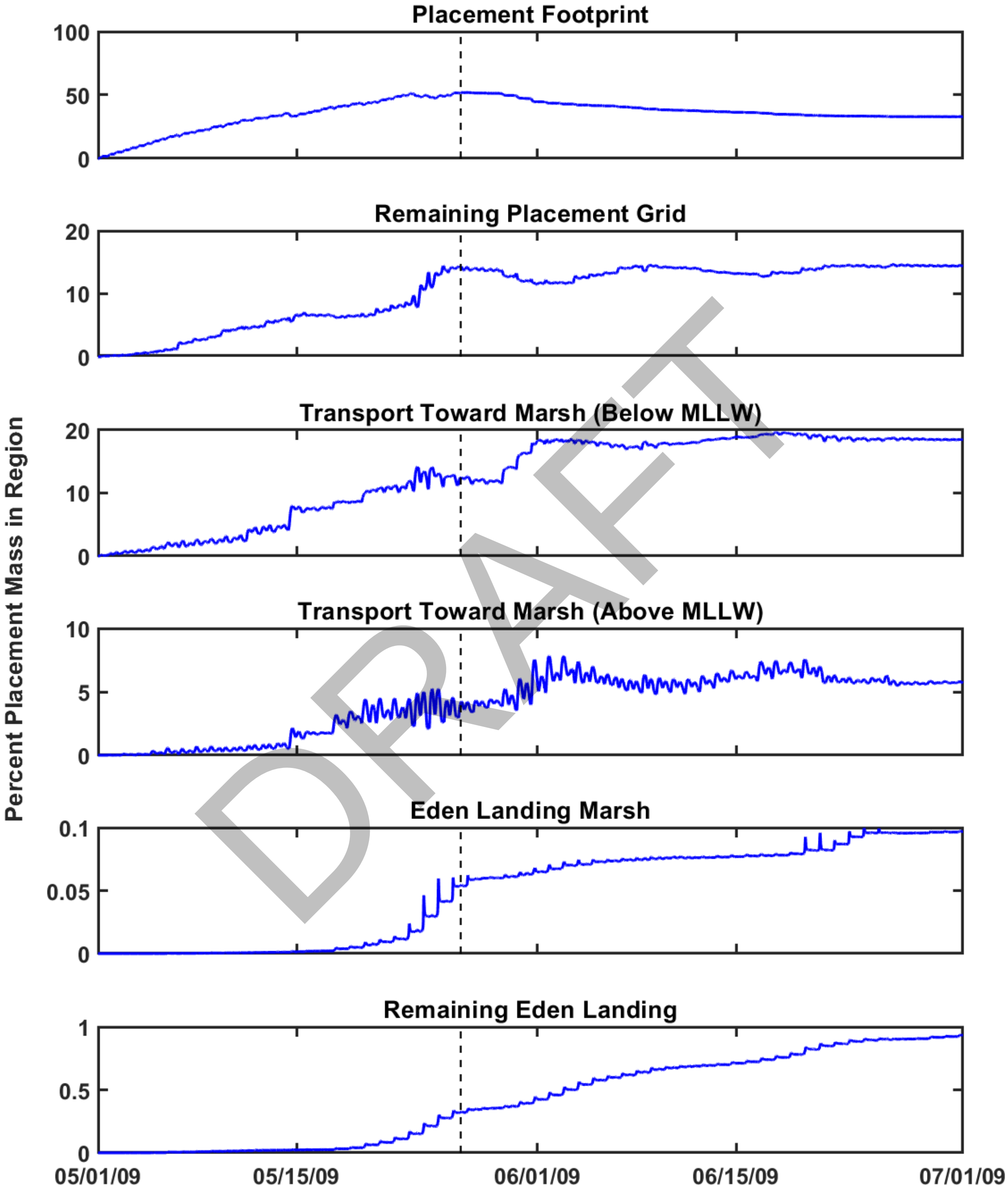
About 0.2% of the dredged material was predicted to be transported into Redwood City Harbor, and 0.3% was transported into the Alameda FCC. About 17% of the placed dredged material was predicted to be dispersed within the South Bay below MLLW, 2% dispersed north of Dumbarton Bridge, and 4% dispersed north of the Bay Bridge.

Figure 5.3-16
Predicted Thickness of Dredged Material at the End of the 2-Month Simulation: Scenario 12 Eden Landing Larger Placement Footprint 125,000 yd^3



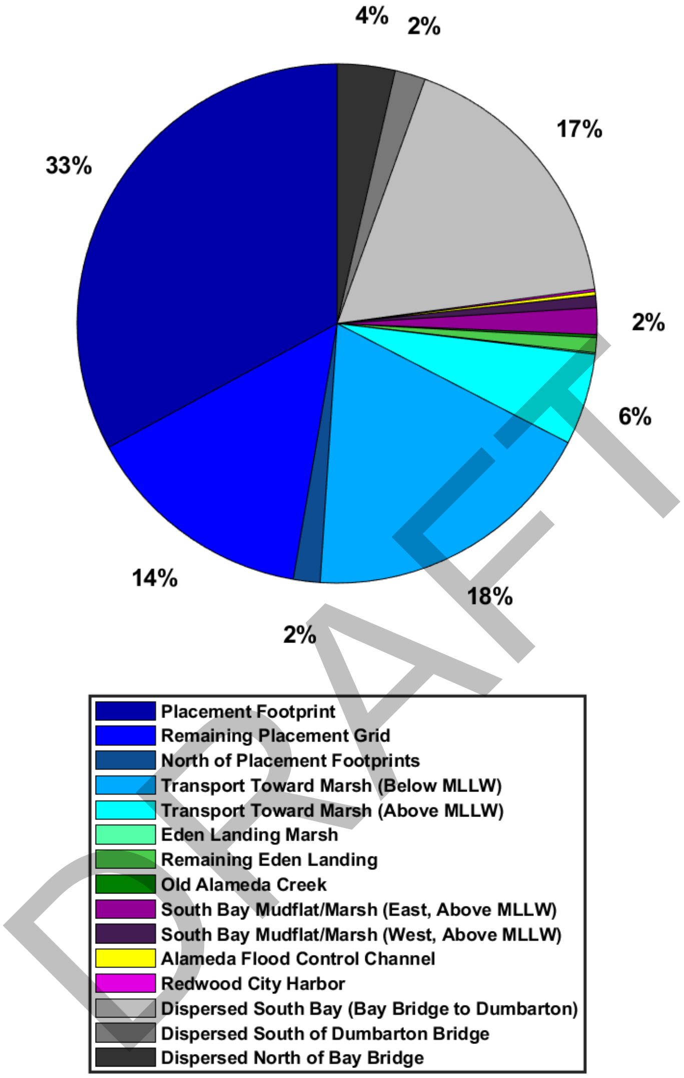
Note:
Note the log scale of the color range.

Figure 5.3-17
Predicted Percentage of Dredged Sediment Mass in Each Region During the 2-Month Simulation: Scenario 12 Eden Landing Larger Placement Footprint 125,000 yd^3



Note:
Vertical dashed line denotes the end of the dredged material placements for this scenario.

Figure 5.3-18
Predicted Percentage of Dredged Sediment Mass in Each Region at the End of the 2-Month Simulation: Scenario 12 Eden Landing Larger Placement Footprint 125,000 yd^3



5.4 Evaluation of Dredged Material Placements at Eden Landing

This section compares the results of the Eden Landing Shallow/East scenario detailed in Section 5.1.6 with the additional Eden Landing scenarios detailed in Section 5.3 and specifically evaluates the following:

- The placement volume in the shallow/east placement footprint
- The sediment source in the shallow/east placement footprint
- Placements during the summer versus winter in the shallow/east placement footprint

- Conducting placements in the shallow/east placement footprint versus an expanded footprint
- The placement volume in the expanded east placement footprint

5.4.1 Evaluation of Placement Volume in the Shallow/East Placement Footprint

Dredged material placements were conducted in the Eden Landing shallow/east placement footprint using 100,000 yd^3, 75,000 yd^3, and 50,000 yd^3 of dredged material. Dispersal away from the placement footprint resulted in similar depositional patterns for each placement volume (Figure 5.4-1); however, the thickness of the dredged material deposition increased with increasing placement volume. That is, the predicted depositional thicknesses were greater with 100,000 yd^3 of dredged material than with 75,000 yd^3 or 50,000 yd^3 of dredged material.

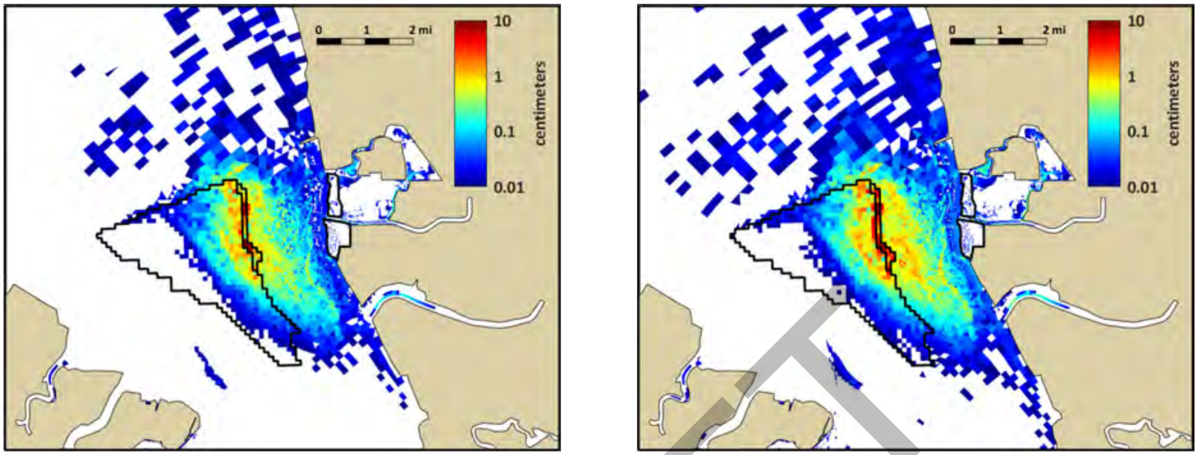
The percentage of dredged material dispersed to the various analysis regions was similar, regardless of the placement volumes considered (Figure 5.4-2 and Table 5.1-4). The placement of different volumes of dredged material (100,000 yd^3, 75,000 yd^3, or 50,000 yd^3) in the shallow/east placement footprint resulted in only small differences in the percentage of the dredged material transported to the analysis regions over the 2 months of the simulations. For the Eden Landing Shallow/East 100,000 yd^3 scenario, 20% of the dredged material was predicted to remain in the placement footprint at the end of the simulation, compared to 17% for the 75,000 yd^3 scenario and 18% for the 50,000 yd^3 scenario. At the end of the simulation, 0.1% of the dredged material was predicted to deposit in the Whale's Tail portion of Eden Landing Marsh for all three of the Eden Landing Shallow/East 100,000 yd^3, 75,000 yd^3, and 50,000 yd^3 scenarios. For the Eden Landing Shallow/East 100,000 yd^3 and 50,000 yd^3 scenarios, 6% of the dredged material was predicted to deposit above MLLW bayward of the marsh at the end of the simulation, compared to 7% for the 75,000 yd^3 scenario. At the end of the simulation, 1% of the dredged material was predicted to deposit in the remaining portion of Eden Landing for all three of the Eden Landing Shallow/East 100,000 yd^3, 75,000 yd^3, and 50,000 yd^3 scenarios.

Because each scenario included a different volume of dredged material, the volume of dredged material dispersed to each analysis region was different for each scenario. The scenario with 100,000 yd^3 of dredged material had the most predicted dispersal to each analysis region, followed by the scenario with 75,000 yd^3 of dredged material, and the scenario with 50,000 yd^3 of dredged material had the lowest predicted volume of dredged material in each region at the end of the simulations (Figure 5.4-3 and Table 5.1-5). The scenario with 100,000 yd^3 of dredged material resulted in the transport of more dredged material toward and into Eden Landing Marsh than the scenarios with a lower total placement volume.

Figure 5.4-1
Predicted Thickness of Dredged Material at the End of the 2-Month Simulations for Evaluating the Placement Volume in the Shallow/East Placement Footprint

East 50k yd^3

East 75k yd^3



East 100k yd^3

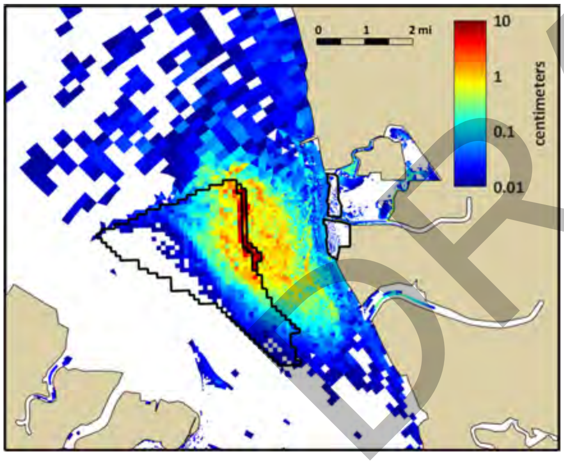
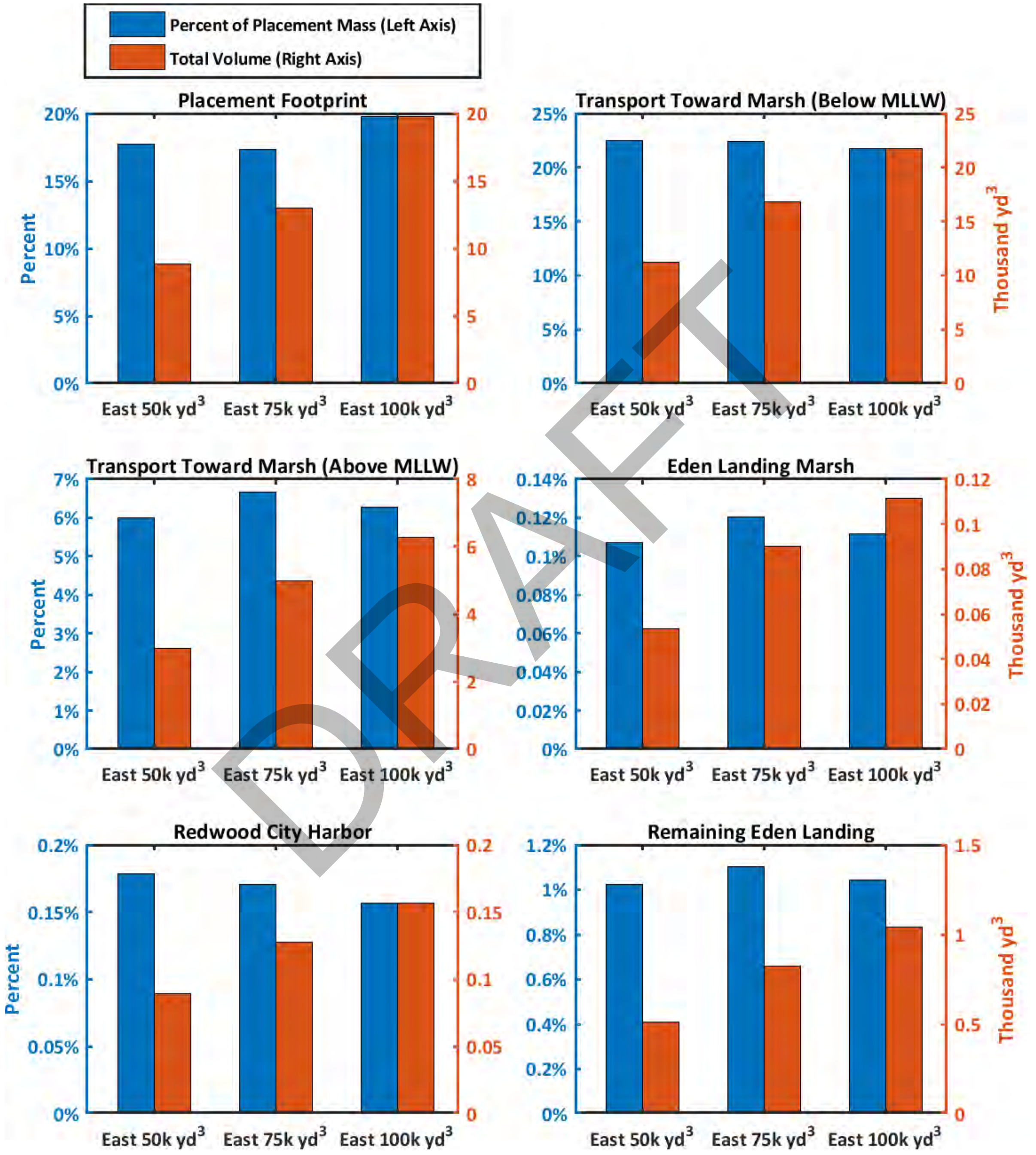


Figure 5.4-2

Predicted Percentage of Dredged Sediment Mass and Dredged Material Volume in Each Region at the End of the 2-Month Simulations for Evaluating the Placement Volume in the Shallow/East Placement Footprint



5.4.2 Evaluation of Sediment Source in the Shallow/East Placement Footprint

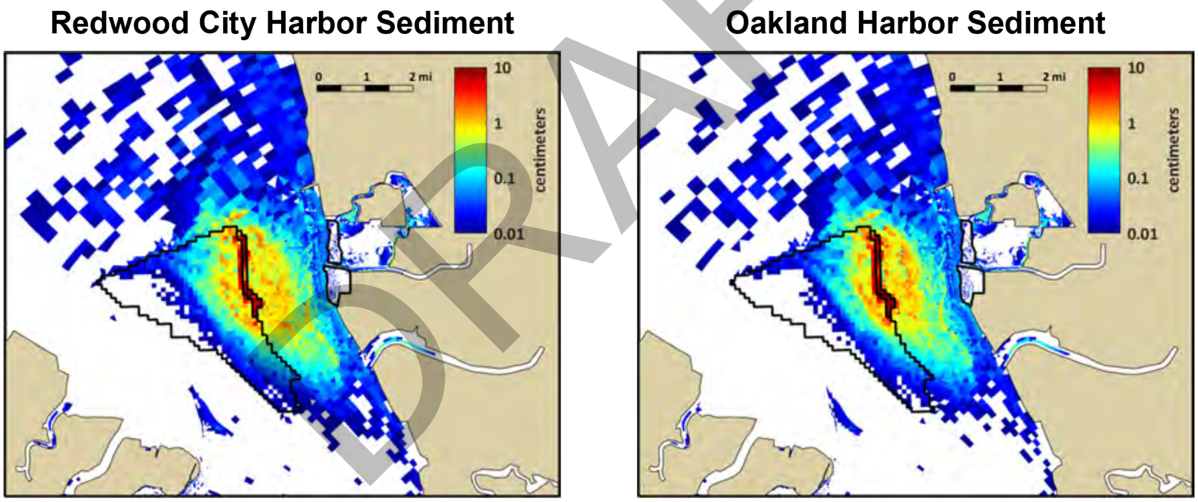
Dredged material placements were conducted in the Eden Landing shallow/east placement footprint using 100,000 yd^3 of dredged material sourced from Redwood City Harbor and Oakland Harbor. The sediment from Oakland Harbor has roughly twice as much sand as the sediment from Redwood City Harbor (Tables 3.2-2 and 3.2-3). Dispersal away from the placement footprint resulted in similar depositional patterns for each sediment source (Figure 5.4-3); however, the thickness of the dredged material deposition was slightly higher in and near the placement footprint with the Oakland Harbor sediment than with the Redwood City Harbor sediment. The slightly higher depositional thicknesses near the placement footprint when using Oakland Harbor sediment result from the increased sand content of the Oakland Harbor sediment because the sand is not transported as far from the placement footprint as the other sediment classes.

The percentage of dredged material dispersed to the various analysis regions was influenced by the source of the dredged material. Using sediment from Oakland Harbor resulted in a higher percentage of the placed dredged material remaining in the placement footprint at the end of the 2-month simulation than using sediment from Redwood City Harbor (Figure 5.4-4 and Table 5.1-4). For the Eden Landing scenario using Redwood City Harbor sediment, 20% of the dredged material was predicted to remain in the placement footprint at the end of the simulation, compared to 27% remaining in the placement footprint for the Oakland Harbor Sediment scenario. There was a corresponding decrease in the percentage of dredged material dispersed toward the marsh and deposited above MLLW, dispersed into Eden Landing, and dispersed into the remaining portion of the Eden Landing complex. At the end of the simulation, 0.1% of the dredged material was predicted to deposit in the Whale's Tail portion of Eden Landing Marsh for both the Eden Landing Redwood City Harbor and Oakland Harbor Sediment scenarios. For the Eden Landing scenario using Redwood City Harbor sediment, 6% of the dredged material was predicted to deposit above MLLW bayward of the marsh at the end of the simulation, compared to 5% for the Oakland Harbor Sediment scenario. At the end of the simulation, 1% of the dredged material was predicted to deposit in the remaining portion of Eden Landing for the scenario using Redwood City Harbor sediment, compared to 0.8% deposited in the remaining portion of Eden Landing for the Oakland Harbor Sediment scenario.

The increased sand content of the Oakland Harbor sediment relative to sediment from Redwood City Harbor resulted in a lower percentage of the placed material being transported out of the placement footprint and transported toward the marsh. Although, the percentage of dredged material transported toward Eden Landing Marsh when placing Oakland Harbor sediment was still higher than when placing Redwood City Harbor sediment in either of the middle or deep placement locations (Table 5.1-4).

The volume of dredged material dispersed to the various analysis regions was influenced by the source of the dredged material. Because both scenarios used 100,000 yd^3 of dredged material, the volume of dredged material transported to the analysis regions correlates with the percentages of dredged material detailed in the previous paragraph. Using sediment from Oakland Harbor resulted in a larger volume of the placed dredged material remaining in the placement footprint at the end of the 2-month simulation than what remained using sediment from Redwood City Harbor (Figure 5.4-4 and Table 5.1-5). There was a corresponding decrease in the volume of dredged material dispersed toward the marsh and deposited above MLLW, dispersed into Eden Landing, and dispersed into the remaining portion of the Eden Landing complex. Although, the volume of dredged material transported toward Eden Landing Marsh when placing Oakland Harbor sediment was still higher than when placing Redwood City Harbor sediment in either of the middle or deep placement locations (Table 5.1-5).

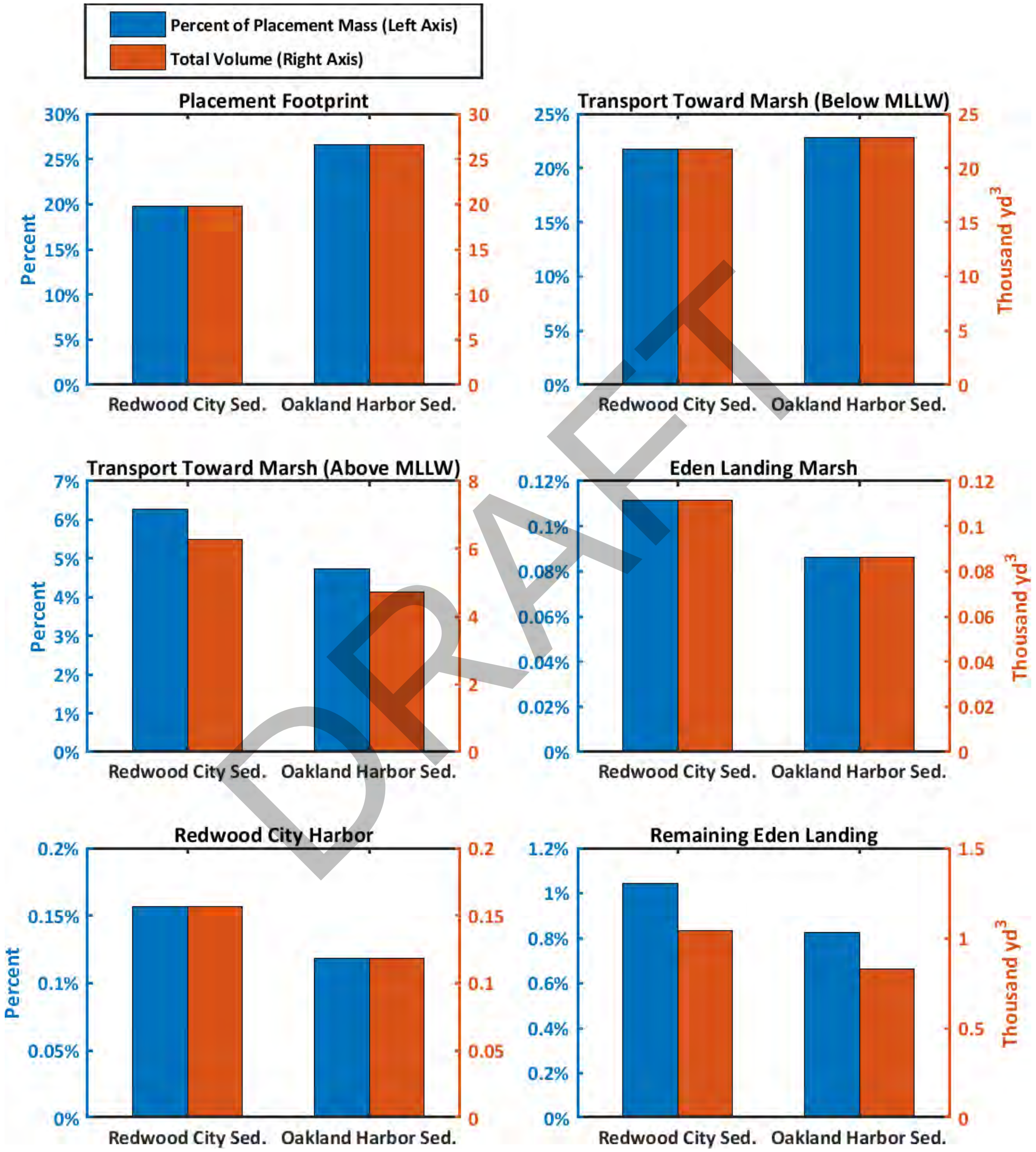
Figure 5.4-3
Predicted Thickness of Dredged Material at the End of the 2-Month Simulations for Evaluating the Sediment Source in the Shallow/East Placement Footprint


Redwood City Harbor Sediment

Oakland Harbor Sediment

Figure 5.4-4

Predicted Percentage of Dredged Sediment Mass and Dredged Material Volume in Each Region at the End of the 2-Month Simulations for Evaluating the Sediment Source in the Shallow/East Placement Footprint



Note:
Sed.: sediment

5.4.3 Evaluation of Placements During the Summer Versus Winter in the Shallow/East Placement Footprint

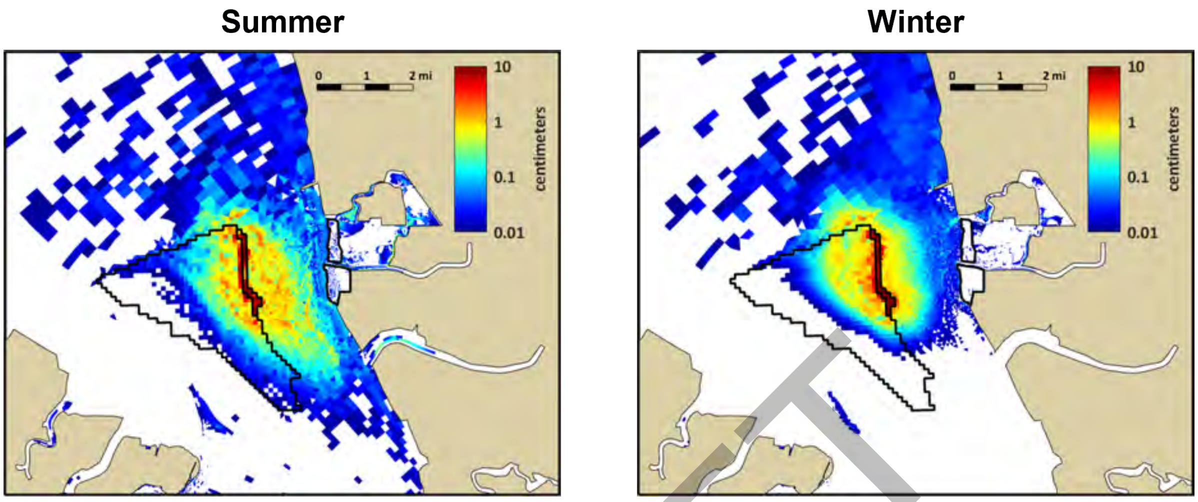
Dredged material placements were conducted in the Eden Landing shallow/east placement footprint using 100,000 yd^3 of dredged material, with placements occurring either in the summer or winter. Wind waves and resulting bed shear stresses are on average higher during the summer simulation period than the winter period (Section 4.1.3), potentially increasing resuspension and dispersal of the dredged material. Freshwater inflows to the Bay are lower in the summer period than during the winter period simulated, which can affect residual circulation and sediment transport in the Bay. Differences in wind speed and direction can also affect residual circulation, particularly in large shallow areas like the eastern side of South Bay. The northward depth-averaged residual circulation was faster during the winter simulation period than during the summer (Figures 4.2-5 and 4.2-7). The winter simulation spanned 3 months, while the summer simulation only spanned 2 months.

Dispersal away from the placement footprint differed between the summer and winter periods and resulted in different depositional patterns for each period simulated (Figure 5.4-5). The deposition resulting from the summer placement was skewed toward the east and south from the placement footprint. However, the deposition resulting from the winter placement was roughly centered around the placement footprint, with additional deposition skewed north of the placement grid and along the shoreline toward the north. The difference in depositional patterns suggests less wave resuspension and dispersal away from the placement footprint and more northward dispersal during the winter period than during the summer period. Lower RMS bed shear stresses during the winter period than during the summer period (Section 4.1.3) supports less wave resuspension during the winter period than during the summer period. Faster northward depth-averaged residual currents during the winter period than during the summer period supports the finding of increased northward sediment dispersal during the winter period than during the summer period.

The percentage of dredged material dispersed to the various analysis regions was influenced by the seasonal period simulated. Conducting the placements during the winter resulted in a higher percentage of the placed dredged material remaining in the placement footprint at the end of the simulations than conducting the placements during the summer (Figure 5.4-6 and Table 5.1-4), even though the winter simulation was 50% longer duration (3 months instead of 2 months). For the Eden Landing Shallow/East scenario, 20% of the dredged material was predicted to remain in the placement footprint at the end of the simulation, compared to 32% remaining in the placement footprint for the Eden Landing Shallow/East Winter scenario. There was a corresponding decrease in the percentage of dredged material dispersed toward the marsh and deposited both below and above MLLW, dispersed into Eden Landing, and dispersed into the remaining portion of the Eden Landing complex. At the end of the simulation, 0.1% of the dredged material was predicted to deposit in the Whale’s Tail portion of Eden Landing Marsh for the Eden Landing Shallow/East scenario, compared to less than 0.1% for the Shallow/East Winter scenario. For the Eden Landing Shallow/East scenario, 6% of the dredged material was predicted to deposit above MLLW bayward of the marsh at the end of the simulation, compared to 2% for the Shallow/East Winter scenario. At the end of the simulation, 1% of the dredged material was predicted to deposit in the remaining portion of Eden Landing for the Eden Landing Shallow/East scenario, compared to 0.3% deposited in the remaining portion of Eden Landing for the Shallow/East Winter scenario. The percentage of dredged material dispersed toward Eden Landing and deposited above MLLW and transported into Eden Landing Marsh when conducting the placements in the winter was similar to when placing sediment in either of the middle or deep placement locations during the summer (Table 5.1-4). Conducting the placements during the winter resulted in a lower percentage of dredged material being transported south of Dumbarton Bridge and a higher percentage of dredged material transported north of the Bay Bridge than when conducting placements during the summer (Table 5.1-4).

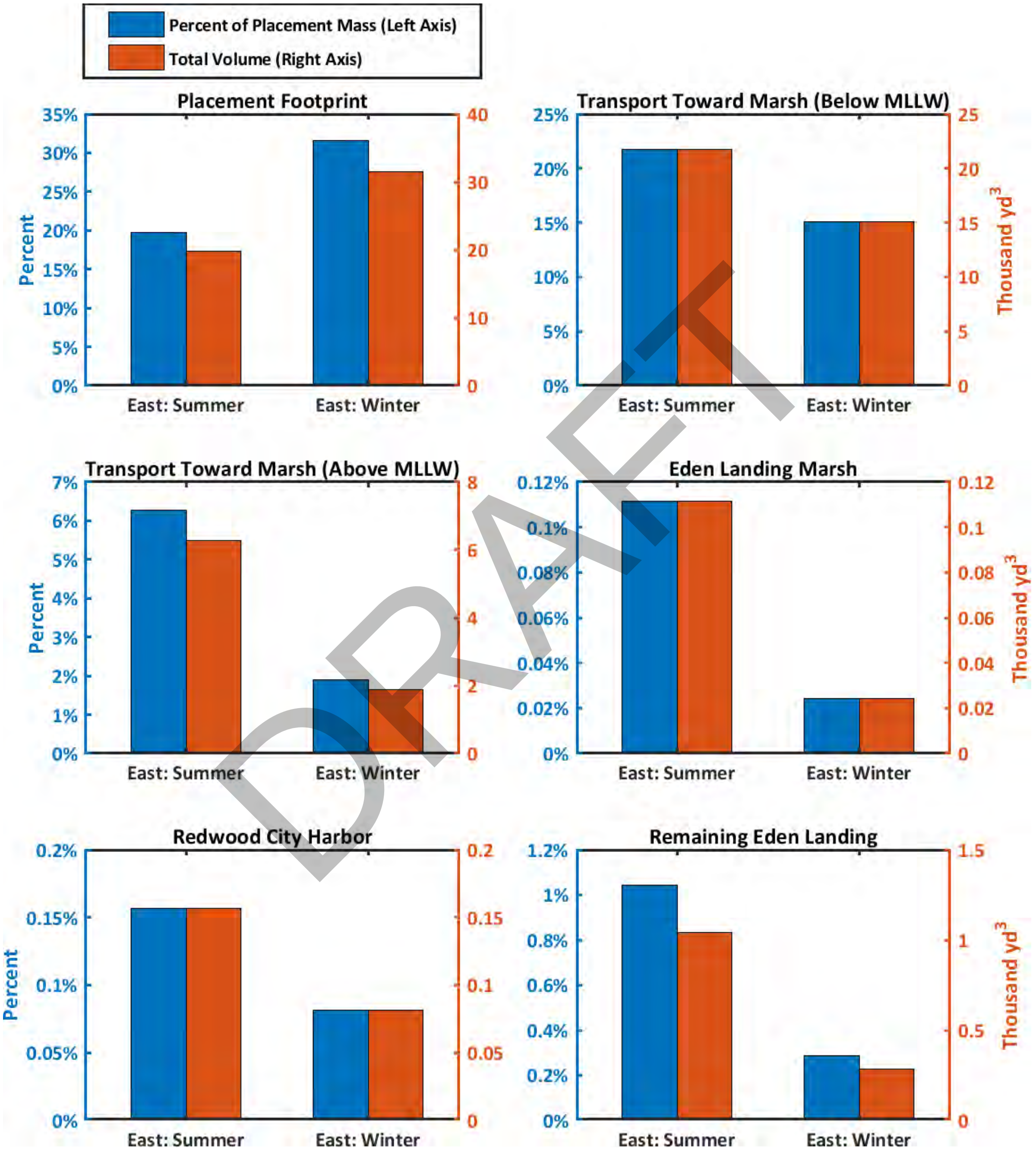
The volume of dredged material dispersed to the various analysis regions was influenced by the seasonal period simulated. Because both scenarios used 100,000 yd^3 of dredged material, the volume of dredged material transported to the analysis regions correlates with the percentages of dredged material detailed in the previous paragraph. Conducting the placements during the winter resulted in a higher volume of the placed dredged material remaining in the placement footprint at the end of the simulations than conducting the placements during the summer (Figure 5.4-6 and Table 5.1-5), even though the duration of the winter simulation was 50% longer (3 months instead of 2 months). There was a corresponding decrease in the volume of dredged material dispersed toward the marsh and deposited both below and above MLLW, dispersed into Eden Landing, and dispersed into the remaining portion of the Eden Landing complex. The volume of dredged material dispersed toward Eden Landing and deposited above MLLW and transported into Eden Landing Marsh when conducting the placements in the winter was similar to when placing sediment in either of the middle or deep placement locations during the summer (Table 5.1-5). Conducting the placements during the winter resulted in a lower volume of dredged material being transported south of Dumbarton Bridge and a higher volume of dredged material transported north of the Bay Bridge than when conducting placements during the summer (Table 5.1-5).

Figure 5.4-5
Predicted Thickness of Dredged Material at the End of the Simulations for Evaluating Summer Versus Winter Placements in the Shallow/East Placement Footprint


Summer
Winter

Note:
The summer placement was a 2-month simulation; the winter placement was a 3-month simulation.

Figure 5.4-6
Predicted Percentage of Dredged Sediment Mass and Dredged Material Volume in Each Region at the End of the Simulations for Evaluating Summer Versus Winter Placements in the Shallow/East Placement Footprint



Note:
The summer placement was a 2-month simulation; the winter placement was a 3-month simulation.

5.4.4 Evaluation of Conducting Placements in the Shallow/East Placement Footprint Versus an Expanded Footprint

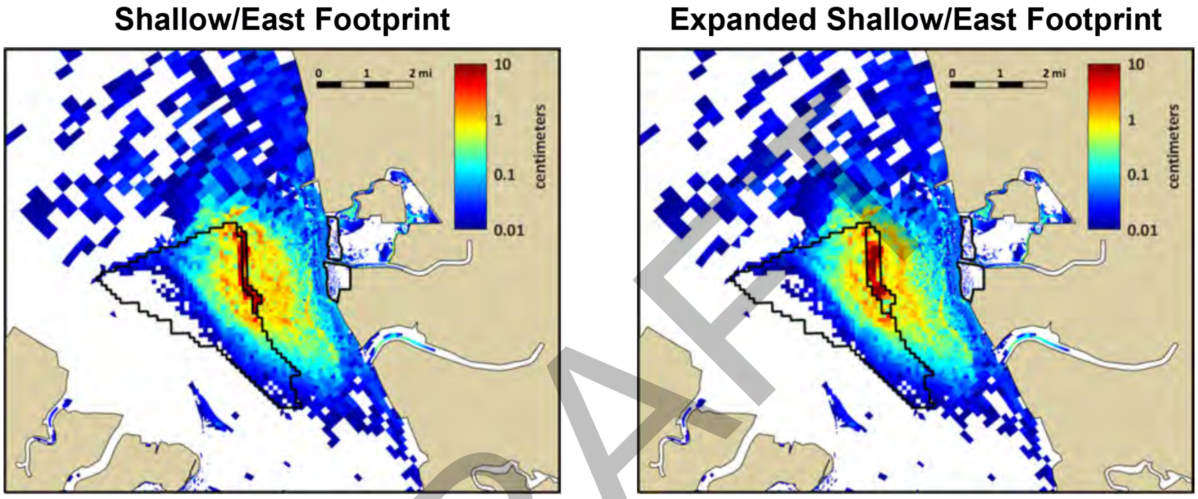
Dredged material placements were conducted in the Eden Landing shallow/east placement footprint and in an expanded shallow/east footprint using 100,000 yd^3 of dredged material. The shallow/east footprint runs along the eastern edge of the placement grid. While the expanded footprint includes all of the placement cells in the original shallow/east footprint, the expanded footprint also includes placement cells to the west of the boundary of the placement grid.

Overall, the depositional pattern resulting from conducting placements in the shallow/east footprint and the expanded footprint were similar (Figure 5.4-7). There was slightly more predicted deposition east of the placement grid when using the shallow/east footprint than when using the expanded footprint.

The percentage of dredged material dispersed to the various analysis regions was influenced by the westward expansion of the placement footprint. Using the expanded placement footprint resulted in a higher percentage of the placed dredged material remaining in the placement footprint at the end of the 2-month simulation versus using the shallow/east placement footprint (Figure 5.4-4 and Table 5.1-4). For the Eden Landing Shallow/East scenario, 20% of the dredged material was predicted to remain in the placement footprint at the end of the simulation, compared to 34% remaining in the placement footprint for the Expanded Shallow/East scenario. There was a corresponding slight decrease in the percentage of dredged material dispersed toward the marsh, dispersed into Eden Landing, and dispersed into the remaining portion of the Eden Landing complex. Although, the percentage of dredged material transported toward Eden Landing Marsh when using the expanded placement footprint was still higher than when placing sediment in either of the middle or deep placement locations (Table 5.1-4). At the end of the simulation, 0.1% of the dredged material was predicted to deposit in the Whale’s Tail portion of Eden Landing Marsh for both the Eden Landing Shallow/East and Expanded Shallow/East scenarios. For the Eden Landing Shallow/East scenario, 6% of the dredged material was predicted to deposit above MLLW bayward of the marsh at the end of the simulation, compared to 5% for the Expanded Shallow/East scenario. At the end of the simulation, 1% of the dredged material was predicted to deposit in the remaining portion of Eden Landing for the Eden Landing Shallow/East scenario, compared to 0.9% deposited in the remaining portion of Eden Landing for the Expanded Shallow/East scenario.

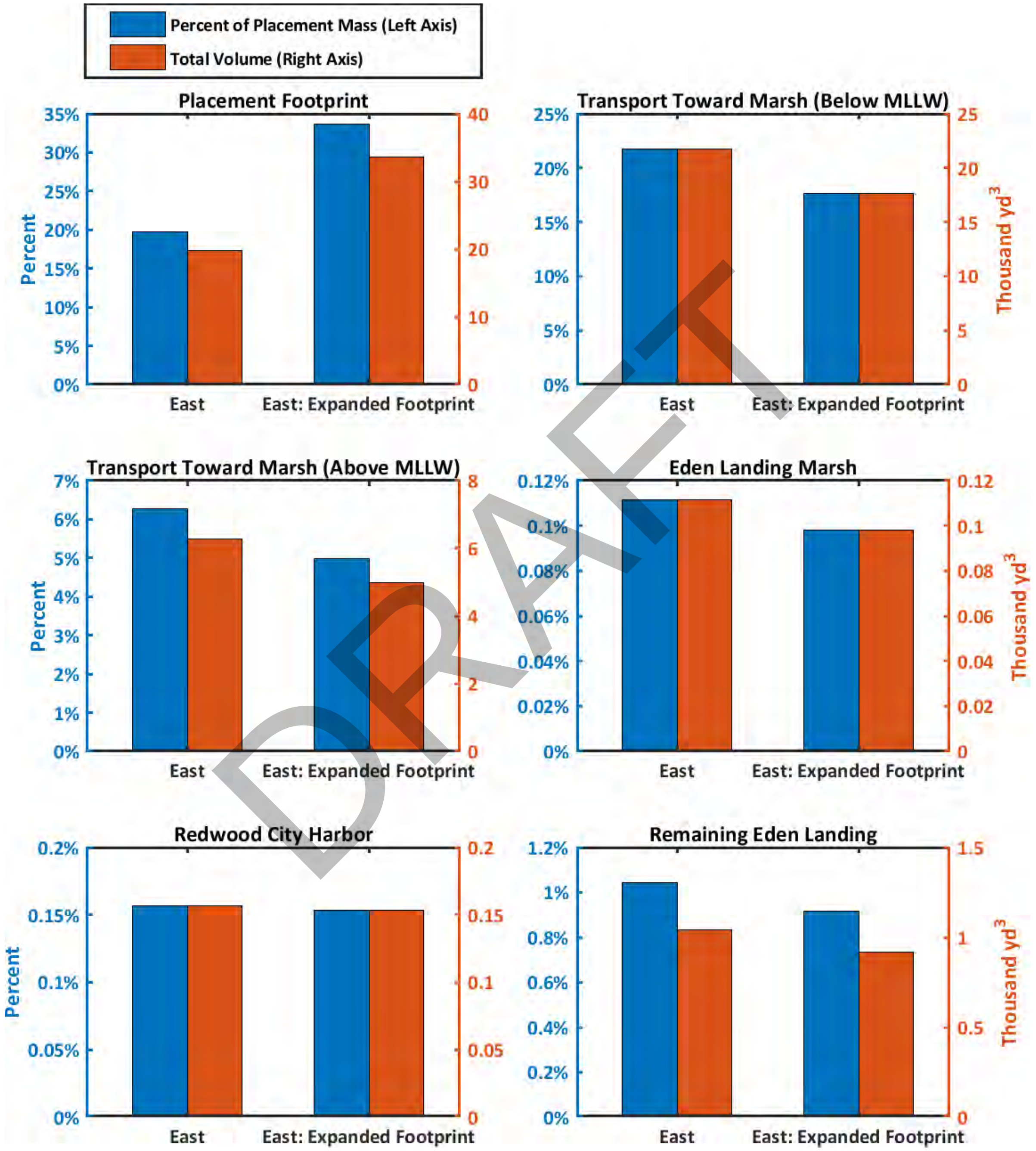
The volume of dredged material dispersed to the various analysis regions was influenced by the westward expansion of the placement footprint. Because both scenarios used 100,000 yd^3 of dredged material, the volume of dredged material transported to the analysis regions correlates with the percentages of dredged material detailed in the previous paragraph. Using the expanded placement footprint resulted in a greater volume of the placed dredged material remaining in the placement footprint at the end of the 2-month simulation versus using the shallow/east placement footprint (Figure 5.4-4 and Table 5.1-5). There was a corresponding slight decrease in the volume of dredged material dispersed toward the marsh, dispersed into Eden Landing, and dispersed into the remaining portion of the Eden Landing complex. Although, the volume of dredged material transported toward Eden Landing Marsh when using the expanded placement footprint was still higher than when placing sediment in either of the middle or deep placement locations (Table 5.1-5).

Figure 5.4-7
Predicted Thickness of Dredged Material at the End of the 2-Month Simulations for Evaluating an Expanded Shallow/East Placement Footprint


Shallow/East Footprint

Expanded Shallow/East Footprint

Figure 5.4-8
Predicted Percentage of Dredged Sediment Mass and Dredged Material Volume in Each Region at the End of the 2-Month Simulations for Evaluating an Expanded Shallow/East Placement Footprint



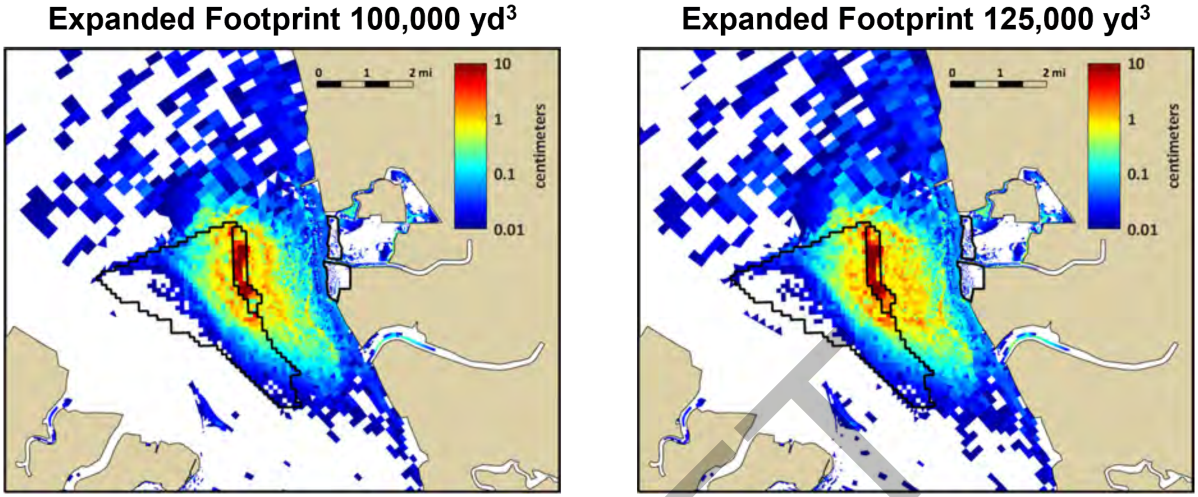
5.4.5 Evaluation of Placement Volume in the Expanded East Placement Footprint

Dredged material placements were conducted in the Eden Landing expanded shallow/east placement footprint using 100,000 yd^3 and 125,000 yd^3 of dredged material. Overall, the depositional pattern resulting from conducting placements in the expanded footprint using 100,000 yd^3 and 125,000 yd^3 of dredged material were similar (Figure 5.4-9). The depositional thicknesses were higher in the 125,000 yd^3 scenario than in the 100,000 yd^3 scenario.

The percentage of dredged material dispersed to the various analysis regions was similar, regardless of the placement volumes considered (Figure 5.4-10 and Table 5.1-4). The placement of different volumes of dredged material, 100,000 yd^3 or 125,000 yd^3, in the expanded shallow/east placement footprint resulted in only small differences in the percentage of the dredged material transported to the analysis regions over the 2 months of the simulations. For the Eden Landing Expanded Shallow/East 100,000 yd^3 scenario, 34% of the dredged material was predicted to remain in the placement footprint at the end of the simulation, compared to 33% remaining in the placement footprint for the Expanded Shallow/East 125,000 yd^3 scenario. At the end of the simulation, 0.1% of the dredged material was predicted to deposit in the Whale's Tail portion of Eden Landing Marsh for both the Eden Landing Expanded Shallow/East 100,000 yd^3 and Expanded Shallow/East 125,000 yd^3 scenarios. For the Eden Landing Expanded Shallow/East 100,000 yd^3 scenario, 5% of the dredged material was predicted to deposit above MLLW bayward of the marsh at the end of the simulation, compared to 6% for the Expanded Shallow/East 125,000 yd^3 scenario. At the end of the simulation, 0.9% of the dredged material was predicted to deposit in the remaining portion of Eden Landing for both the Eden Landing Expanded Shallow/East 100,000 yd^3 and Expanded Shallow/East 125,000 yd^3 scenarios.

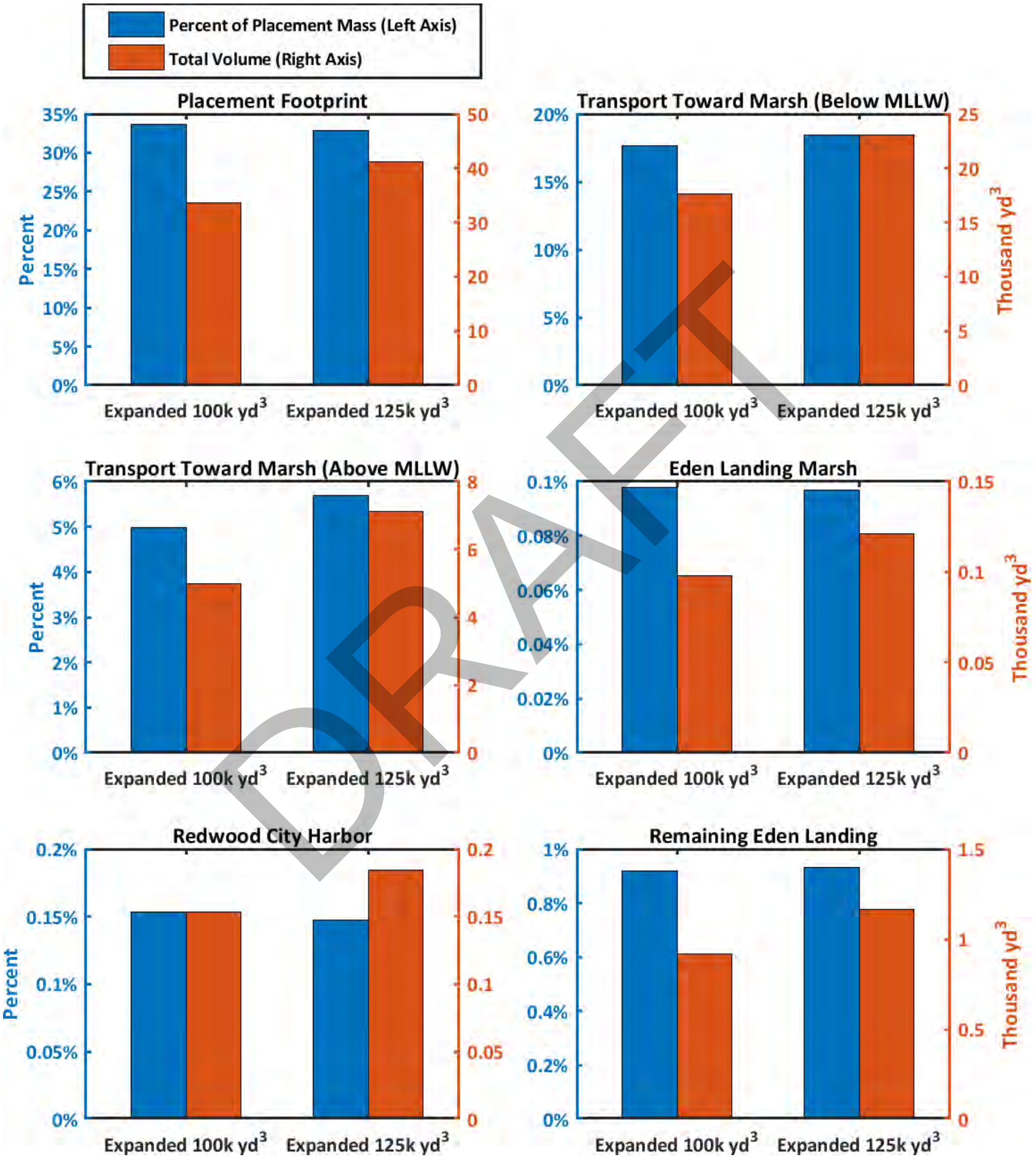
Because each scenario included a different volume of dredged material, the volume of dredged material dispersed to each analysis region was different for each scenario. The scenario with 125,000 yd^3 of dredged material had the most predicted dispersal to each analysis region (Figure 5.4-10 and Table 5.1-5). The scenario with 125,000 yd^3 of dredged material resulted in the transport of more dredged material toward and into Eden Landing Marsh than the scenario with a lower total placement volume.

Figure 5.4-9
Predicted Thickness of Dredged Material at the End of the 2-Month Simulations for Evaluating Placement Volume in the Expanded Shallow/East Placement Footprint


Expanded Footprint 100,000 yd^3

Expanded Footprint 125,000 yd^3

Figure 5.4-10
Predicted Percentage of Dredged Sediment Mass and Dredged Material Volume in Each Region at the End of the 2-Month Simulations for Evaluating Placement Volume in the Expanded Shallow/East Placement Footprint



6 Summary and Conclusions

Previous sediment transport modeling in San Francisco Bay focused on the dispersal of dredged material south of Dumbarton Bridge and demonstrated that dredged material could be naturally transported into breached salt ponds and onto mudflats (Bever and MacWilliams 2014; Bever et al. 2014). The study detailed in this report takes a similar approach and simulates the continual erosion, deposition, and transport of dredged material following open-water placements in San Francisco Bay.

In support of the WRDA Section 1122 Pilot Project in San Francisco Bay, a 3D hydrodynamic, wave, and sediment transport model was applied to predict the fate and transport of open-water dredged material placements in San Francisco Bay. This modeling was used to evaluate the suitability of two potential placement sites for implementation of the pilot study and to assess the most effective placement strategy for each site. A total of 12 sediment transport modeling scenarios were conducted to evaluate how the location of the placements, total volume of placed material, dredged material source, and seasonal timing of the placement affect dispersal away from the placement location.

Dredged material placement scenarios were conducted near two marshes in San Francisco Bay, Emeryville Crescent Marsh (Figure 1-1) and the Whale's Tail portion of Eden Landing Marsh (Figure 1-2). These two marshes were the target marshes for the natural dispersal of dredged material. The surface elevations of both of these marshes are high enough that the majority of the inundation and sediment transport onto the marshes will occur when water surface elevations are near MHHW or higher.

Predicted wave characteristics and wave-induced bed shear stress were evaluated to qualitatively determine differences within a placement area based on varying water depths, between summer versus winter periods, and between the Emeryville and Eden Landing placement areas. Significant wave height, bottom orbital velocity, and bed shear stress were higher during the summer period than during the winter period at both Emeryville and Eden Landing. The larger waves and higher bed shear stress result from the seasonally stronger winds in late-spring and early-summer than during the winter. The bottom orbital velocity and bed shear stress that act to resuspend sediment were the lowest on the western side of the placement grids and highest on the eastern side, at both Emeryville and Eden Landing. This results from the shallowing of the placement grids from the western to the eastern side and the increasing effect of wind waves as the water depth gets lower. The bed shear stress was further evaluated based on a 0.2-Pa cutoff. At Emeryville, the RMS bed shear stress was greater than the 0.2-Pa threshold over much of the placement grid. However, at Eden Landing, the RMS bed shear stress was only greater than this threshold toward the eastern side of the placement grid.

A total of 12 dredged material placement scenarios were conducted using the UnTRIM Bay-Delta model. A two-stage approach was used to develop the assumptions for the 12 scenarios. The first six scenarios were used to evaluate whether Emeryville or Eden Landing was most suitable for pilot study and to evaluate different placement strategies at each location to narrow in on most effective placement strategy. The remaining six scenarios were conducted to evaluate other aspects of the placements at Eden Landing, including the following:

- The placement volume in the shallow/east placement footprint
- The sediment source in the shallow/east placement footprint
- Placements during the summer versus winter in the shallow/east placement footprint
- Conducting placements in the shallow/east placement footprint versus an expanded footprint
- The placement volume in the expanded east placement footprint

Based on the initial six scenarios that evaluated placements at Emeryville and Eden Landing in the deep, middle, and shallow/east portions of the placement grids at each site, the highest percentage of the dredged material was transported toward and supplied to the respective marshes in the shallow/east placement scenarios for the Emeryville and Eden Landing placement locations. The deep placement scenarios resulted in the most dredged material being transported back into the federal navigation channels. The deep scenarios also resulted in the largest percentage of dredged material being dispersed away from any of the other analysis regions.

A lower percentage of the dredged material was predicted to remain in the placement footprints in the Eden Landing scenarios than in the scenarios with dredged material placements at Emeryville. This indicates more predicted dispersal from the Eden Landing placement footprints than from the Emeryville placement footprints. The Eden Landing scenarios also had more predicted deposition in the target marsh and on other mudflats and marshes—that is, above MLLW outside Eden Landing Marsh or Emeryville Crescent Marsh. The Eden Landing placement location was also predicted to supply dredged material to the other portion of the Eden Landing complex, not simply the Whale’s Tail portion of Eden Landing Marsh.

These findings suggest the Eden Landing placement location may be more suitable than the Emeryville placement location for the natural transport of dredged material away from the initial placement footprint and toward the marsh and to other mudflats/marshes. The findings also demonstrate that placements toward the shallower (eastern) side of the placement grids are more effective at getting transport toward the marshes and mudflats than placements in deeper water further toward the west of the placement grids.

Dredged material placements were conducted in the Eden Landing shallow/east placement footprint using 100,000 yd^3, 75,000 yd^3, and 50,000 yd^3 of dredged material. For the range of placement volumes simulated, the model predicted that the percentage of dredged material dispersed to the various analysis regions was similar, regardless of the placement volumes considered. Because each scenario included a different volume of dredged material, the volume of dredged material dispersed to each analysis region was different for each scenario. The scenario with 100,000 yd^3 of dredged material had the most predicted dispersal to each analysis region, followed by the scenario with 75,000 yd^3 of dredged material, and the scenario with 50,000 yd^3 of dredged material had the lowest predicted volume of dredged material in each region at the end of the simulations. The scenario with 100,000 yd^3 of dredged material resulted in the transport of more dredged material toward and into Eden Landing Marsh than the scenarios with a lower total placement volume.

Dredged material placements were conducted in the Eden Landing shallow/east placement footprint using 100,000 yd^3 of dredged material sourced from Redwood City Harbor and Oakland Harbor. The sediment from Oakland Harbor has roughly twice as much sand as the sediment from Redwood City Harbor, and the sand is not transported as far as the other sediment classes used in this sediment transport modeling study. The percentage of dredged material dispersed to the various analysis regions was influenced by the source of the dredged material. The increased sand content of the Oakland Harbor sediment relative to sediment from Redwood City Harbor resulted in a lower percentage of the placed material being transported out of the placement footprint and transported toward the marsh than when placing sediment sourced from Redwood City Harbor. However, the percentage of dredged material transported toward Eden Landing Marsh when placing Oakland Harbor sediment was still higher than when placing Redwood City Harbor sediment in either of the Eden Landing middle or deep placement locations. Because both scenarios used 100,000 yd^3 of dredged material, the volume of dredged material transported to the analysis regions correlates with the percentages of dredged material dispersed to the analysis regions. The comparison of these two scenarios showed that the source of the dredged material influenced the percentages and volumes of material dispersed to the analysis regions, but the effects were smaller than when shifting the placement footprint toward the west. However, the effects of the source of the dredged material could become larger if the sand content of the dredged material was higher than the sand content of the dredged material simulated for these scenarios.

Dredged material placements were conducted in the Eden Landing shallow/east placement footprint using 100,000 yd^3 of dredged material and placements occurring in the summer and winter. The winter simulation spanned 3 months, while the summer simulation only spanned 2 months. The percentage of dredged material dispersed to the various analysis regions was influenced by the seasonal period simulated. Conducting the placements during the winter resulted in a higher percentage of the placed dredged material remaining in the placement footprint at the end of the simulations than conducting the placements during the summer, even though the duration of the winter simulation was 50% longer (3 months instead of 2 months). There was a corresponding decrease in the percentage of dredged material dispersed toward the marsh and deposited both below and above MLLW, dispersed into Eden Landing, and dispersed into the remaining portion of the Eden Landing complex. When conducting the placements in the winter, the percentage of dredged material dispersed toward Eden Landing and deposited above MLLW and transported into Eden Landing Marsh was similar to when placing sediment in either of the middle or deep placement locations during the summer. Because both scenarios used 100,000 yd^3 of dredged material, the volume of dredged material transported to the analysis regions correlates with the percentages of dredged material dispersed to the analysis regions. There was increased predicted northward transport of dredged material in the winter period than the summer period, possibly resulting from the increased northward depth-averaged residual velocity in the winter compared to the summer. The comparison of these two scenarios indicates that differences in waves and hydrodynamics and the seasonal timing of the placements influences the dispersal away from the placement locations, especially when only considering dispersal over a 2- to 3-month period.

Dredged material placements were conducted in the Eden Landing shallow/east placement footprint and in an expanded shallow/east footprint using 100,000 yd^3 of dredged material. While the expanded footprint includes all of the placement cells in the original shallow/east footprint, the expanded footprint also includes placement cells to the west of the boundary of the placement grid. The percentage of dredged material dispersed to the various analysis regions was influenced by the westward expansion of the placement footprint. Using the expanded placement footprint resulted in a higher percentage of the placed dredged material remaining in the placement footprint at the end of the 2-month simulation versus using the shallow/east placement footprint. There was a corresponding slight decrease in the percentage of dredged material dispersed toward the marsh, dispersed into Eden Landing, and dispersed into the remaining portion of the Eden Landing complex. However, the percentage of dredged material transported toward Eden Landing Marsh when using the expanded placement footprint was still higher than when placing sediment in either of the middle or deep placement locations. Because both scenarios used 100,000 yd^3 of dredged material, the volume of dredged material transported to the analysis regions correlates with the percentages of dredged material dispersed to the analysis regions.

Dredged material placements were conducted in the Eden Landing expanded shallow/east placement footprint using 100,000 yd^3 and 125,000 yd^3 of dredged material. The percentage of dredged material dispersed to the various analysis regions was similar, regardless of the placement volumes considered. Because each scenario included a different volume of dredged material, the volume of dredged material dispersed to each analysis region was different for each scenario. The scenario with 125,000 yd^3 of dredged material had the most predicted dispersal to each analysis region. The scenario with 125,000 yd^3 of dredged material resulted in the transport of more dredged material toward and into Eden Landing Marsh than the scenario with a lower total placement volume.

This modeling study evaluated dispersal using discrete placement volumes ranging from 50,000 yd^3 to 125,000 yd^3 and simulations that spanned either 2 or 3 months. The periods simulated for this study were relatively short due to the limited timeline to complete the analysis to support site selection. It is expected that dredged material predicted to remain in the placement footprint or being transported toward the target marsh will continually be transported over time and that a larger fraction of that material will eventually reach the target marshes than was predicted over the first 2 to 3 months. However, because of the short duration of the simulations, there is uncertainty in attempting to extrapolate the results to a longer time period. This uncertainty in extrapolating the results to a longer time period (e.g., 1 year or more) is increased because a large portion of the dispersal away from the placement footprint occurs early in the simulations during the placements and because the results indicate large differences in dispersal between the summer and winter scenarios.

There is inherent uncertainty in the application of hydrodynamic models to predict sediment transport, and a number of assumptions were made to represent the placement of dredged material for this study. Some of these assumptions and limitations are described in Appendix B. Many of these assumptions are likely to affect the scenarios similarly, so the relative comparison between placement sites is less likely to be affected by this uncertainty than the exact magnitude of the deposited sediment. There is greater uncertainty in the exact magnitude of the predicted sediment deposition thicknesses, largely due to the absence of any data to validate the predicted deposition following actual dredged material placements in San Francisco Bay. Additional modeling following the implementation of the 1122 pilot project in San Francisco Bay and validation based on monitoring data collected during the pilot project can be used to further calibrate the model and reduce uncertainty in the long-term predictions of the sediment dispersal and deposition following placement.

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Appendix A
Model Validation

A.1 Summary

Because the UnTRIM Bay-Delta model has already been extensively calibrated for water levels, salinity, and flows (MacWilliams et al. 2015), no further model calibration was conducted as part of this study. To validate the prediction of suspended sediment concentration (SSC) in the study area, the predicted SSC was compared to observed SSC at all locations in San Francisco Bay where SSC measurements were available during the two analysis periods used in this study to evaluate the dredged material placement scenarios. This appendix provides model validations of SSC throughout the Bay during the period that dredged material dispersal was evaluated. Predicted SSC was compared to observed SSC using time series at discrete locations from Dumbarton Bridge to Mallard Island. Time series data were available from six locations through the U.S. Geological Survey (USGS; USGS 2020) and at another location in San Pablo Bay (Schoellhamer et al. 2008).

A.2 Statistics Used for Model Validation

Following the approach used by MacWilliams et al. (2015), model skill and target diagrams were used to provide quantitative metrics for evaluating model accuracy. Willmott (1981) defined the predictive skill of a model based on the quantitative agreement between observations (*O*) and model predictions (*M*), as shown in Equation A-1.

Equation A-1

$$Skill = 1 - \left[\sum_{i=1}^{N} \left| X_{Mi} - X_{Oi} \right|^2 \right] / \left[\sum_{i=1}^{N} \left(\left| X_{Mi} - \overline{X_O} \right| + \left| X_{Oi} - \overline{X_O} \right| \right)^2 \right]$$

where:

X = the variable being compared

$\bar{X}$ = time average of *X*

M_i = model value at time *i* of *N* total comparison times

O_i = observation at time *i*

Perfect agreement between model results and observations yields a skill of 1. Although the Willmott (1981) model skill metric has some shortcomings (Ralston et al. 2010), it has nevertheless been used for comparing model predictions to observed data in numerous hydrodynamic modeling studies (e.g., Warner et al. 2005b; Haidvogel et al. 2008; MacWilliams and Gross 2013; MacWilliams et al. 2015).

Jolliff et al. (2009) and Hofmann et al. (2011) provide detailed descriptions of target diagrams and their use in assessing model skill. This approach uses the *bias* and the unbiased root-mean-square difference (*ubRMSD*) to assess the accuracy of the model predictions. The *bias* of the model estimates is calculated as shown in Equation A-2.

Equation A-2

$$bias = \frac{1}{N}\sum_{i=1}^{N} X_{Mi} - \frac{1}{N}\sum_{i=1}^{N} X_{Oi}$$

The *ubRMSD* is calculated as shown in Equation A-3.

Equation A-3

$$ubRMSD = \left(\frac{1}{N}\sum_{i=1}^{N}\left[\left(X_{Mi} - \overline{X_M} \right) - \left(X_{Oi} - \overline{X_O} \right) \right]^2 \right)^{0.5}$$

To indicate whether the modeled variability is greater than or less than the observed variability, the *ubRMSD* is multiplied by the sign of the difference in the modeled and observed standard deviations, as shown in Equation A-4.

Equation A-4

$$ubRMSD_2 = ubRMSD(\sigma_M - \sigma_O)/|\sigma_M - \sigma_O|$$

where:

σ_M = modeled standard deviation

σ_O = observed standard deviation

The *bias* and the $ubRMSD_2$ are normalized (denoted by subscript *N*) by the observed standard deviation to make their absolute values comparable among different variables and different sets of observed data, as shown in Equations A-5 and A-6.

Equation A-5

$$bias_N = bias/\sigma_O$$

Equation A-6

$$ubRMSD_N = ubRMSD_2/\sigma_O$$

On each target diagram, the *bias$_N$* between modeled and observed values is plotted on the y-axis, and the *ubRMSD$_N$* is plotted on the x-axis. The radial distance from the origin to each data point is the normalized root-mean-square difference (*RMSD$_N$*), as shown in Equation A-7.

Equation A-7

$$RMSD_N = \sqrt{bias_N^2 + ubRMSD_N^2}$$

MacWilliams et al. (2015) provide a more detailed description of the model validation methods and suggest thresholds for the validation metrics that indicate model accuracy. These target diagram thresholds were adopted in this report to classify the model accuracy. Very accurate predictions are classified as those with an *RMSD$_N$* of less than 0.25, and accurate predictions are classified as those with an *RMSD$_N$* of less than 0.5. Acceptable predictions are indicated by an *RMSD$_N$* of less than 1.0, and an *RMSD$_N$* of greater than 1.0 indicates less accurate predictions.

A.3 Validation of Predicted SSC

Predicted SSCs were validated using continuous-monitoring time-series data at fixed locations in the Bay (Figures A-1 and A-2). Time-series SSC was validated at a total of seven locations, with four locations having both upper and lower sensors. This resulted in a total of 11 comparisons. Predicted SSC was validated for the 2009 and 2016 dredged material analysis periods separately, and not all locations were available for both years. The figures for comparing predicted and observed time series include an upper panel that highlights the instantaneous predicted and observed SSC over relatively short time intervals, tidal-averaged predicted and observed SSC on the lower left panel over the complete analysis period, and a scatter plot on the lower right panel incorporating the complete analysis period.

Using the thresholds for model accuracy from MacWilliams et al. (2015), SSC in 2016 to 2017 was acceptably predicted for five comparisons, but the *RMSD$_N$* was greater than 1.0 for three comparisons (Table A-1; Figures A-3 through A-11). At the Alcatraz station, predicted SSC accurately captured the increase in SSC as a result of the 2017 high Delta outflow period (Figure A-4). This suggests that the predicted SSC accurately captured the timing of the turbid pulse of water from elevated Delta outflow. The predicted SSC had similar tidal timescale variability to the observed SSC. The model did not capture the very short-duration spikes in observed SSC. At the Pier 17 station, predicted SSC also accurately captured the increase in SSC as a result of the 2017 high Delta outflow period and underestimated the relatively short-duration large-magnitude spikes in the observed SSC at Pier 17. Overall, the predicted SSC accurately reproduced the observed SSC from Benicia Bridge to Dumbarton Bridge.

Using the thresholds for model accuracy from MacWilliams et al. (2015), SSC in 2009 was acceptably predicted for six comparisons, but the $RMSD_N$ was greater than 1.0 for four comparisons (Table A-2; Figures A-12 through A-22). At the Alcatraz station, predicted SSC very accurately captured the tidal and spring-neap variability in the observed SSC (Figure A-13). At the Hamilton Disposal Site (Aquatic Transfer Facility) location on the San Pablo Bay shoals, the predicted SSC captured the tidal and spring-neap variability but did not capture the very short-duration spikes in observed SSC (Figure A-16). Overall, the predicted SSC accurately reproduced the observed SSC from Mallard Island to Dumbarton Bridge.

Table A-1
Predicted and Observed SSC, Cross-Correlation Statistics, Model Skill, and Target Diagram Statistics for SSC Continuous Monitoring Stations for the 2016-2017 Simulation

Station	Mean SSC		Cross Correlation		r^2	Skill	Target Diagram		
	Observed (mg/L)	Predicted (mg/L)	Amp Ratio	Lag (min)			$bias_N$	$ubRMSD_N$	$RMSD_N$
Alcatraz (ALC)	29.5	25.7	0.711	NA	0.445	0.801	-0.212	0.845	0.871
Pier 17 (P17)	50.1	32.1	0.287	NA	0.311	0.607	-0.398	-0.831	0.921
Richmond-San Rafael Bridge (RSR, Upper)	31.8	51.6	0.790	NA	0.366	0.706	0.494	1.061	1.170
Richmond-San Rafael Bridge (RSR, Lower)	63.2	69.7	0.396	NA	0.315	0.699	0.076	-0.840	0.843
Benicia Bridge (BEN, Upper)	63.0	36.0	0.308	8	0.716	0.650	-0.556	-0.719	0.909
Benicia Bridge (BEN, Lower)	100.0	67.5	0.123	24	0.129	0.500	-0.589	-0.933	1.103
Dumbarton Bridge (DUM, Upper)	71.8	56.5	0.241	47	0.366	0.602	-0.250	-0.823	0.860
Dumbarton Bridge (DUM, Lower)	129.4	69.4	0.163	23	0.347	0.498	-0.624	-0.867	1.068

Note:
The cross correlation did not find a maximum r^2 within a lag of ±60 minutes (indicated as "NA" for not applicable).

Table A-2
Predicted and Observed SSC, Cross-Correlation Statistics, Model Skill, and Target Diagram Statistics for SSC Continuous Monitoring Stations for the 2009 Simulation

Station	Mean SSC		Cross Correlation		r^2	Skill	Target Diagram		
	Observed (mg/L)	Predicted (mg/L)	Amp Ratio	Lag (min)			bias_N	ubRMSD_N	RMSD_N
Alcatraz (ALC)	18.5	16.2	0.677	-56	0.636	0.861	-0.302	-0.605	0.676
Richmond-San Rafael Bridge (RSR, Upper)	33.6	33.9	0.322	-7	0.378	0.679	0.012	-0.794	0.794
Richmond-San Rafael Bridge (RSR, Lower)	33.6	45.6	0.322	NA	0.224	0.600	0.405	-0.905	0.991
Hamilton Disposal Site (ATF)	71.8	58.7	0.213	5	0.331	0.561	-0.187	-0.843	0.863
Benicia Bridge (BEN, Upper)	34.6	42.2	0.257	23	0.242	0.611	0.493	-0.871	1.001
Benicia Bridge (BEN, Lower)	83.1	81.2	0.188	38	0.148	0.545	-0.049	-0.929	0.930
Mallard Island (MAL, Upper)	30.7	26.9	0.332	27	0.204	0.600	-0.529	-0.936	1.075
Mallard Island (MAL, Lower)	29.2	28.8	0.168	45	0.030	0.465	-0.048	-1.264	1.265
Dumbarton Bridge (DUM, Upper)	57.5	75.5	0.446	40	0.343	0.666	0.684	-0.829	1.075
Dumbarton Bridge (DUM, Lower)	90.4	88.6	0.280	52	0.311	0.647	-0.042	-0.832	0.833

Note:
The cross correlation did not find a maximum r^2 within a lag of ±60 minutes (indicated as "NA" for not applicable).

Figure A-1
SSC Continuous Monitoring Stations Used for Model Validation for the 2016 to 2017 Simulation Period

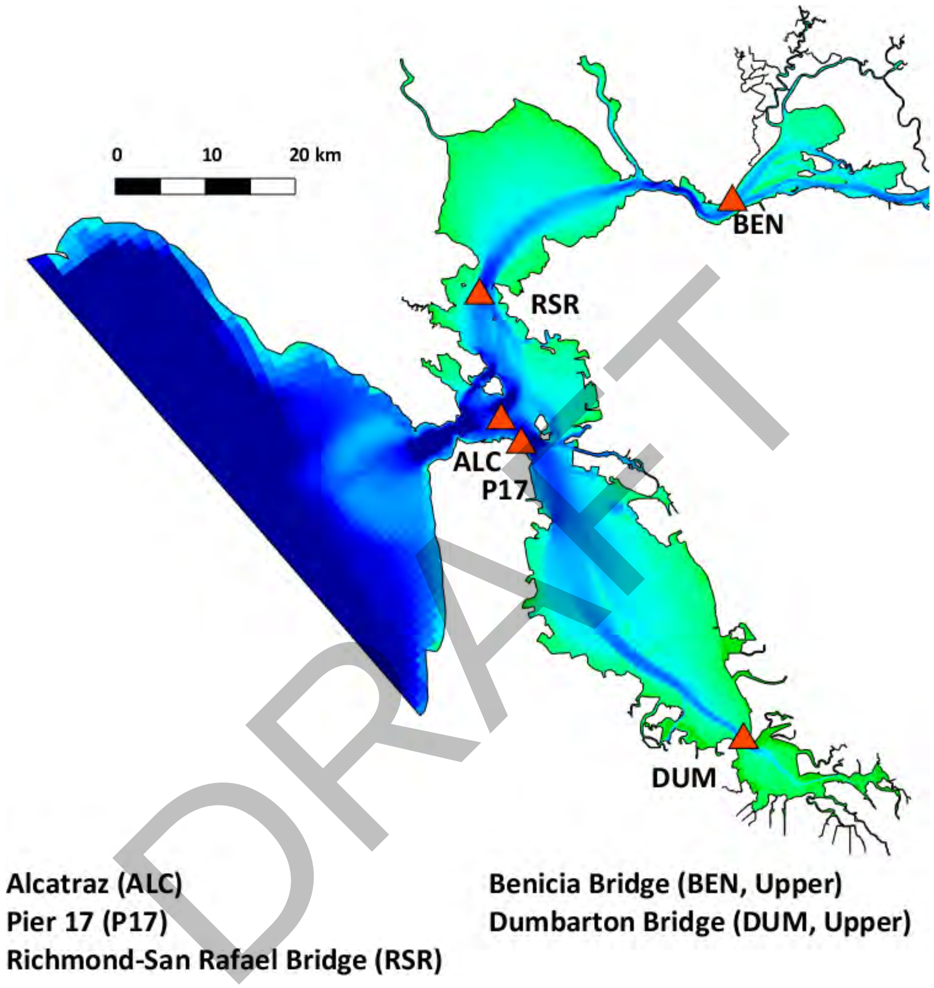


Figure A-2
SSC Continuous Monitoring Stations Used for Model Validation for the 2009 Simulation Period

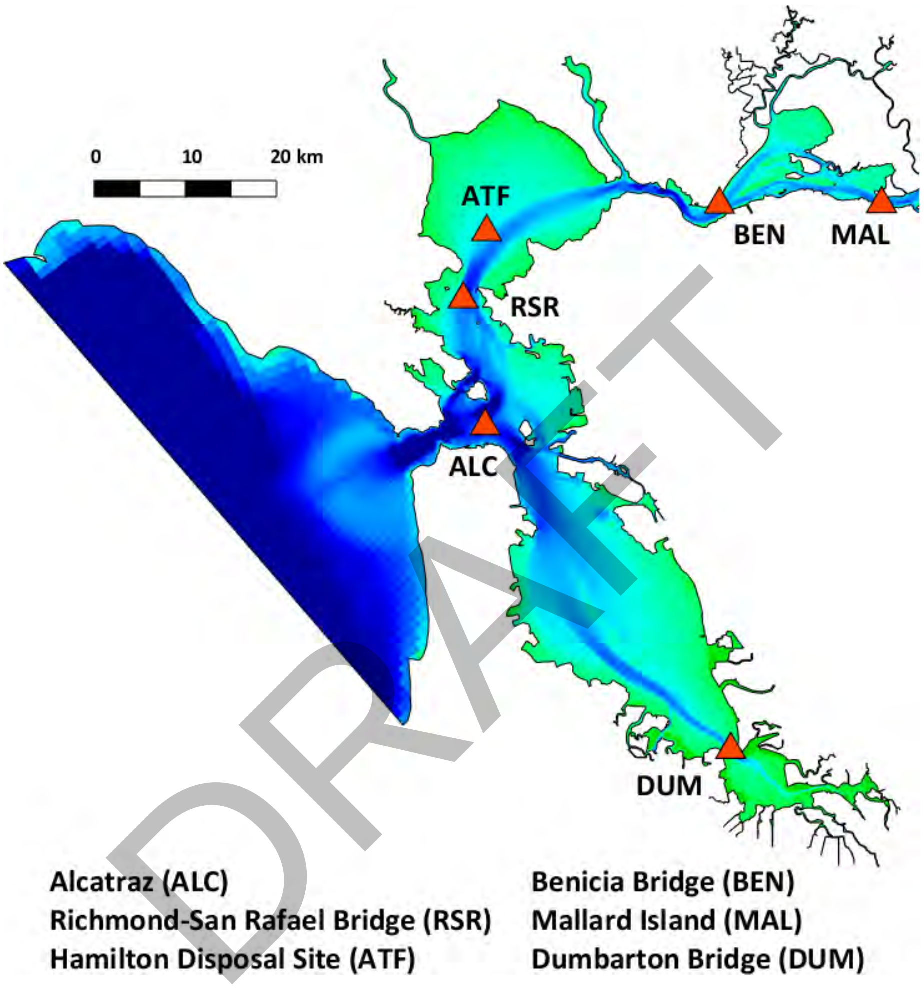


Figure A-3
Target Diagram Showing the Model Validation Using the Time Series SSC for the 2016 to 2017 Simulation Period

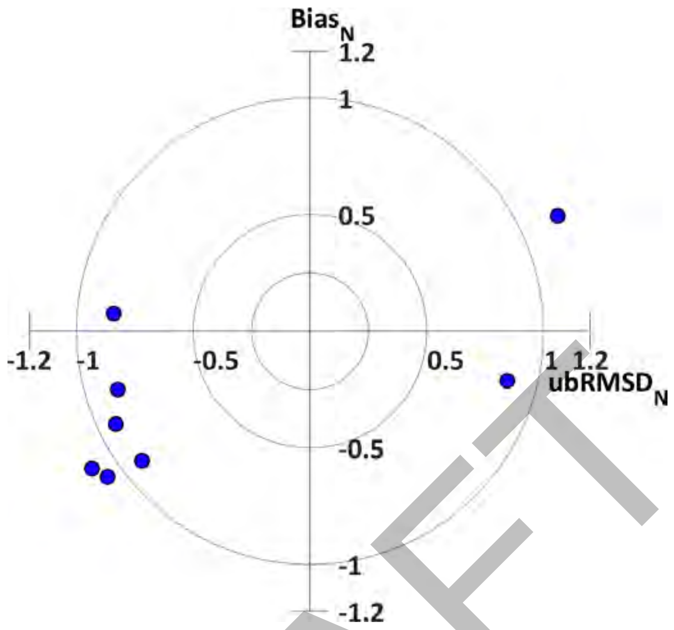


Figure A-4
Observed and Predicted SSC at Alcatraz During the 2016 to 2017 Simulation Period

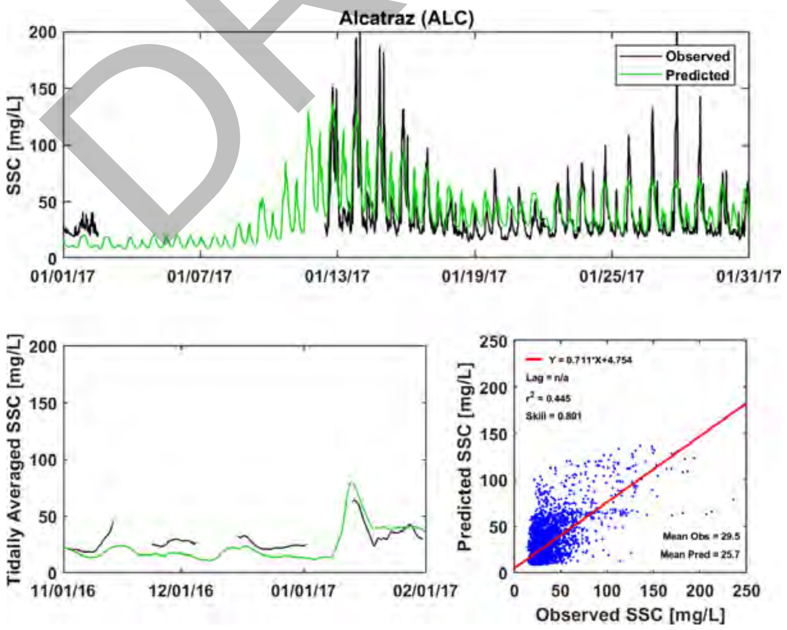


Figure A-5
Observed and Predicted SSC at Pier 17 During the 2016 to 2017 Simulation Period

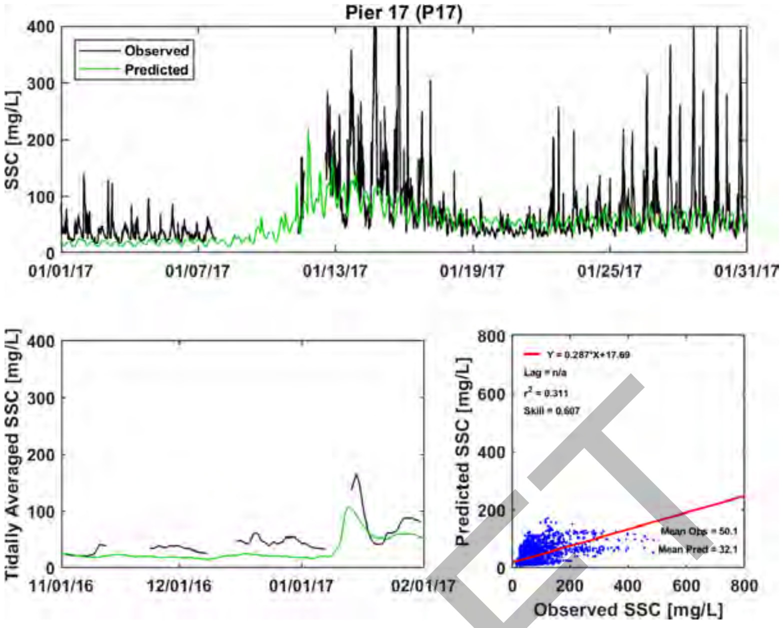


Figure A-6
Observed and Predicted SSC at Richmond-San Rafael Bridge (Upper) During the 2016 to 2017 Simulation Period

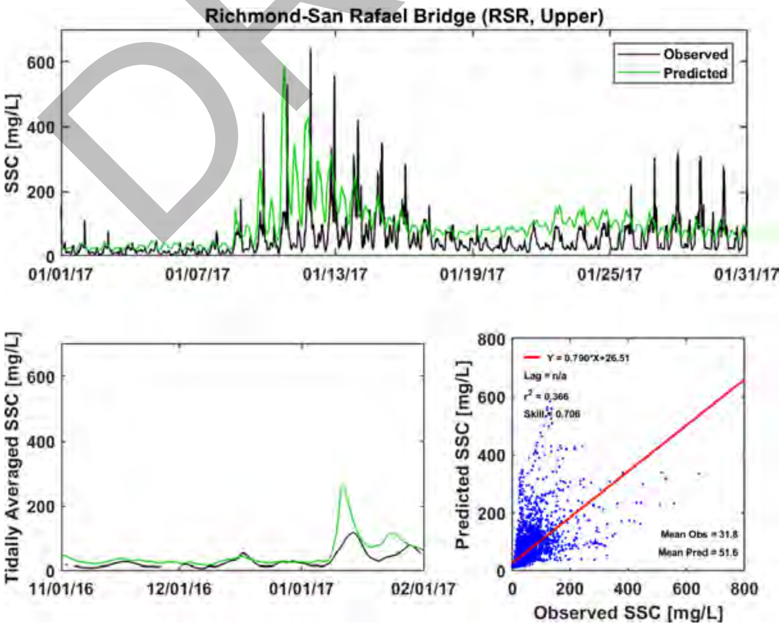


Figure A-7
Observed and Predicted SSC at Richmond-San Rafael Bridge (Lower) During the 2016 to 2017 Simulation Period

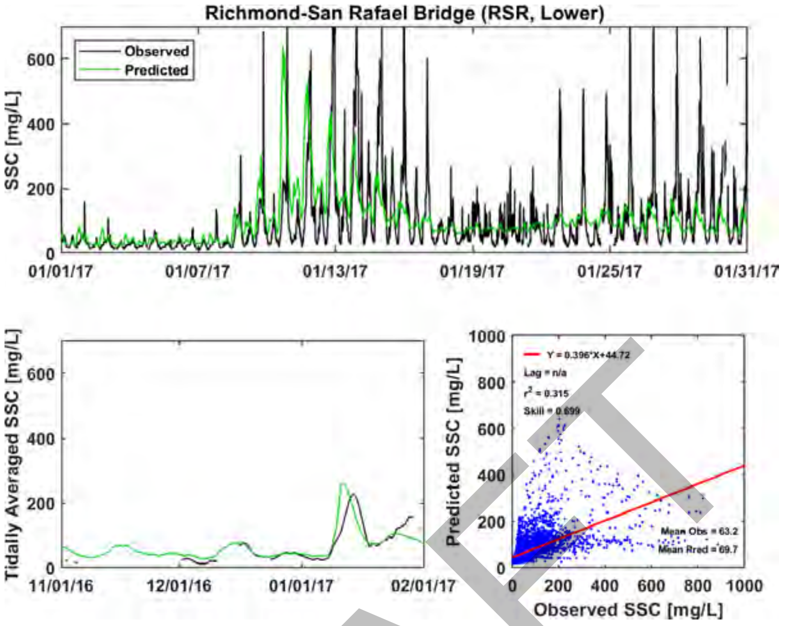


Figure A-8
Observed and Predicted SSC at Benicia Bridge (Upper) During the 2016 to 2017 Simulation Period

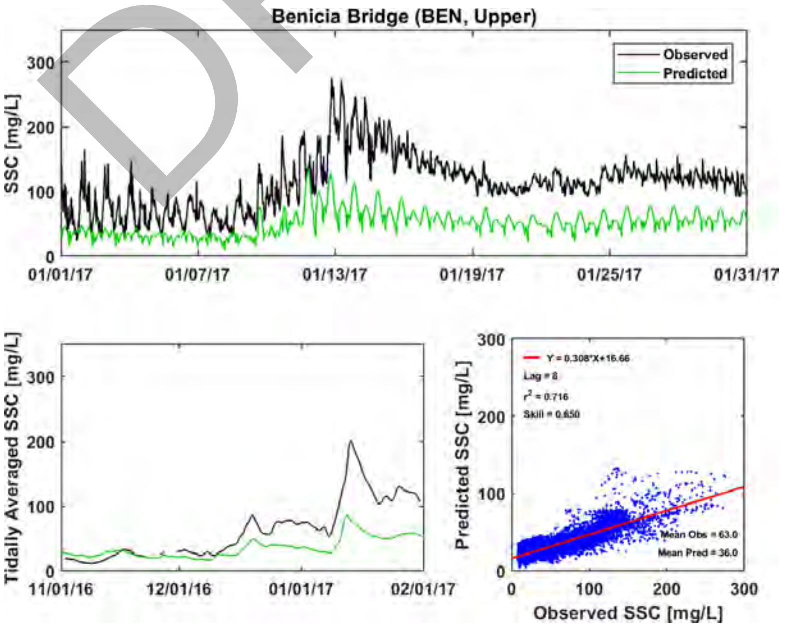


Figure A-9
Observed and Predicted SSC at Benicia Bridge (Lower) During the 2016 to 2017 Simulation Period

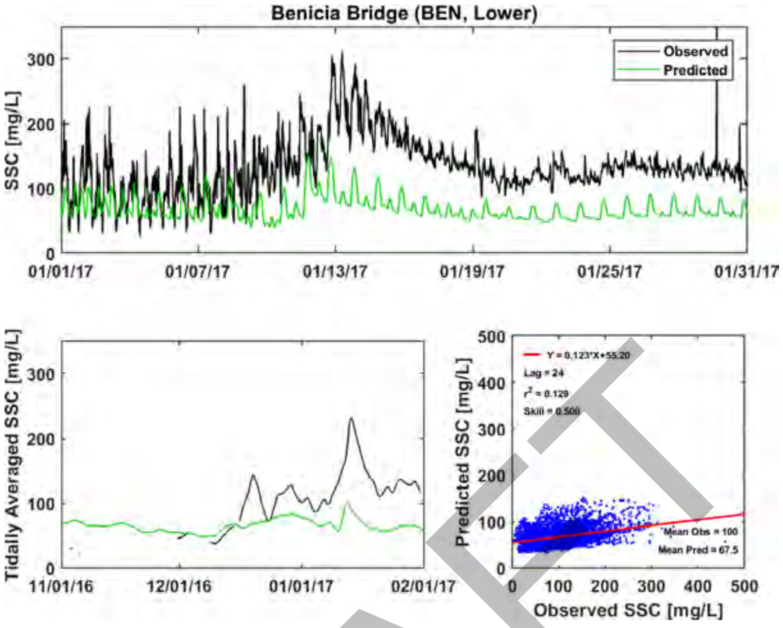


Figure A-10
Observed and Predicted SSC at USGS Dumbarton Bridge (Upper) During the 2016 to 2017 Simulation Period

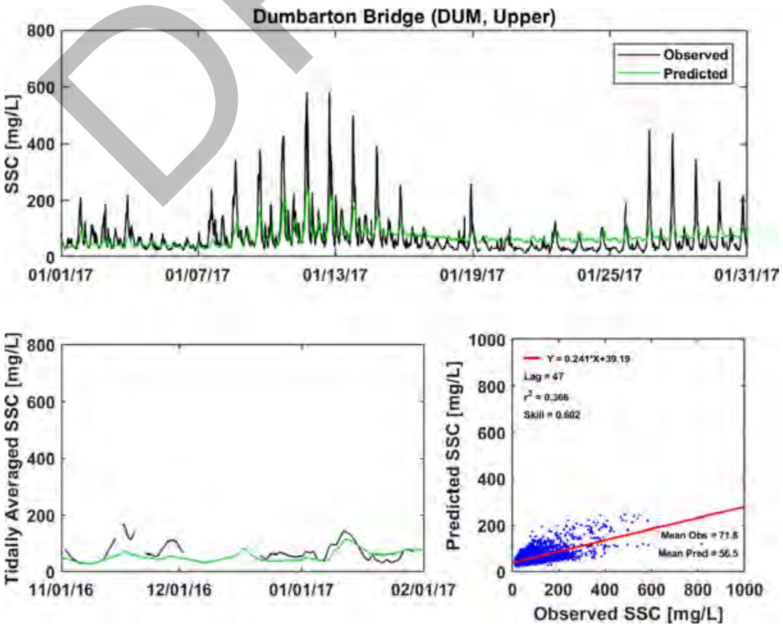


Figure A-11
Observed and Predicted SSC at USGS Dumbarton Bridge (Lower) During the 2016 to 2017 Simulation Period

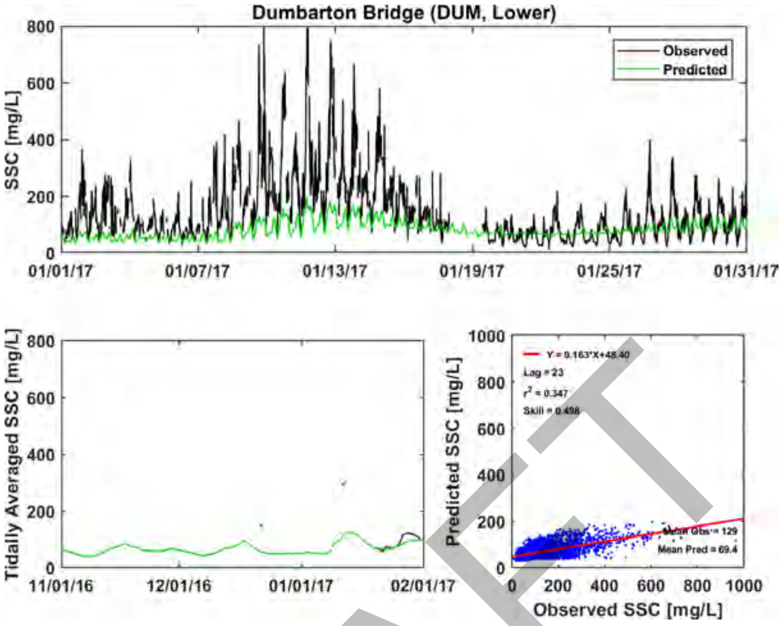


Figure A-12
Target Diagram Showing the Model Validation Using the Time Series SSC for the 2009 Simulation Period

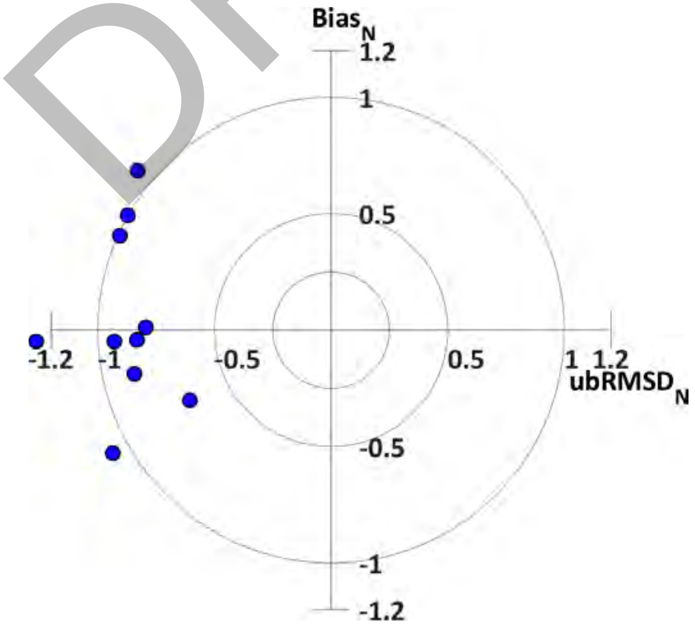


Figure A-13
Observed and Predicted SSC at Alcatraz During the 2009 Simulation Period

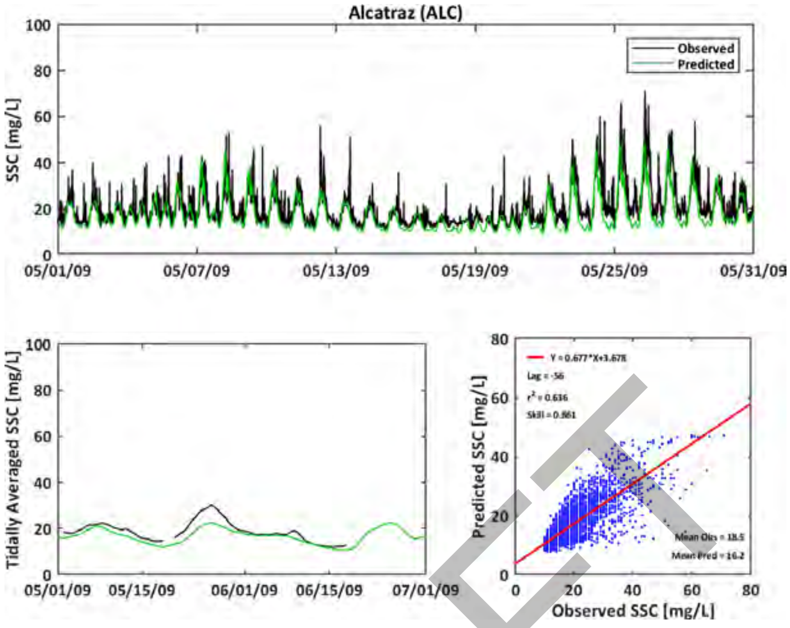


Figure A-14
Observed and Predicted SSC at Richmond-San Rafael Bridge (Upper) During the 2009 Simulation Period

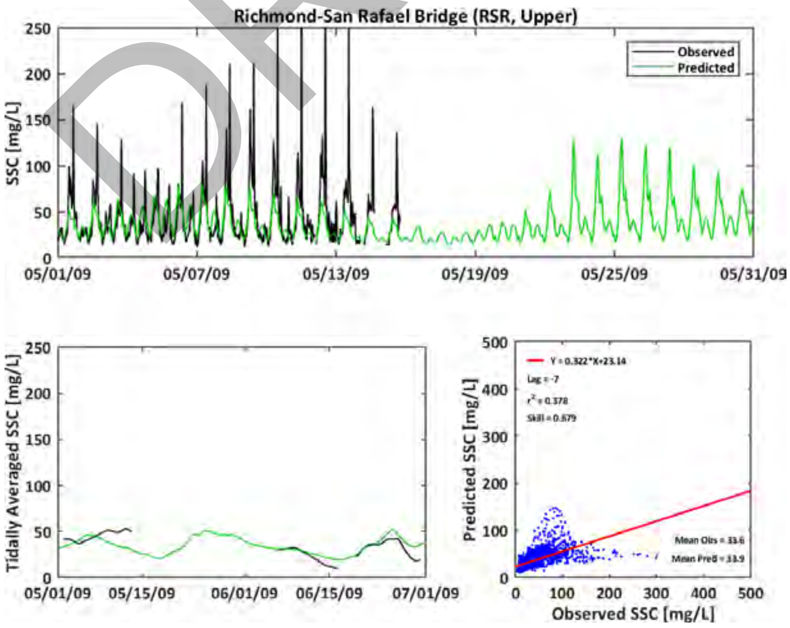


Figure A-15
Observed and Predicted SSC at Richmond-San Rafael Bridge (Lower) During the 2009 Simulation Period

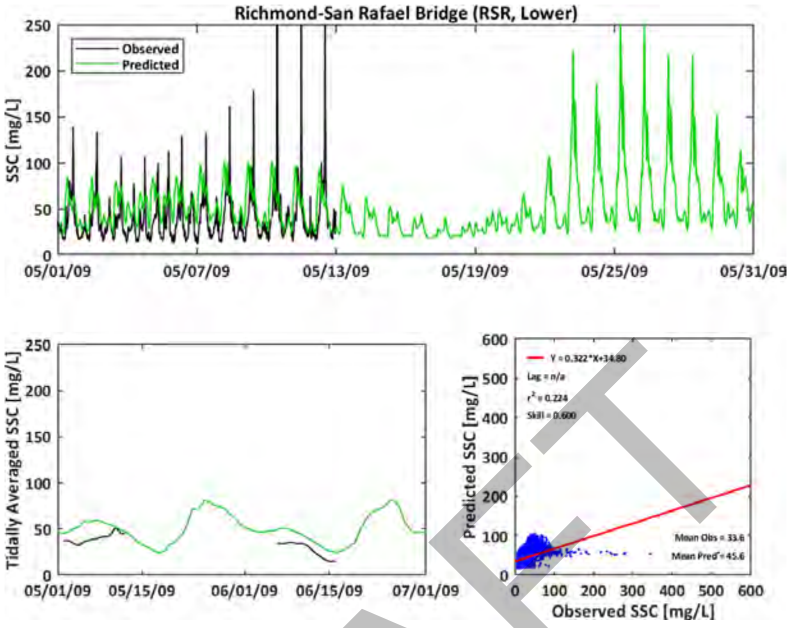


Figure A-16
Observed and Predicted SSC at Hamilton Disposal Site During the 2009 Simulation Period

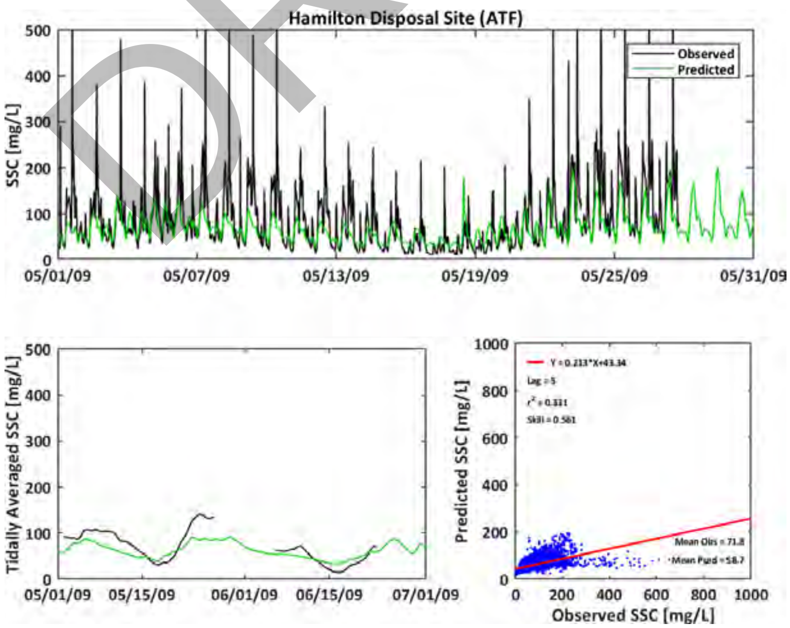


Figure A-17
Observed and Predicted SSC at Benicia Bridge (Upper) During the 2009 Simulation Period

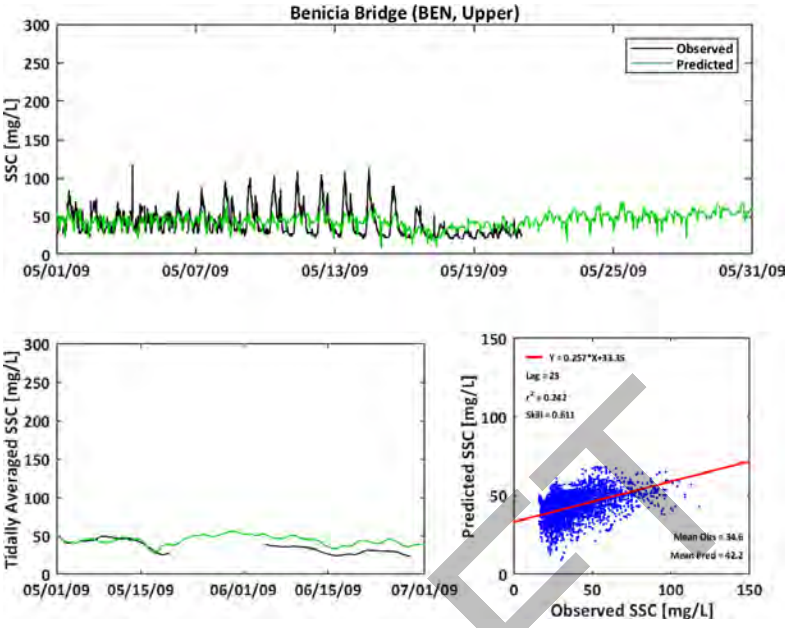


Figure A-18
Observed and Predicted SSC at Benicia Bridge (Lower) During the 2009 Simulation Period

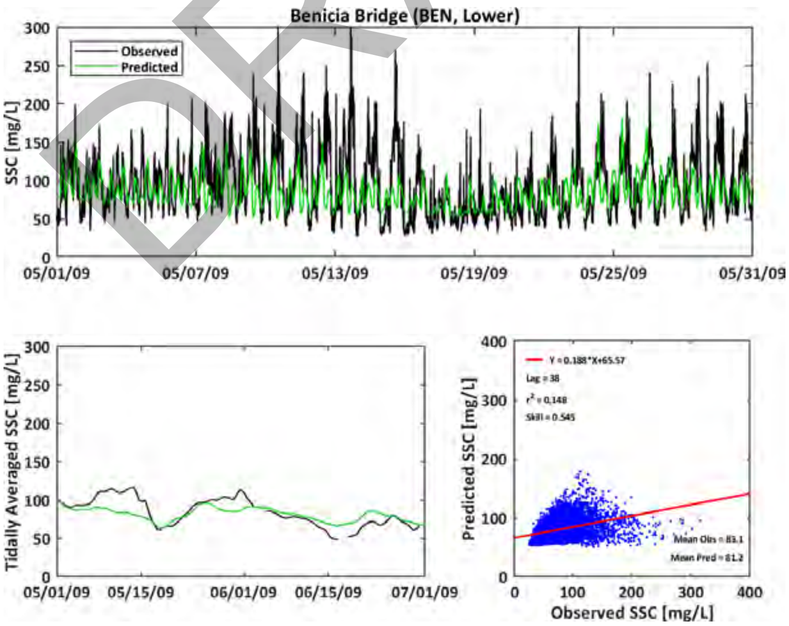


Figure A-19
Observed and Predicted SSC at Mallard Island (Upper) During the 2009 Simulation Period

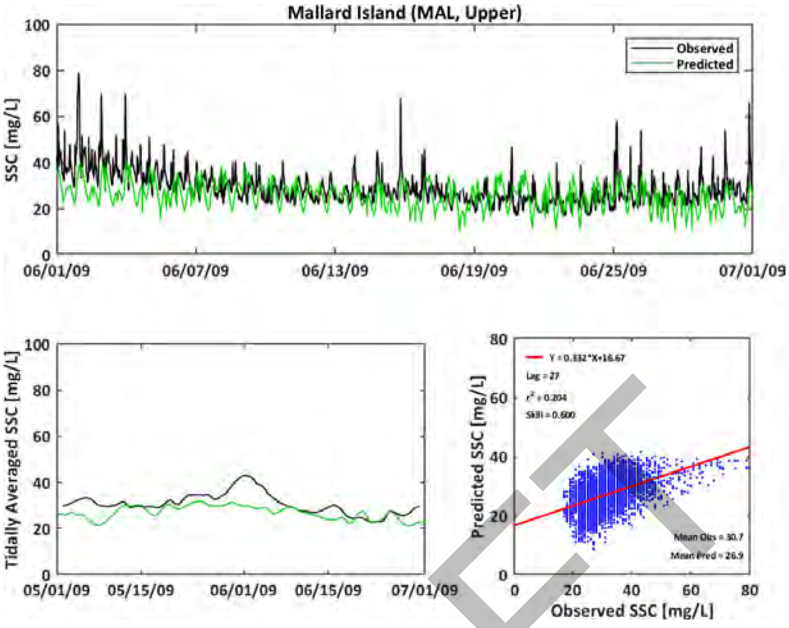


Figure A-20
Observed and Predicted SSC at Mallard Island (Lower) During the 2009 Simulation Period

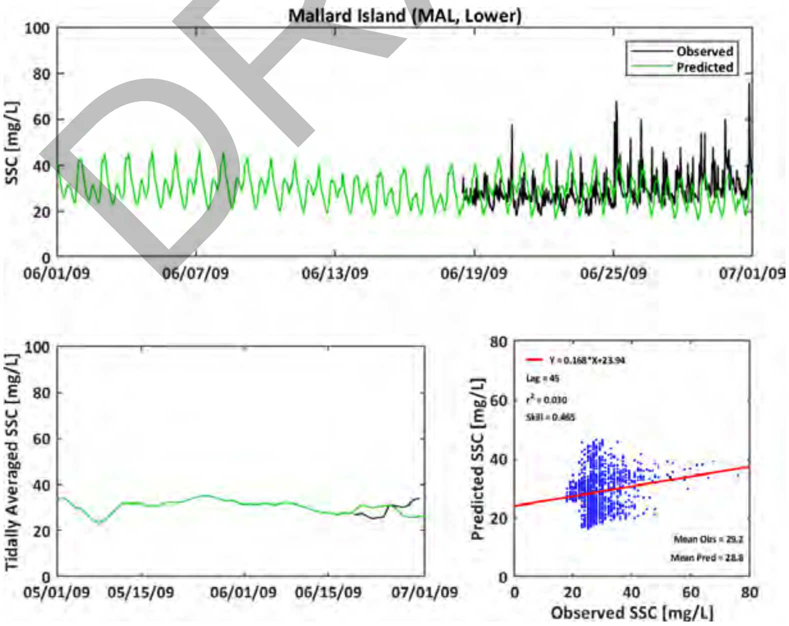


Figure A-21
Observed and Predicted SSC at Dumbarton Bridge (Upper) During the 2009 Simulation Period

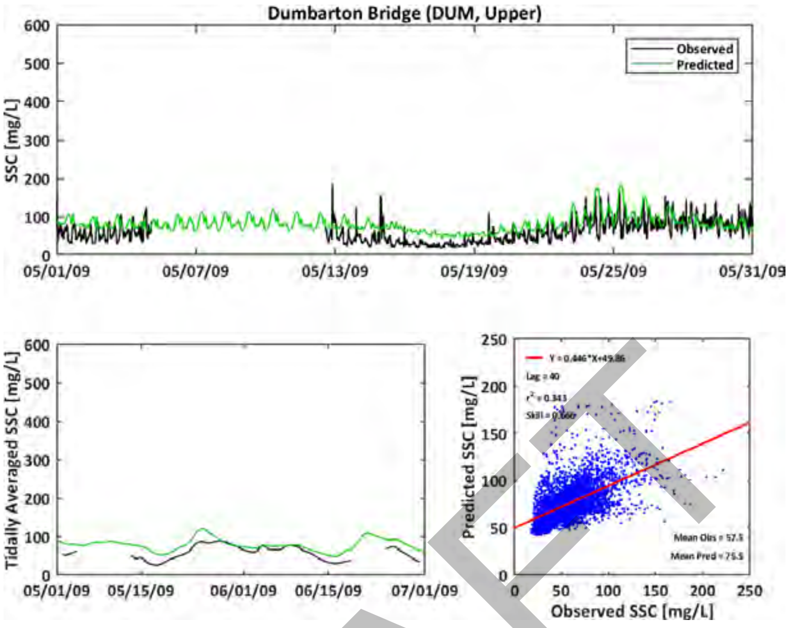
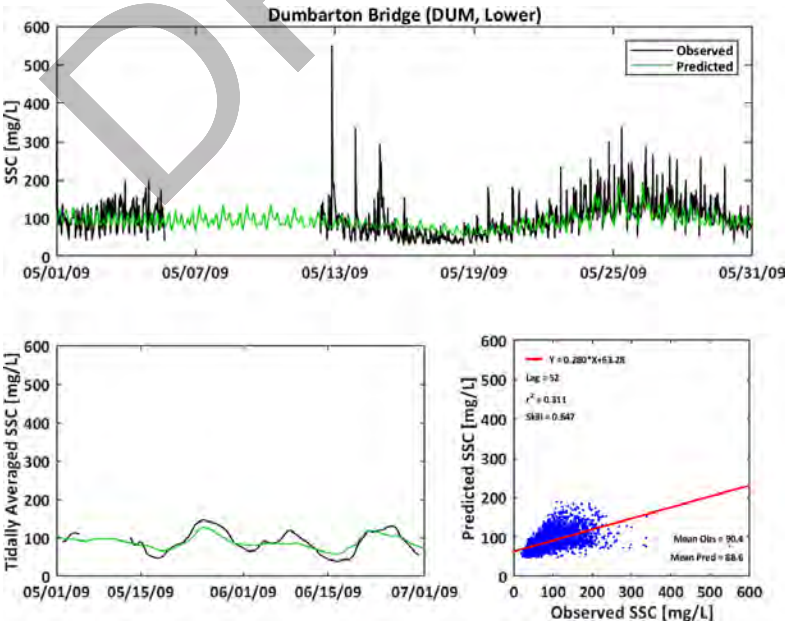


Figure A-22
Observed and Predicted SSC at Dumbarton Bridge (Lower) During the 2009 Simulation Period



Appendix B
Assumptions and Limitations of the Coupled Modeling System

B.1 Data Sources Used Within the UnTRIM Bay-Delta Model

Detailed descriptions of the boundary conditions and the data used to develop the boundary conditions for the UnTRIM Bay-Delta model, the Simulating WAves Nearshore (SWAN) wave model, and the SediMorph seabed and sediment transport model are presented in MacWilliams et al. (2015), Bever and MacWilliams (2013), and Bever et al. (2018). This appendix summarizes the model boundary conditions and data sources that can be used as a quick reference (Figure B-1; Table B-1), while the previously mentioned references should be consulted for detailed descriptions.

The UnTRIM Bay-Delta model grid was developed with varying grid resolution along the axis of the estuary as necessary to resolve the bathymetric variability, with smaller grid cells used in narrower channels and in regions of complex bathymetry. The bathymetry was incorporated into the model using the highest-resolution data that were available at any location (MacWilliams et al. 2015). The observed water level at the National Oceanic and Atmospheric Administration (NOAA) San Francisco tide station (9414290) was used to force the tidal water level at the open boundary. The open boundary salinity was set using daily salinity observations from the Farallon Islands, approximately 20 kilometers west of the open boundary. The initial salinity field in the Bay was specified based on vertical salinity profiles collected by the U.S. Geological Survey (USGS) at 38 stations along the axis of the estuary and in the Delta by interpolating from continuous monitoring stations. At the bottom boundary, the roughness coefficient z_0 was specified according to the elevation of each grid cell edge following the approach used by Cheng et al. (1993), Gross et al. (2010), and MacWilliams and Gross (2013), with higher roughness coefficients in shallower and higher elevation areas.

River inflows to the model included tributaries to the Bay and Delta and discharges from water pollution control plants (Figure B-1). Daily water exports were also specified at six locations. Hourly wind data was specified for six subregions of the Bay-Delta based on observations from the Bay Area Air Quality Management District (BAAQMD). Evaporation and precipitation in the Bay were set based on hourly data from the California Irrigation Management Information System (CIMIS), while evaporation and precipitation in the Delta was included in the Delta Island Consumptive Use (DICU). Monthly estimates of DICU (CDWR 1995) were used to specify the seepage, agricultural diversions, return flows, and return flow salinity within the Delta. Nine control gates and temporary barriers in the Delta were incorporated into the model to represent the effects of these gates and barriers on flow and transport in the Delta (Figure B-1). For each control structure, the seasonal timing of the installation, removal, and associated culvert and gate operations were specified (MacWilliams et al. 2009; MacWilliams and Gross 2013).

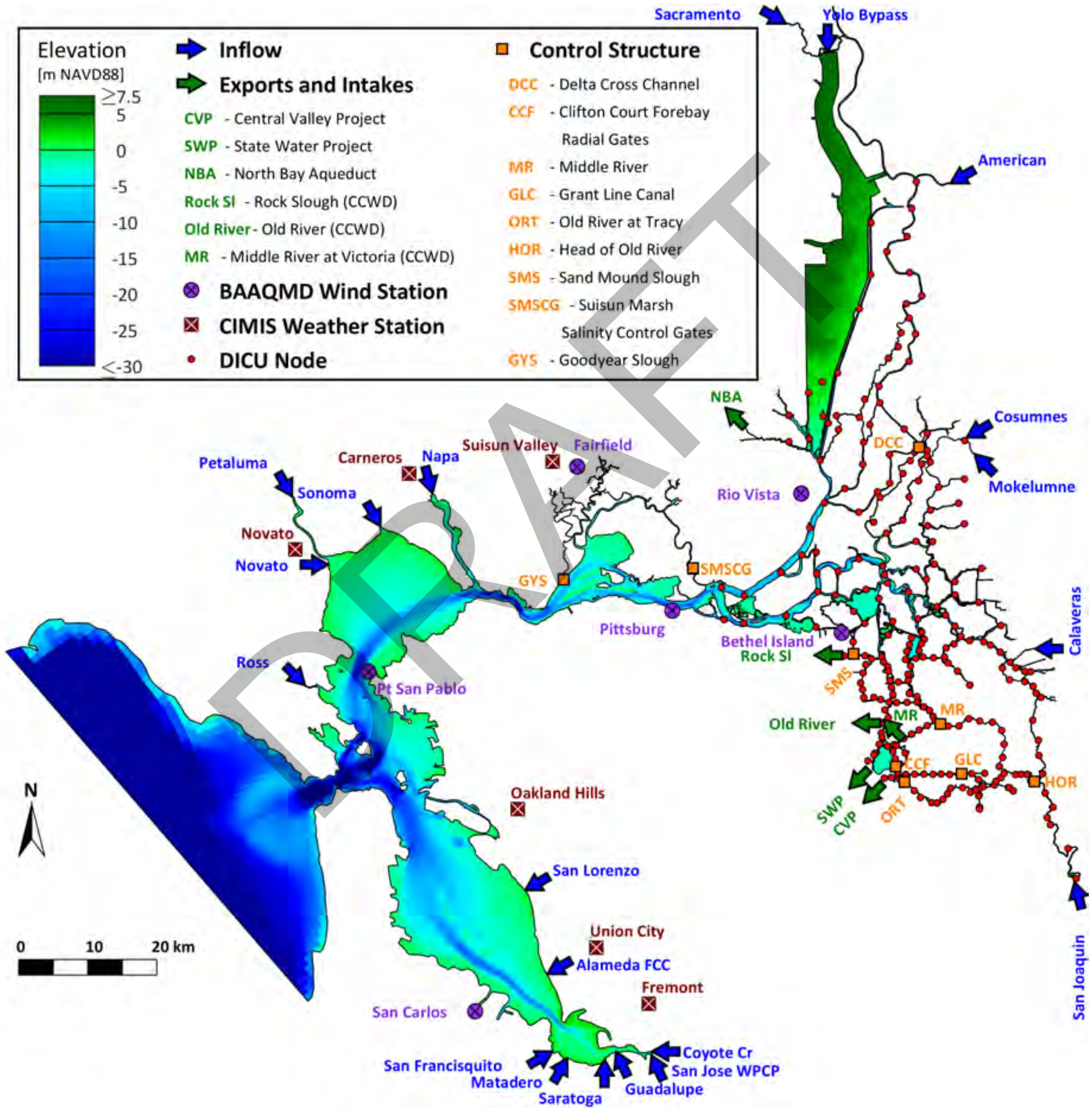
Sediment transport calculations included five sediment classes, each with different particle size, settling velocity, critical shear stress, density, and erosion rate parameter (Table 2-1). The five sediment classes were chosen to represent the dominant constituents in the real Bay grain size distribution and were fine clay/silt, single particle silt, flocculated silts and clays called “flocs,” sand, and gravel with characteristics based on data from the Bay (Kineke and Sternberg 1989; Sea Engineering 2008; Smith and Friedrichs 2011). Observed surface grain size distributions were used to generate a realistic initial sediment bed for the entire Bay-Delta system. Grain size distribution data were compiled from a U.S. Army Corps of Engineers (USACE) long-term management strategy report (Pratt et al. 1994), the dbSEABED West Coast surface grain size distribution database (Jenkins 2010), the USGS sand provenance study (Barnard et al. 2013), and the Delta sediment grain size study (Wright 2012). Suspended sediment was supplied through river input to the Delta, the North Bay, and the South Bay. Sediment was supplied to the Delta by five tributaries representing nearly 100% of the sediment inflow to the delta (Wright and Schoellhamer 2005). SSCs were set based on time series concentrations from USGS, daily concentrations from USGS, or rating curves, depending on data availability.

The SWAN wave calculations used the same model grid and bathymetry as the UnTRIM hydrodynamic model, except that the quadrilaterals in the UnTRIM grid were converted to triangles, as explained in Bever and MacWilliams (2013). The wind was the same as that used in the hydrodynamic model and the bottom roughness was the Nikuradse roughness based on the roughness from the hydrodynamic model.

Table B-1
Summary of Data Sources Used for Model Boundary Conditions

Boundary Condition Type	Boundary Condition/Forcing	Description/Sources
UnTRIM Initial Conditions	Bathymetry	High-resolution bathymetric data from several sources
	Navigation channel alignments in the grid	Provided by USACE
	Salinity	Based on USGS water quality sampling in the Bay and interpolated using continuous monitoring stations in the Delta
Hydrodynamic Forcing	Tidal forcing	6-minute data from NOAA San Francisco tide station (9414290)
	Open boundary salinity	Daily salinity at Farallon Islands
	Inflows	Daily using Dayflow for Delta tributaries and USGS data for Bay tributaries
	Exports	Daily from Dayflow and the California Data Exchange Center
	DICU	Monthly based on the Delta Island Consumptive Use Model
	Flow control structures	Seasonally nine Delta control structures (MacWilliams et al. 2009)
	Evaporation/precipitation	Hourly data from CIMIS
	Wind	Hourly data from BAAQMD
	Seabed roughness	Elevation dependent Z_0 ranging from 0.001 mm to 1.0 cm
Sediment	Sediment settling velocity, critical shear stress, diameter, and erosion rate	Based on data in San Francisco Bay from Kineke and Sternberg (1989), Sea Engineering (2008), and Smith and Friedrichs (2011)
	Seabed grain size distribution	Based on surface grain size distributions from USGS (Barnard et al. 2013; Wright 2012), USACE (Pratt et al. 1994), and dbSEABED database (Jenkins 2010)
	Inflow SSC	Daily based on USGS time series observations, USGS daily measurements, or rating curves, based on data availability
Waves	Bathymetry	Same as the hydrodynamic model
	Wind	Same as the hydrodynamic model
	Bottom roughness	Nikuradse roughness based on the roughness used in the hydrodynamic model

Figure B-1
Golden Gate High-Resolution UnTRIM Bay-Delta Model Domain, Bathymetry, and Locations of Model Boundary Conditions that Include Inflows, Export Facilities, Contra Costa Water District (CCWD) Intakes, Wind Stations from the Bay Area Air Quality Management District (BAAQMD), Evaporation and Precipitation from California Irrigation Management Information System (CIMIS) Weather Stations, Delta Island Consumptive Use (DICU), and Flow Control Structures



B.2 UnTRIM Numerical Model Uncertainty

As discussed in Section 2, the UnTRIM model has been widely used in the Bay, and numerous detailed model calibrations have been performed. The equations governing fluid motion and salt transport, representing conservation of water volume, momentum, and salt mass, are well established but cannot be solved analytically for complex geometry and boundary conditions. Therefore, numerical models are used to give approximate solutions to these governing equations. Many decisions are made in constructing and applying numerical models. The governing equations are first chosen to represent the appropriate physical processes in one, two, or three dimensions and at the appropriate timescale. Then these governing equations that describe fluid motion and salt transport in a continuum are discretized, giving rise to a set of algebraic equations. The resulting discretized algebraic equations must be solved, often requiring the use of an iterative matrix solver. The discretization and matrix solution must be developed carefully to yield a numerical scheme that is consistent with the governing equations, stable, and efficient. To apply the models, the bathymetric grid, boundary conditions, initial conditions, and several model parameters must be chosen. The accuracy of the model application depends on the appropriate choice of these inputs, including site-specific parameters, the numerical scheme for solving the governing equations, and the associated choice of time step and grid size.

The 3D model applied in this project provides a more detailed description of fluid motion in the Bay than depth-averaged or 1D models. The UnTRIM model, like almost all large-scale hydrodynamic models, averages over the turbulent timescale to describe tidal timescale motions. The resulting 3D hydrodynamic models represent the effect of turbulent motions as small-scale mixing of momentum and salt, parameterized by eddy viscosity and eddy diffusivity coefficients, respectively. These turbulent mixing coefficients are estimated from the tidal flow properties (velocity and density) by turbulence closure models embedded within the 3D models. 3D models estimate the variability in velocity and salinity in all dimensions and through the tidal cycle and, therefore, provide a detailed description of hydrodynamics and salinity. However, several sources of uncertainty are inherent in the application of these 3D models, detailed as follows:

- **Spatial resolution/computational speed:** The spatial resolution of the bathymetry of the model domain, and velocity and salinity distributions, is limited by the large computational expense associated with high-resolution models. The description of the Bay-Delta bathymetry is improved by the use of a flexible unstructured grid, with coarser grid resolution used in the open bay portions of the grid and higher grid resolution within the project study area to optimize computational efficiency. The computational speed of the Bay-Delta model roughly scales with the number of grid cells. For example, halving of the horizontal resolution of the model would lead to four times as many 3D grid cells and an implementation that takes roughly four times the computation time, making general system-wide reductions in grid resolution infeasible and showcasing the benefit of using grid refinement approaching study regions.

- **Bathymetric data:** Limited spatial coverage and accuracy of bathymetric data can be a substantial source of uncertainty. Converting all data to a uniform vertical datum and horizontal datum can lead to some error. In particular, Light Detection and Ranging (LiDAR) data may have substantial errors in vertical datum, and removing vegetation from the dataset can be difficult. In the present application, bathymetric data from multiple sources were merged to develop the model bathymetry.
- **Bottom roughness:** The UnTRIM model requires bottom friction coefficients to parameterize the resistance to flow at solid boundaries. These parameters are specified and adjusted in model calibration. The roughness values used in the present application have been applied in several recent applications (e.g., MacWilliams et al. 2007, 2008, 2009, 2015).
- **Turbulence closure:** The effect of turbulent motions on the tidal timescale motions is parameterized by a turbulence closure, as is done in other 3D hydrodynamic numerical models of similar spatial and temporal scale as the UnTRIM Bay-Delta model (e.g., Warner et al. 2005a; Wang et al. 2011). While many turbulence closures are available (e.g., Warner et al. 2005a), this is an ongoing area of research and, particularly in stratified settings, the effect of turbulence on tidal flows and salinity is not easy to estimate accurately. Different turbulence closures may give significantly different results in stratified settings (e.g., Stacey 1996).
- **Numerical errors:** A numerical method approximates the governing equations to some level of accuracy. The mathematical properties of the numerical method of the UnTRIM model are well understood due to detailed mathematical analysis presented in several peer-reviewed publications. While the stability and conservation properties of the method are ideal, a remaining source of error in the numerical method is some limited numerical diffusion of momentum, which may cause some damping of tidal propagation.
- **Boundary conditions and initial conditions:** The salinity in the Bay varies laterally (e.g., Huzzey et al. 1990), but this lateral variability cannot be described by existing observations. In addition, only limited observations are available to describe the vertical distribution of salinity. Therefore, lateral and vertical salinity distributions must be achieved by interpolation and extrapolation from the limited observations to obtain initial salinity fields. Inflows to the estuary are also quite uncertain in several regions due to ungauged portions of watersheds and uncertainty in estimates of outflows and diversions in the Delta.

Though additional potential sources of uncertainty can be identified, the largest sources of uncertainty for hydrodynamic predictions are the accuracy and resolution of available bathymetry and the grid resolution used to represent this bathymetry in the model. This study makes use of the best available high-resolution bathymetric data, especially in Central Bay and South Bay, and the highest computationally practical grid resolution throughout the domain. However, some of the available bathymetric data sets in other portions of the Bay are relatively old, and they required vertical and/or horizontal coordinate transformations for the grid used in this project. Additionally, the most recent bathymetry for the Delta does not include many in-channel islands and other subtidal areas that are subject to flooding at high water, particularly during spring tide.

The uncertainty in Delta outflows can also be a substantial source of uncertainty in predicting salinity intrusion during summer conditions, particularly when consumptive use within the Delta (which is only known approximately) is typically the same order of magnitude as Delta tributary flows.
The current application makes use of monthly DICU estimates from the California Department of Water Resources. However, because these estimates of diversions and return flows and salinities are approximate, they may not be representative of actual consumptive use in a particular year. This uncertainty would impact the accuracy of net Delta outflows predicted at the flow monitoring stations in the western Delta, when compared to observed flows, and would thereby influence salinity intrusion into the Western Delta during summer conditions. This uncertainty in Delta outflow may also influence the accuracy of sediment transport calculations.

B.3 SWAN Numerical Model Uncertainty

SWAN is a state-of-the-art and full-featured spectral wave model. However, several simplifications and limitations are associated with this model. Wave-induced currents are not computed by SWAN. Because a phase-decoupled approach is used, SWAN "does not properly handle diffraction in harbors or in front of reflecting obstacles" (SWAN Team 2009b). Some additional uncertainty is introduced by interpolation of UnTRIM parameters and variables from side and cell center locations to node locations for use by SWAN. However, in practical SWAN applications, the uncertainty is likely to be driven primarily by the limited accuracy of input parameters such as wind velocity and bottom friction.

B.4 SediMorph Numerical Model Uncertainty

Significant uncertainty exists in the prediction of sediment transport. This uncertainty results from the complexity of representing sediment physics, the limited data available to characterize heterogeneous bed sediment and inflow sediment properties in a dynamic environment, and the difficulty in the specification of representative sediment parameters, such as settling velocity, critical shear stress, and erosion rate. Erosion and deposition processes are also highly sensitive, both to the specified sediment parameters and to the calculated bed shear stress, which in turn is sensitive to the selection or calculation of appropriate bed roughness parameters. Effective bed roughness is influenced by the grain size distribution of the bed material, as well as bed forms such as ripples and dunes, and can also vary significantly in both space and time.

B.5 Sediment Transport Modeling Assumptions and Limitations

The interaction of tides, winds, waves, and sediments results in complex physical processes that need to be simplified and parameterized in order to be represented in a numerical model. As a result, the numerical simulation of sediment transport processes requires some simplifying assumptions that can influence the accuracy of the model predictions. The interpretation of the model results must, therefore, take into account how these assumptions influence both the model predictions and any conclusions drawn from the model predictions. This section outlines the major assumptions and simplifications that were made in the development of the UnTRIM-SWAN-SediMorph coupled modeling system used in this study, and it discusses how these simplifying assumptions may affect the interpretation of the model results.

The major simplifications made in this application were the partitioning of the full range of sediment sizes in the Bay to a discrete set of sediment classes with constant sediment parameters, assuming a single sediment class to represent flocculated particles rather than modeling the aggregation and disaggregation of sediment particles, and the treatment of sediment material in the seabed. Each of these simplifying assumptions is discussed as follows.

SediMorph allows for multiple sediment classes, each with different settling velocity, critical shear stress, erosion rate parameter, diameter, and density. In the simulations presented in this report, the mud fraction was partitioned between the fine silt, silt, and floc sediment classes. The sediment properties for the five modeled sediment classes were selected to represent fine silts, single particles of silt (silt), aggregated clay and silt particles that behave as flocculated particles (flocs), coarser material (sand), and gravel bedload (gravel). The characteristics of the "flocs" sediment class were set based on field observations of flocs within San Pablo Bay by Kineke and Sternberg (1989), from observations of the size and settling velocity of flocs in the plume from a suction hopper dredge in the Bay by Smith and Friedrichs (2011), from data on sediment mass eroded from the top of cores collected in San Pablo Bay by Sea Engineering (2008), and through comparison of modeled and observed time-series SSCs within the Bay. However, in reality, flocs continuously undergo aggregation and disaggregation due to physical and biological changes in the water (Mikkelsen et al. 2006), such as changes to turbulence and the Kolmogrov microscale, varying SSCs, compaction of the seabed and subsequent resuspension, sediment interaction with biofilms, and incorporation into fecal pellets (some examples in Eisma 1986; Fugate and Friedrichs 2003; Hill and McCave 2001). These processes are extremely complex and are not easily incorporated into a numerical model. Previous sediment modeling studies in the Bay (e.g., Bever and MacWilliams 2013, 2014; Bever et al. 2018; van der Wegen et al. 2011; Schoellhamer et al. 2008; Ganju and Schoellhamer 2009) have also made a similar simplifying assumption by specifying a sediment class with characteristics representing flocculated material but assuming that mass is not aggregated or disaggregated between sediment classes. This simplification potentially leads to decreased peak SSCs during energetic periods and faster settling of the sediment from the water column because large flocs are not broken into smaller flocs or constituent particles. The simplification may also lead to an underestimation of the amount of sediment transported out of a channel onto the mudflats because flocs may be disaggregated during high tidal flows into smaller particles that are more easily transported out of the channel.

Because bed consolidation is not currently represented in the model, the model may overpredict the transport distance of the sediment. With bed consolidation, some sediment would consolidate during neap tide periods and be harder to erode the following spring tide. Neglecting bed consolidation may lead to increased SSCs at the start of spring tides in the model predictions because the sediment deposited in the model during neap tides does not consolidate and is easily erodible as the currents start to increase approaching spring tides. Without seabed consolidation, the model also does not dewater or compact the seabed, which would reduce the depositional thicknesses and volumes over time. On a spring-neap time scale, compaction likely only negligibly affects model predictions of depositional thicknesses because of the relatively small depositional and erosional thicknesses undergoing compaction. However, on longer timescales with thicker deposition, compaction could affect model predictions of depositional thickness and the feedbacks on the hydrodynamics. This lack of compaction and dewatering is mostly counteracted by tuning the seabed porosity based on the estimates of sediment depositional volume and thickness from hydrographic survey data so the modeled thicknesses and volumes agree with the hydrographic survey estimates. However, additional data are needed to more fully validate predictions of sediment fluxes and morphologic change outside of the ship channels.

The complexity inherent in sediment transport modeling detailed previously results in the accuracy of sediment transport predictions based on numeric skill metrics such as those used by MacWilliams et al. (2015) being lower for comparisons of SSCs than is typical for modeling of salinity or water level. This is especially true when considering simulations such as those in this report that span a wide range in environmental conditions and simulate the transport of sediment over large distances from upstream portions of freshwater rivers through the entire San Francisco Estuary and into the Pacific Ocean. However, when the comparisons between observed and predicted SSCs indicate that the model is predicting a similar magnitude of concentration as the observations, capturing the seasonal and spatial trends, and capturing the observed tidal timescale variations and along-estuary spatial structure, this suggests the model is capturing the primary physical processes responsible for sediment transport in the system.

Draft Monitoring Plan

Title: **Evaluating the benefits and impacts in shallows and marshes of a pilot strategic sediment placement project in San Francisco Bay**

Scope of Work

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ParTrac Sediment Tracing
Keith Merkel and Associates

Background

Tidal salt marshes are an important part of the San Francisco Bay estuary (SFBE) landscape, with extensive plans for restoration over the coming years. The combination of accelerating sea-level rise (SLR) and declining sediment supply to SFBE threatens the persistence of marsh habitats (Schoellhamer 2011, Buffington et al. 2021). A key management questions is how nature-based solutions, including sediment augmentation/placement (also called sediment addition, strategic placement, sediment enhancement, beneficial reuse of dredged material) can nourish tidal mudflats and marshes to build SLR resilience and facilitate marsh restoration projects to prevent submergence. These types of projects have been successful in other parts of the world but are novel in the SFBE. Marshes in SFBE are mineral dominated and rely on sediment delivery from the shallows and creeks to build elevations to support vegetation and wildlife. However, sediment availability varies spatially around the bay and delivery to the mudflat and marshes can vary seasonally. Therefore, the outcomes of sediment placement projects are greatly uncertain and robust monitoring is essential to inform future projects.

Section 1122 of WRDA 2016 requires USACE to establish a pilot program to carry out projects for the beneficial use of dredged material using natural deposition processes to augment marsh elevations. The USACE will lead a pilot program to test an innovative method of strategic shallow water placement of beneficial dredged material to promote mudflat and tidal marsh sedimentation, which would be the first of its kind in the San Francisco Bay region. Using natural transport processes to move the dredged material onshore, this method may be a more cost-effective means than direct sediment placement on tidal marshes and may also promote mudflats and tidal marsh resilience to sea level rise. This also represents a unique opportunity for testing hypotheses and addressing questions regarding maximizing benefits and minimizing unintended consequences to essential fish habitat and associated benthic invertebrate prey resources (De La Cruz et al. 2020).

The Section 1122 Pilot Project is planning a sediment placement project near Eden Landing Ecological Reserve with the goal of nourishing mudflat, marsh, and restoration habitats adjacent to the project site. Placement will occur over at least 20 days (total placement time is TBD) and will deploy around 100,000 cy3 of sediment to reduce impacts; modeling results show minimal accretion on the marsh may be (approximately0.01cm) and mudflats (approximately0.1 cm) in response to the nearby placement (Anchor QEA 2022 report). We propose here to monitor four general locations: sediment placement area, shallows and mudflats, marshes, and restorations.

Study Questions

- How quickly does the sediment disperse from the placement area?
- How do the local wave energy, storms, and the spring-neap tidal cycle influence sediment flux and dispersal of the disposed sediment in the study area?
- Does placement material deposit on the marsh surface or in the restoration area? How long and what abiotic processes determined arrival?
- Are sediment tracers an effective monitoring tool for sediment addition projects?
- How does shallow dredged material placement influence the benthic community and foraging resources for demersal fishes and waterbirds?
- What is the spatial extent of impacts on the benthic community?
- How long does it take for functional recovery of the benthic community to occur?
- How does eelgrass respond to strategic shallow water placement?

Study site

This project will occur at the Section 1122 Pilot Project dredged material placement site and the adjacent mudflats. This project will also take place at Eden Landing Ecological Reserve. Specific sample sites will be chosen during the initial planning process and site visits.

Approach

Task 1 Bathymetric surveys to detect changes in morphology and bayfloor properties

USGS will perform repeated bathymetric surveys to determine the initial impact of placement of dredged sediment on the bayfloor morphology and to assess the rate of sediment dispersal out of the placement area. Surveys will be conducted immediately prior to, and following, completion of the dredged material placement operations to quantify the thickness of sediment deposited. We will survey a portion of the placement area approximately 1.7 km in the alongshore direction and 300 m in the cross-shore direction. The cross-shore extent will span the width of the placement area (approximately 150 m) and an extended circa 75 m buffer in both the offshore and onshore directions. Within this area (more than 50% of the placement area), the survey will achieve full coverage of the bayfloor. Because the placement operations have been designed to minimize sediment accumulation, it may be that it is difficult to detect bathymetric change during the project. If deposition is detected (minimum detectable change in elevation estimated at 10 cm) within the survey area during the initial post-placement survey, additional surveys will be conducted to determine how quickly the deposited sediment is eroded and dispersed from the placement area. In addition, acoustic backscatter data derived from the bathymetric surveys will be inspected and interpreted for indications of change in bayfloor properties (particle size, bulk density) which may show the presence of newly deposited sediment.

Bathymetric data will be acquired utilizing a USGS survey vessel equipped with a 234.5 kHz Systems Engineering and Assessment Ltd. SWATHplus-M interferometric side-scan sonar. Accurate geographical positioning will be achieved using an Applanix Pos M/V that combines positions from global navigation satellite system (GNSS) receivers, with attitude data from an integrated inertial motion unit.

Task 2 Oceanographic data collection

USGS will measure and collect time-series oceanographic data in bay shallows to: 1) monitor for changes in suspended-sediment concentration (SSC) produced by the sediment placement; and 2) document oceanographic forcing before, during, and after the placement of the dredged material, to support the interpretation and modeling of the fate and transport of the sediment. Using specialist oceanographic instruments, deployed on the bayfloor at specific stations around the study site, we will measure currents (speed and direction), wave height, direction and period, tidal height (stage), and suspended-sediment concentrations at 15-minute intervals. Data will be collected over the period from 1 month prior to placement operations commencing; during placement operations (approximately2 months); and up to 3 months after placement is completed (total deployment duration 6 months). The measurement stations will be located both in subtidal waters immediately onshore of the placement area (as close as is practical without impeding operations or risking instrumentation; 1 to 1.5 m below MLLW) and in the intertidal shallows, close to the marsh edge. USGS will measure turbidity via optical backscatter sensors (OBS) and subsequently convert the OBS data to SSC (in mg/l) based upon calibration relationships derived from SSC measured in water samples collected from the study area. Instruments and bayfloor frames will be serviced, data downloaded, and redeployed every 60 days during the deployment period. A data buoy equipped with a wind sensor, to assist in characterizing wind forcing upon the waterbody, will be located offshore of the placement area during the instrument deployment period.

Task 3 Bed sediment properties

Sampling at instrumentation sites

USGS will collect bed shallow sediment core samples (3 replicate push cores) at locations adjacent to three of the intertidal shallows stations. Core samples will be collected every 60 days during site visits for the above-described instrument servicing. The core samples will be subsequently sectioned (vertically) for analyses. All vertical sections of sediment will be analyzed for bulk density, and four sections per push core will undergo grain size analysis. Both these properties influence the erodibility of sediment.

Sampling of the deposited sediment

Following the first and/or second bathymetry surveys after the placement, we will collect push cores in and adjacent to the region of accumulation that is indicated by the bathymetry surveys. The purpose of the sampling will be to verify the thickness of the deposit detected by the bathymetric survey, and, potentially, to measure deposit thickness in regions where it is too thin to detect with the swath bathymetry. Analysis may include visual inspection (documented by photography), grain size analysis, and bulk density, and will be adapted depending upon what is encountered in the field.

Task 4 Tracer study: bay shallows

USGS will provide vessel support and participate in the tracer deployment conducted by Partrac. To track muddy sediments, Partrac will utilise a practical approach commonly termed *floc tagging*, which requires the tracer particles to have similar hydraulic characteristics (i.e. size, density and settling rate) to one or more of those constituent sediment size fractions found within naturally flocculated material, which facilitates floc tracing by directly labelling them (i.e. the floc aggregates will carry tracer particles during ensuing cycles of resuspension and deposition enabling a means of tracking the movement, and crucially, the fate of the mud flocs. The tracer material (1000 kg) will be manufactured to reflect the mean grain size (d_{50}) of dredged sediments. Following manufacture, the tracer properties will be independently tested, and the results considered in the light of potential effects upon transport dynamics. Tracer studies require the tracer material to be introduced into the field with minimal loss and redistribution; ideally tracer material deployment will be conducted under relatively benign meteorological and oceanographic conditions. The tracer should be deployed during slack water or on an ebbing tide. It is envisaged that the tracer will be deployed onto the dredged material placement at a number of strategic locations across the placement area. The tracer will be deployed, as best as is possible, on to the bayfloor through a length of large bore pipe, secured to the side of the vessel. The pipe will be secured in such a manner as to deliver tracer particles to the bayfloor, limiting dispersal in the upper part of the water column during release.

The Tracer introduction field operations will be conducted in three stages, being:

- Preparation and background survey;
- Tracer release (introduction); and,
- Post release sampling.

The Partrac team will be on site to assist with stages 1, 2 and 3. Staff from USGS and USACE will deploy magnets at shallows stations as determined by the design of the tracer study. We will sample bed sediments and the magnets in the shallows for the tracer study prior to tracer deployment and in 4 repeat surveys afterwards, with survey timing and number of sampling locations to be determined in collaboration with Partrac and the wider USGS and USACE project team.

Task 5 Marsh and restoration sampling

Sediment deposition transects will be established across elevation gradients and vegetation type (see Buffington et al. 2020 for details) across Eden Landing marsh and restoration sites. At each sampling location we will deploy glass filter pads along a shore/channel-normal transect that collect mineral and organic matter deposited on the marsh surface. Sediment pad samples will be analyzed in the lab for mineral mass and organic matter. Data collection will occur prior to placement and post placement. Samples will be collected monthly for up to 6 months post-placement.

For all sampling locations, elevation and location will be measured and distance to the nearest marsh creek will be determined. Percent time flooded and depth will be calculated for sampling locations from water level and elevation data. Plant species composition and density can play an important role in rates of sediment deposition. We will conduct vegetation surveys to inventory dominant plant species, density, and elevations pad location. We will determine species, % cover, and average height. To translate deposition into accretion rates we will collect short soil cores adjacent to sediment traps in the marsh to analyze for bulk density and organic matter. Marker Horizons will be deployed using feldspar plots and can provide a comparison between this short-term study and long-term trends. These will be measured throughout the project period.

Task 6 Support for tracer study: marsh and restoration

Sample for dual signature tracer material across the tidal marsh and restoration areas using strong-field magnets. Magnets will be deployed in the water column at strategic locations, for example, at the channel entrances to restorations, for up to 1-year post-placement. A subset of the sediment deposition pads will be analyzed for the tracer. We will conduct six post-placement surveys. The timing of surveys will be adaptive depending on the monitoring of the shallows.

Task 7 Effects of sediment placement on benthic biological community and fish/avian foraging resources

To assess the impacts of the shallow placement of beneficial dredged material on the benthos, we propose to evaluate both the modeled impact zone as well as a "reference" site using a Before After Control Impact (BACI) framework. A BACI framework is more rigorous than a Before and After only study and will allow us to distinguish the impact of environmental or seasonal changes from the impact of dredged material placement (McAtee et al. 2020). Our sampling design will incorporate benthic coring on parallel transects within the placement area to ensure intensive sampling of this zone, as well as perpendicular transects extending in all directions from the placement area. The addition of perpendicular transects will allow us to analyze impacts to the benthos as distance from source increases and modeled sediment depth decreases. The number of cores taken during each sampling event will be based on previous power analyses run on benthic core data from both the Dumbarton shoals and the Central Bay (De La Cruz et al. 2020) to identify the minimum sample size needed to determine a 50% reduction in invertebrate density with 80% power (Steidl et al. 1997; Quinn & Keough, 2002; Di Stefano 2003)

We will use a modified Benthic Resources Assessment Technique (BRAT), a functional approach first developed by the USACE, to quantitatively evaluate and compare dredge-impacted sites in terms of trophic support for bottom feeding fishes (Lunz & Kendall 1982). The BRAT framework integrates information on fish foraging ecology and prey profitability to estimate the energy that is available to particular fish feeding guilds. The modified BRAT (hereafter, MBRAT) is based on SFBE benthic fish foraging ecology and diet information and has been used previously for studies of dredged sites in the estuary (De La Cruz et al. 2017, 2020).

A Sample benthic prey resources at impact and reference sites

Using a BACI framework, we will sample the impact and pre-determined reference site immediately prior to the sediment placement operation, within a month of final sediment placement, and at additional intervals as determined by project team to access duration of placement effects and enable quantification of foraging resources during key points in the annual cycle of benthic consumers such as fish and waterbirds.

Two replicate sediment core samples will be collected at locations set equidistant apart along each transect. Each core will be 10 cm in diameter and a minimum of 20 cm deep to capture the effect of placing up to 10 cm of sediment. Cores will be sliced into shallow (0-4 cm) and mid (4-10 cm) and deep (10-20 cm) increments to measure prey distribution at different depths in the sediment according to MBRAT methodology. Water quality is an important driver of invertebrate communities and continuous measurements will enable us differentiate effects of water quality from those of the sediment placement. To quantify water level (m), temperature (°C), and salinity (PSU) we will install loggers in both the impact and reference areas. Each time we sample an area we will spot check water quality (temperature, salinity, dissolved oxygen (mg/L) using a multi-parameter sonde at the water surface and just above the benthic surface in the demersal zone, at 3 points along each transect. Sediment cores will be collected at multiple points along each transect analyzed at an external laboratory to determine sediment grain size and other characteristics (e.g. organic matter content, sediment texture, sediment pH).

Sample processing

Cores fractions will be immediately transported to the USGS Invertebrate Ecology Laboratory on ice and refrigerated until processed. Within 1-3 days cores will be rinsed through a 500 µm mesh sieve, and fauna retained by the sieve will be preserved in a 70% ethanol with 1% rose bengal dye. All taxa within cores will be sorted, identified and enumerated. Macroinvertebrates will be sorted into four size classes based on fish and waterbird foraging ecology: 0-4 mm, 4-12 mm, 12-24 mm, and 24-50 mm. Taxa from all samples will be identified to a broad taxonomic level (class, order); however, macroinvertebrates in a subset of randomly selected cores from the control and impact sites will be identified to the lowest possible taxonomic level (family, genus, species) to evaluate structural benthic recovery. Ten percent of macroinvertebrate samples will be submitted to an external laboratory for QA/QC procedures (EcoAnalysts, Inc., Moscow, ID). We will calculate dry weight biomass and energy density of available prey using established conversion factors (Brey et al. 1988) or via direct measurement in a micro-calorimeter (Parr 6725 Semi-Micro Calorimeter) as needed.

Data integration and analyses

We will assess the effects of treatment (placement versus control), time since placement, and distance to placement separately for three response variables 1) density (individuals/m^2), 2) dry biomass (g/ m^2), and 3) energetic content (kJ/ m^2) of macroinvertebrates.

Task 8. Eelgrass monitoring:

To verify avoidance of eel grass beds, the PDT or Contractor shall perform pre-construction eelgrass surveys of the Project area during the months of May through

September (i.e., the active growth period for eelgrass in San Francisco Bay). All eelgrass surveys shall be performed in accordance with the National Marine Fisheries Service's (NMFS's) California Eelgrass Mitigation Policy (October 2014). The pre-construction survey shall be completed prior to the anticipated start of in- or over-water construction and shall be valid for either 60 days or until the next active growth period if construction occurs after the end of the active growth period. The results of the pre-construction eel grass survey shall be submitted to the Water Board prior to commencement of construction activities. If the results of the pre-construction survey indicate that eel grass beds are located where the mooring or construction equipment will be installed, the Applicant shall prepare and submit to the Water Board a mitigation and monitoring plan that will be implemented to compensate for impacts to eel grass beds. Furthermore, construction of the Project shall not commence until the Applicant receives written approval of the mitigation and monitoring plan from the Water Board's Executive Officer.

Monitoring timing will vary by task, but will begin 2 months before placement, and will extend one year after placement. Decisions about specific timing and duration will be made adaptively in consultation with the monitoring team, and project team.

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Appendix E – REAL ESTATE PLAN

APPENDIX E

REAL ESTATE PLAN

San Francisco Bay
Strategic Placement Pilot Project

Alameda County

PREPARED FOR
SAN FRANCISCO DISTRICT
SOUTH PACIFIC DIVISION
U.S. ARMY CORPS OF ENGINEERS

BY

LOS ANGELES DISTRICT
REAL ESTATE DIVISION
SOUTH PACIFIC DIVISION
U.S. ARMY CORPS OF ENGINEERS

SEPTEMBER 2022

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1. INTRODUCTION

The overall purpose of the Strategic Placement Pilot Project is to test a novel approach to increase mudflat and tidal marsh resilience to sea-level rise (SLR) in the San Francisco Bay in Northern California via strategic placement of sediment dredged from federal navigation channels at a shallow, in-bay location adjacent to the mudflat and tidal marsh. The study area is in the South San Francisco Bay and is bounded by the San Mateo Bridge to the north and the southern shoreline of the Bay to the south. Although the pilot project is entirely federally funded, the California State Coastal Conservancy will serve as the non-cost share non-federal sponsor.

The Real Estate Plan is prepared in support of the *Environmental Assessment (with Draft FONSI) and 404 (b)(1) Analysis & Initial Study (with Draft Mitigated Negative Declaration), San Francisco Bay Strategic Shallow-Water Placement Pilot Project* and is in accordance with ER 405-1-12, Chapter 12, Section 12-16.

The Real Estate Plan is tentative in nature; it is for planning purposes only and both the final real property acquisition lines and the real estate cost estimates provided are subject to change even after approval of the Environmental Assessment.

2. PROJECT AUTHORITY

The study is authorized under Section 1122 of the Water Resources Development Act (WRDA) of 2016. Section 1122 directed the U.S. Army Corps (USACE) to establish a pilot program consisting of ten projects for the beneficial use of dredged material for one of the purposes described below:

1. Reducing storm damage to property and infrastructure;
2. Promoting public safety;
3. Protecting, restoring, and creating aquatic ecosystem habitats;
4. Stabilizing stream systems and enhancing shorelines;
5. Promoting recreation;
6. Supporting risk management adaptation strategies; and
7. Reducing the costs of dredging and dredged material placement such as projects that use dredged material for:
    a. Construction or fill material;
    b. Civic improvement objectives; and
    c. Other innovative uses and placement alternatives that produce public economic or environmental benefits

USACE solicited project proposals through a notice in the *Federal Register* dated 9 February 2018. After review and evaluation of ninety-five proposals, the Assistant Secretary of the Army for Civil Works signed the Programmatic Environmental Assessment and FONSI on 10 October 2018 recommending the ten pilot projects, including the Strategic Placement Project in San Francisco Bay. Of the specific purposes outlined in the pilot program's implementation guidance, the Strategic Placement Project falls under "Other innovative uses and placement alternatives that produce public, economic, or environmental benefits".

The Strategic Placement Project was originally part of a much larger California State Coastal Conservancy proposal for Restoring San Francisco Bay's Natural Infrastructure with Dredged Sediment. For the purposes of a pilot effort, per WRDA 2016 Section 1122, the Strategic Shallow Water Placement Project was considered a separable element that is innovative, has a high potential for benefits, and can be accomplished in one or a few dredging cycles.

3. PROJECT DESCRIPTION

The Recommended Plan would place approximately 100,000 yd^3 of annual maintenance dredged material from the Redwood City Harbor Federal Navigation Channel directly into shallow water adjacent to the mudflat and salt marsh known as Eden Landing. Eden Landing Ecological Reserve, which includes Whale's Tail Marsh, is adjacent to Hayward and Union City in Alameda County and is bounded by Alameda Creek to the south, Old Alameda Creek and a portion of Don Edwards San Francisco Bay National Wildlife Refuge to the north and is west of a mix of restored marsh and post-industrial salt evaporation ponds. The project would evaluate the ability of tides and currents to move dredged sediment placed in the nearshore environment to the adjacent mudflat and marsh.

Placement would be approximately 2 miles offshore of Eden Landing at less than 10 feet below Mean Lower Low Water (MLLW) and at a thickness between 4 inches and 1 foot. Placements will take place during flood tides within a 138-acre placement footprint that was determined by computer modeling and geospatial analysis to be most suitable for successful placement. Scows which will be light loaded to 900 yd^3, will make approximately 112 round trips between Redwood City and the placement site. The placement area and adjacent mudflat-marsh complex will be monitored before and after placement.

4. DESCRIPTION OF LANDS, EASEMENTS, RIGHTS-OF-WAY, RELOCATIONS, AND DISPOSAL AREAS (LERRDs)

There are no lands, easements or rights-of-way necessary for the project. Placement of the dredged material will be below the Ordinary Mean High Water Mark and therefore available under the government's dominant right of navigation servitude as discussed further in Section 9.

5. NON-FEDERAL SPONSOR OWNED LER

There are no lands owned by the Non-Federal Sponsor required for the project.

6. STANDARD AND NON-STANDARD ESTATES

There are no estates required for the project.

7. EXISTING FEDERAL PROJECTS

The Strategic Placement Project would utilize dredged material from the Redwood City Harbor Operations and Maintenance Federal Navigation project. Redwood City Harbor consists of San Bruno Shoal Channel, an entrance channel, outer channel, inner channel, and two turning basins. The project is the only commercial deep-draft harbor in southern San Francisco Bay. Project Operations and Maintenance (O&M) provides for a two-year cycle of maintenance dredging of the main ship channel, which has an authorized project depth of 30 feet MLLW. The dredged material from the Redwood City Harbor is typically placed at SF-11, the in-bay placement site near Alcatraz Island.

There is no overlap with any other existing Federal projects.

8. FEDERALLY OWNED LANDS REQUIRED FOR THE PROJECT

There are no federally owned lands required for the project.

9. AVAILABILITY OF NAVIGATION SERVITUDE

The navigation servitude is the dominant right of the Government under the Commerce Clause of the U.S. Constitution (Art. I, §8, cl.3) to use, control and regulate the navigable waters of the United States and the submerged lands hereunder for various commerce-related purposes. There is a two-step process to determine the availability of the navigation servitude. First, the Government must determine whether the project feature serves a purpose in aid of commerce such as navigation, flood control and hydroelectric power. Second, the subject lands must fall below the mean or ordinary high water mark of a navigable waterway. As the beneficial reuse of dredged material from a federal navigation project has a direct nexus to navigation and the placement of the dredged material will occur below the MLLW it appears the project meets the criteria necessary to exercise navigation servitude.

10. PROJECT MAPS

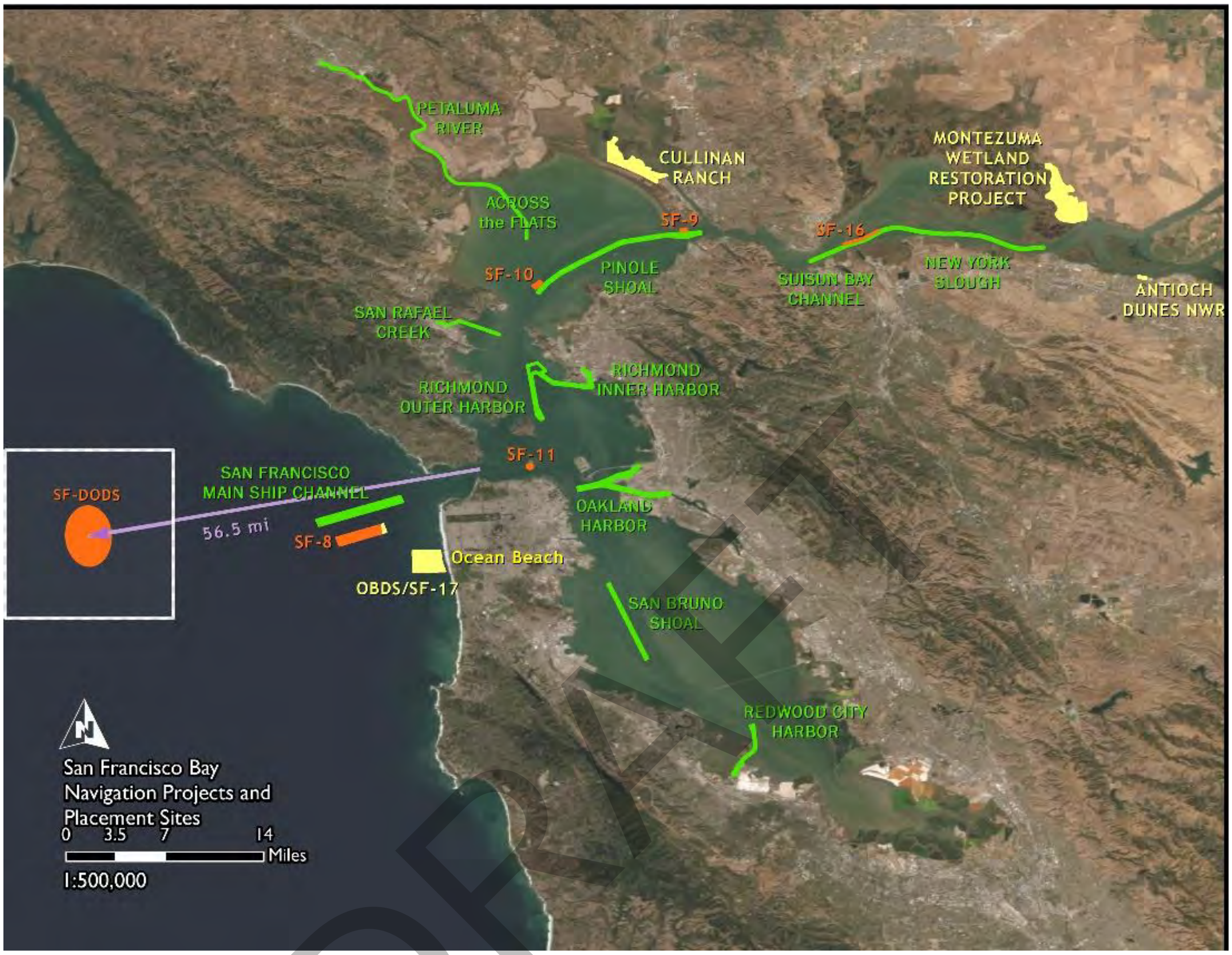

Figure 1. San Francisco District federal navigation projects (green) and traditional placement sites (orange [aqueous] and yellow [beneficial use]).

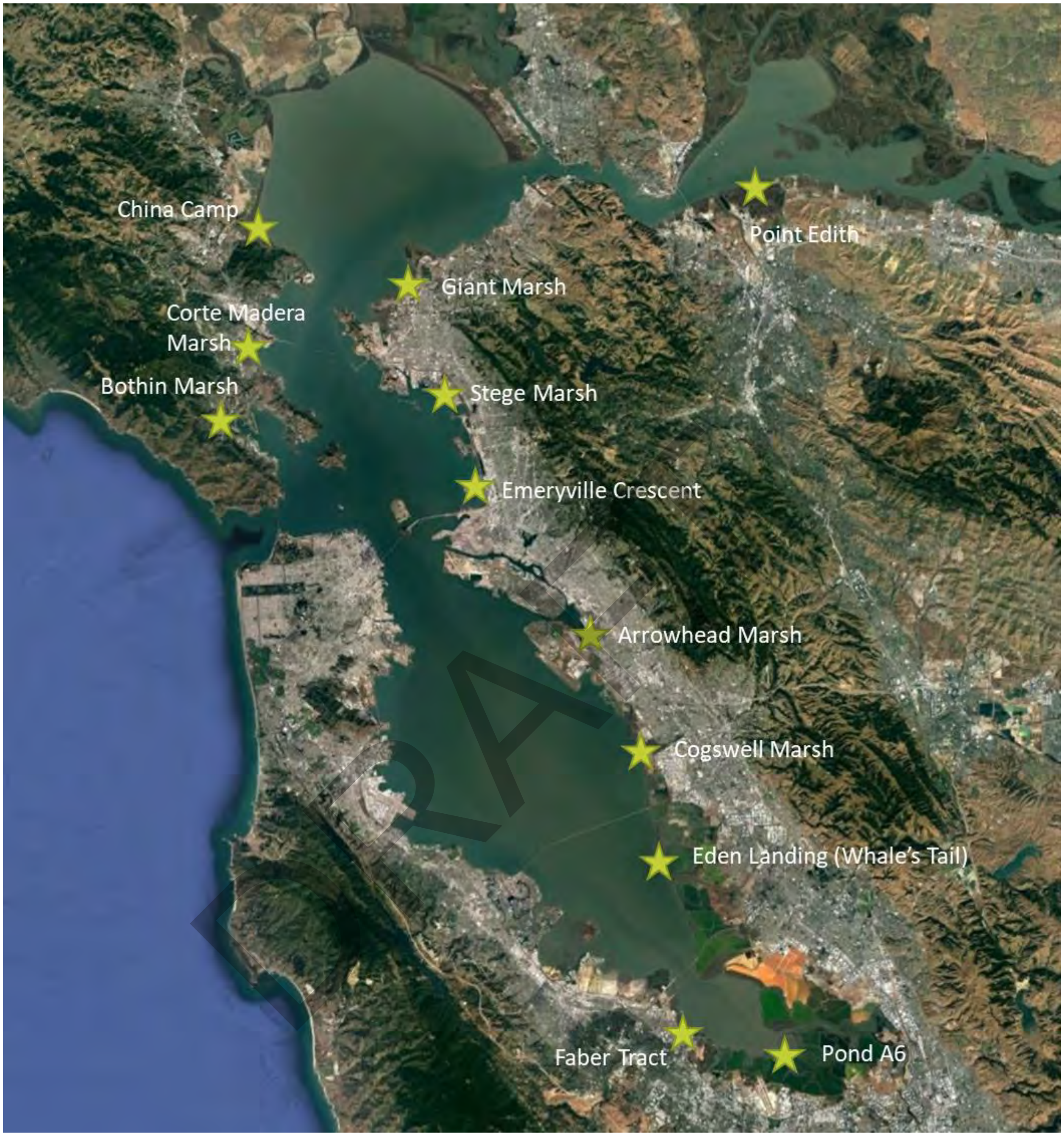

Figure 2. Twelve potential placement sites considered across the San Francisco Bay for strategic placement, including the chosen alternative, Eden Landing.

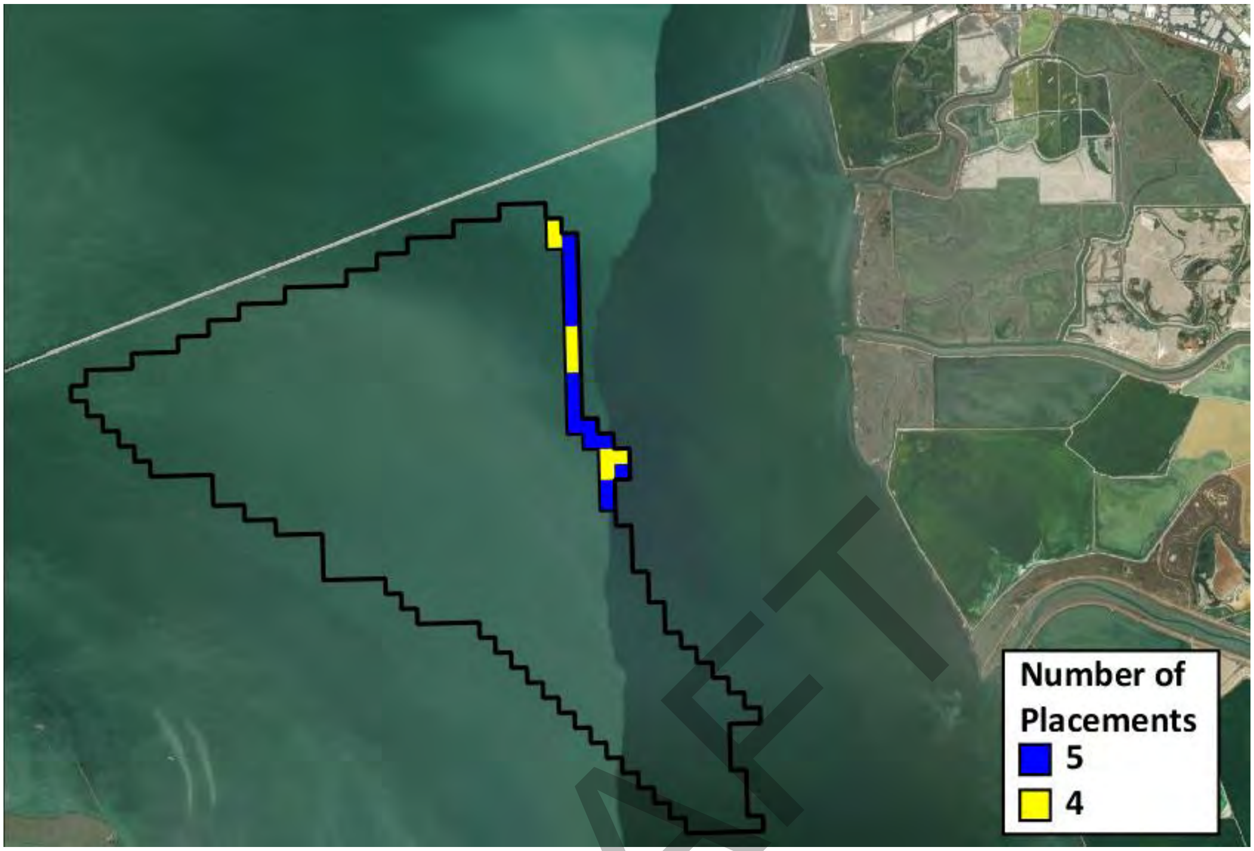

Figure 3. Placement cells in shallow water approximately two miles off the marsh at Eden Landing (i.e., Whale's Tail) for the Shallow/East placement. The black outline represents the entire placement grid, while the blue and yellow cells represent the Eden Landing Shallow/East placement footprint cells with five and four placements respectively depending on the water depths and tidal timings. The placement footprint is approximately 9,700 feet long and 630 feet wide.

11. POTENTIAL FOR INDUCED FLOODING

The project will not induce any flooding. In fact, the shallow water placement of dredged material would have beneficial impacts on flood-control functions of the adjacent marsh.

12. COST ESTIMATE

There are no real estate acquisitions costs associated with the project as all activities will occur within the bay where navigation servitude will be invoked.

13. RELOCATION ASSISTANCE BENEFITS

The project will not displace any residential, commercial, industrial or habitable structures; therefore, the provisions under Title II of Public Law 91-646, as amended, are not applicable.

14. MINERAL/TIMBER ACTIVITIY

All work is anticipated to occur by invoking the navigation servitude. Mineral rights will not be impacted.

15. NON-FEDERAL SPONSOR'S ABILITY TO ACQUIRE

The non-federal sponsor will not be expected to perform any acquisitions.

16. ZONING IN LIEU OF ACQUISITION

There is no zoning in lieu of acquisition planned in connection with the project.

17. ACQUISITION SCHEDULE

All work will be performed under the right of navigation servitude and no acquisitions will be required.

18. FACILITY/UTILITY RELOCATIONS

As all work will occur in shallow water, no facilities or utilities will be impacted by the project.

19. ENVIRONMENTAL CONCERNS

Sediments are tested prior to dredging, and the results are reviewed by the Dredged Material Management Office (DMMO) prior to dredging, transport, and placement, including evaluation of the potential for impact to aquatic organisms. Sediment testing results for previous USACE maintenance dredging episodes at Redwood City Harbor Harbor indicate that, in general, dredged materials from the subject federal navigation channel have been suitable for unconfined aquatic disposal. Some isolated areas in Reach 5 of the Redwood City channel have been identified as containing sediment that is not suitable for unconfined aquatic disposal; USACE would avoid importing material from these areas. Therefore, dredging and placement activities would not be expected to increase contaminant concentrations in the environment above baseline conditions.

Dredging, transport, and placement of dredged material would be conducted in cooperation with the DMMO. This process would identify contaminated sediments and screen out any material that is unsuitable for shallow water placement.

20. LANDOWNER CONCERNS

All work is anticipated to be performed in areas subject to the navigation servitude so no landowners will be affected. The California State Lands Commission has also acknowledged the Government's dominant right of navigation servitude and expressed its support for the pilot project. Additionally, there is strong public support for the restoration of the tidal wetlands in the San Francisco Bay.

21. RECOMMENDATION

This real estate plan has been prepared in accordance with ER405-1-12, Chapter 12 and is recommended for approval.

PREPARED BY:

Kelly Boyd

Kelly Boyd
Realty Specialist
Los Angeles District

REVIEWED AND RECOMMENDED BY:

Cheryl L. Connett

20 SEP 2022

Cheryl L. Connett
Chief, Real Estate Division
Los Angeles District

Date

Appendix F – CEQA CHECKLIST

Appendix F – Environmental Checklist

1. Project Title: San Francisco Bay Strategic Shallow-Water Placement Pilot Project

2. Lead Agency Name and Address:
San Francisco Bay Regional Water Quality Control Board
1515 Clay Street, Suite 1400
Oakland, California 94612

3. Contact Person and Phone: Christina Toms, 510-622-2506

4. Project Location: Offshore of Eden Landing Ecological Reserve within San Francisco Bay, approximate location of 37.596561° N, 122.181325° W

5. Project Sponsor's Name & Address:
U.S. Army Corps of Engineers
450 Golden Gate Ave., 4th Floor
San Francisco, CA 94012

6. General Plan Designation: Not Applicable

7. Zoning: Not Applicable

8. Description of Project: The project is for the U.S. Army Corps of Engineers (USACE or Corps) to test a novel approach to increase mudflat and salt marsh resilience to sea level rise in San Francisco Bay via strategic placement of dredged sediment at a shallow, in-Bay location adjacent to target mudflats and tidal marshes. The project proposes to use dredge and dump scows to place approximately 100,000 cubic yards of sediment to a shallow-water placement site slightly more than two miles offshore of target wetlands and mudflats in and near the California Department of Fish and Wildlife's Eden Landing Ecological Reserve. The dredged sediment would come from the Corps' approved maintenance dredging of federal navigation channels at the Port of Redwood City that were evaluated for environmental impacts in the *Final Environmental Assessment/Environmental Impact Report for Maintenance Dredging of the Federal Navigation Channels in San Francisco Bay Fiscal Years 2015-2024*. The placement site is 138 acres in size and runs roughly parallel to the tidal marshes at Whale's Tail North and South. Only sediment that meets the criteria for beneficial reuse established by the interagency Dredged Material Management Office would be placed. The average thickness of the sediment deposits would be around half a foot deep. Based on wave and current modeling, the scows would unload in water depths less than 10 ft in absolute depth (i.e., the shore-normal placement location will vary depending on the stage of the tide) to maximize marsh-ward transport by waves and currents. Placements will take place during flood tides within the 138-acre placement footprint that was determined by computer modeling and geospatial analysis to be most suitable for successful placement. Scows which will be light loaded to 900 cubic yards and will make approximately 112 round trips to the placement site.

The placement area and adjacent mudflat-marsh complex will be monitored before and after placement.

9. Surrounding Land Uses and Setting: The strategic sediment placement site is in shallow water along the eastern shoreline of southern San Francisco Bay, south of the San Mateo Bridge and west of the 6,400-acre Eden Landing Ecological Reserve (ELER or Eden Landing). The site is roughly two miles offshore of the high tidal marsh complex known as Whale’s Tail, which flanks the north and south sides of Old Alameda Creek. Shallow subtidal bay waters, subtidal mudflats, and intertidal mudflats separate the sediment placement site from Whale’s Tail. Landward of Whale’s Tail is a large complex of former salt production ponds within ELER, some of which are gradually being restored to tidal action through the South Bay Salt Pond Restoration Project (SBSPRP). Public access to ELER is limited to a trail that circumnavigates ponds E12 and E13, and a short spur trail that extends from pond E13 and follows Mt. Eden Creek to a terminus near Whale’s Tail North.

10. Other public agencies whose approval is required:

Agency	Approval	Status
San Francisco Bay Conservation and Development Commission	McAter-Petris Act Administrative Permit, Coastal Zone Management Act Consistency Determination	
U.S. Fish and Wildlife Service	Endangered Species Act Section 7 Consultation	
National Marine Fisheries Service	Endangered Species Act Section 7 Consultation	

11. Have California Native American tribes traditionally and culturally affiliated with the project area requested consultation pursuant to Public Resources Code section 21080.3.1? If so, is there a plan for consultation that includes, for example, the determination of significance of impacts to tribal cultural resources, procedures regarding confidentiality, etc.?

    Pursuant to Public Resources Code section 21080.3.1, the USACE and the Water Board contacted the Native American Heritage Commission (NAHC) requesting an updated Native American tribal consultation list for the Project. The Sacred Lands File search was negative. USACE obtained a tribal consultation list from the NAHC on 14 April 2020. The following Ohlone Tribes were identified as tribal consulting parties under Section 106 of NHPA and the National Environmental Policy Act (NEPA): The Amah Mutsun Tribal Band, Amah Mutsun Tribal Band of Mission San Juan Bautista, Costanoan Ohlone Rumsen-Mutsun Tribe, Indian Canyon Mutsun Band of Costanoan, and the Muwekma Ohlone Indian Tribe of the SF Bay Area.

On June 1, 2022, a virtual, informal Tribal consultation meeting was held with the Confederated Villages of Lisjan (CVL). The CVL is interested in the project and wishes to be involved in the monitoring of plants and the effectiveness of the study. The Tribe identified tidal marshes near the sediment placement site as a cultural resource, would like access to the monitoring data that is collected, and are interested in learning if the Pilot Project is successful.

I. Aesthetics

Would the Project:

Environmental Issue	Potentially Significant Impact	Less Than Significant with Mitigation	Less Than Significant Impact	No Impact
a) Have a substantial adverse effect on a scenic vista?			X	
b) Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?				X
c) In nonurbanized areas, substantially degrade the existing visual character or quality of public views of the site and its surroundings? (Public views are those that are experienced from publicly accessible vantage point). If the project is in an urbanized area, would the project conflict with applicable zoning and other regulations governing scenic quality?			X	
d) Create a new source of substantial light or glare, which would adversely affect day or nighttime views in the area?				X

Discussion

a), c) Public access to the project site is limited to levee-top trails within California Department of Fish and Wildlife (CDFW) lands north of Old Alameda Creek; for resource protection purposes, there is currently no public access to CDFW lands south of Old Alameda Creek. Scenic vistas from these public access points include open water, mudflat, and marsh habitats within the Eden Landing complex and along the San Francisco Bay (SF Bay) shoreline. Nearshore vistas within SF Bay and at the project site typically include barges, tugboats, ferries, and related industrial and commercial shipping operations, as well as recreational vessels, such as sailboats and kayaks. Proposed sediment placement activities will result in the temporary presence of scows and associated sediment management equipment consistent with the existing visual landscapes of nearshore SF Bay and would occur more than two miles offshore from the nearest public vista point within the CDFW Eden Landing complex. The impacts on scenic vistas would therefore be **less than significant.**

b) There are no trees, rock outcroppings, historic buildings, or scenic highways on the project site and no scenic highways with views of the project site. Therefore, there would be **no impact** to scenic resources.

d) The sediment placement activities proposed as part of the project are temporary and will occur more than two miles offshore of an ecological reserve with no legal public access between sunset and sunrise. Therefore, there would be **no impact** on nighttime views.

II. Agricultural and Forestry Resources

Would the Project:

Environmental Issue	Potentially Significant Impact	Less Than Significant with Mitigation	Less Than Significant Impact	No Impact
a) Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?				**X**
b) Conflict with existing zoning for agricultural use, or a Williamson Act contract?				**X**
c) Conflict with existing zoning for, or cause rezoning of, forest land (as defined in Public Resources Code section 12220(g)), timberland (as defined by Public Resources Code section 4526), or timberland zoned Timberland Production (as defined by Government Code section 51104(g))?				**X**
d) Result in the loss of forest land or conversion of forest land to non-forest use?				**X**
e) Involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland, to non-agricultural use or conversion of forest land to non-forest use?				**X**

Discussion

a-e) The project site and vicinity are within San Francisco Bay and does not include agricultural or forested lands. Therefore, the project would have **no impact** on agricultural or forest resources.

III. Air Quality

Where available, the significance criteria established by the applicable air quality management or air pollution control district may be relied upon to make the following determinations. Would the project:

Environmental Issue	Potentially Significant Impact	Less Than Significant with Mitigation	Less Than Significant Impact	No Impact
a) Conflict with or obstruct implementation of the applicable air quality plan?		X		
b) Result in a cumulatively considerable net increase of any criteria for which the Project region is non-attainment under an applicable federal or state ambient air quality standard?		X		
c) Expose sensitive receptors to substantial pollutant concentrations?				X
d) Result in other emissions (such as those leading to odors) adversely affecting a substantial number of people?				X

Background

This section summarizes construction air quality impacts associated with the proposed project and is consistent with the methods described in the Bay Area Air Quality Management District (BAAQMD) *California Environmental Quality Act* (*CEQA) Air Quality Guidelines* (May 2017). Additional detail regarding air quality impacts can be found in Section 4.1.11 and Appendix A-5 of the Environmental Assessment – Mitigated Negative Declaration (EA-MND).

The air quality analysis includes a review of criteria pollutant emissions such as carbon monoxide, nitrogen oxides, volatile organic compounds as reactive organic gases, particulate matter less than 10 micrometers (coarse or PM_{10}), and particulate matter less than 2.5 micrometers (fine or $PM_{2.5}$). Diesel particulate matter is also a concern regarding health risk assessment (HRA).

The United States Environmental Protection Agency (USEPA) has established National Ambient Air Quality Standards (NAAQS) under the Clean Air Act (CAA) for the criteria pollutants and California Air Resources Board (CARB) has established California Ambient Air Quality Standards (CAAQS). Air basins where NAAQS and/or CAAQS are exceeded are designated as a "nonattainment" area. If standards are met, the area is designated as an "attainment" area.

The project site is located within the San Francisco Bay Area Air Basin (Air Basin) under the jurisdiction of the BAAQMD. The BAAQMD is the local agency responsible for the administration and enforcement of air quality regulations for the area. The Bay Area is currently designated "nonattainment" for state and national (1-hour and 8-hour) ozone standards, for the state PM_{10} standards, and for state and national (annual average and 24-hour) $PM_{2.5}$ standards. The Bay Area is designated "attainment" or "unclassifiable" with respect to the other ambient air quality standards. Table AQ-1 below describes the effective NAAQS, USEPA Yearly Significance Thresholds, CAAQS, and BAAQMD thresholds within the project area.

Table AQ-1. NAAQS, USEPA Yearly Significance Thresholds, CAAQS, and BAAQMD thresholds that are effective within the project area.

NAAQS, CAAQS, Federal, and BAAQMD Thresholds for Criteria Air Pollutants Criteria Pollutant	NAAQS	EPA Yearly Significance Thresholds (tons/year)	CAAQS	BAAQMD Daily Threshold (Pounds/Day)	BAAQMD Yearly Threshold (Tons/Year)
Reactive Organic Gases (ROG)	N/A	100	N/A	54	10
Nitrogen Oxides (NOx)	0.05 ppm (Annual) 0.10 ppm (1-Hour)	100	0.03 ppm (Annual) 0.18 ppm (1-Hour)	54	10
Ozone (O3)	0.07 ppm (Annual)	N/A	0.07 ppm (Annual) 0.09 ppm (1-Hour)	N/A	N/A
PM10	150 µg/m3 (24-Hour)	100	20 µg/m3 (Annual) 50 µg/m3 (24-Hour)	82	15
PM2.5	12 µg/m3 (Annual) 35 µg/m3 (24-Hour)	100	12 µg/m3 (Annual)	54	10
Sulfur Dioxide (SO2)	0.03 ppm (Annual) 0.14 ppm (24-Hour)	100	0.04 ppm (24-Hour)	N/A	N/A
Lead	0.15 µg/m3 (90-Day)	N/A	1.5 µg/m3 (30-Day)	N/A	N/A
Sulfate	N/A	N/A	25 µg/m3 (24-Hour)	N/A	N/A
Carbon Monoxide (CO)	9 ppm (Annual) 35 ppm (1-Hour)	100	9 ppm (Annual) 20 ppm (1-Hour)	N/A	N/A
Hydrogen Sulfide (H2S)	N/A	N/A	0.03 ppm (1-Hour)	N/A	N/A
Vinyl Chloride	N/A	N/A	0.01 ppm	N/A	N/A

			(24-Hour)		

Notes: ppm = parts per million; µg/m3 = micrograms per cubic meter

Appendix A-5 of the EA-MND describes the details of the air quality analysis. The results of this analysis are summarized in Table AQ-2:

Table AQ-2. Air quality analysis of the proposed project.

Redwood City Sediments taken to Eden Landing Placement Site						
	ROG	CO	NOx	SOx	PM10	PM2.5
Peak Daily Emissions Totals (lbs/day)	1.24	3.87	28.45	5.09	0.61	0.55
Yearly Project Emissions Totals (tons/year)	0.04	0.13	0.94	0.17	0.02	0.02
BAAQMD Average Daily Threshold (lbs/day)	54.00	N/A	54.00	N/A	82.00	54.00
Project Emissions Exceed BAAQMD Daily Thresholds?	NO	N/A	NO	N/A	NO	N/A
BAAQMD Yearly Threshold (tons/year)	10.00	N/A	10.00	N/A	15.00	10.00
Project Emissions Exceed BAAQMD Yearly Thresholds?	NO	NO	NO	NO	NO	NO
EPA Yearly Significance Thresholds (tons/year)	100.00	100.00	100.00	100.00	100.00	100.00
Project Emissions Exceed Federal Yearly Threshold?	NO	NO	NO	NO	NO	NO

Notes: ROG = reactive organic gases; CO = carbon monoxide; NOx = nitrogen oxides; SOx = sulfur oxides; PM10 = particulate matter smaller than 10 micrometers; PM2.5 = particulate matter smaller than 2.5 micrometers

Discussion

a) The BAAQMD *2017 Clean Air Plan/Regional Climate Protection Strategy (CAP/RCPS)* provides a roadmap for BAAQMD's efforts over the next few years to reduce air pollution and protect public health and the global climate.

When a public agency contemplates approving a project where an air quality plan consistency determination is required, BAAQMD recommends that the agency analyze the project with respect to the following questions: (1) Does the project support the primary goals of the air quality plan; (2) Does the project include applicable control measures from the air quality plan; and (3) Does the project disrupt or hinder implementation of any air quality plan control measures? If the first two questions are concluded in the affirmative and the third question concluded in the negative, the BAAQMD considers the project consistent with air quality plans prepared for the Bay Area.

The recommended measure for determining project support of these goals is consistency with the previously mentioned BAAQMD thresholds of significance. As indicated in Table AQ-2, the proposed project would not exceed the BAAQMD significance thresholds; therefore, the proposed project would support the primary goals of the *2017 CAP/RCPS* and would not hinder implementation of any of the control measures. Impacts to air quality would be limited to the duration of construction, during which Mitigation Measure AQ-1 would be implemented; no long-term changes to emissions would occur as a result of the project.

Construction Impacts

Project construction would generate short-term emissions of air pollutants, including equipment exhaust emissions. The BAAQMD *CEQA Air Quality Guidelines* recommend quantification of construction-related exhaust emissions and comparison of those emissions to significance thresholds.

Table AQ-2 provides the estimated construction emissions for the proposed project. The average daily construction period emissions (i.e., total construction period emissions divided by the number of construction days) were compared to the BAAQMD significance thresholds. Construction-related emissions would be below the BAAQMD significance thresholds. Implementation of mitigation measure AQ-1 would reduce impacts to air quality from project construction to **less than significant with mitigation.**

Mitigation Measure AQ-1

Basic Exhaust Emissions Reduction Measures.

BAAQMD's *CEQA Air Quality Guidelines* require several best management practices to control exhaust emissions regardless of the estimated construction emissions. The BAAQMD requires that the following measures be implemented by the construction contractor:

- Idling times shall be minimized either by shutting equipment off when not in use or reducing the maximum idling time to five minutes (as required by the California airborne toxics control measure Title 13, Section 2485 of California Code of Regulations). Clear signage shall be provided for construction workers at all access points.
- All construction equipment shall be maintained and properly tuned in accordance with manufacturer's specifications. All equipment shall be checked by a certified mechanic and determined to be running in proper condition prior to operation.

As indicated, the estimated construction emissions would be below the BAAQMD's significance thresholds and the proposed project construction impacts would be **less than significant with mitigation.**

b) As demonstrated in (a), the project-related construction emissions would be below the BAAQMD significance thresholds. As previously discussed, the Bay Area is currently designated "nonattainment" for state and national (1-hour and 8-hour) ozone standards, for the state PM_{10} standards, and for state and national (annual average and 24-hour) $PM_{2.5}$ standards. The project when considered with additional projects in the region (see list in Chapter 5 of the EA-MND) would not result in a cumulatively considerable net increase of ozone, PM_{10}, or $PM_{2.5}$.Impacts would be **less than significant with mitigation AQ-1**.

c,d) The project site is more than two miles offshore of Eden Landing, and there are no sensitive receptors in the project area that could be exposed to substantial pollutant concentrations or odors. Therefore, there would be **no impact.**

IV. Biological Resources

Would the Project:

Environmental Issue	Potentially Significant Impact	Less Than Significant with Mitigation	Less Than Significant Impact	No Impact
a) Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies or regulations, or by the California Department of Fish and Wildlife or U.S. Fish and Wildlife Service?		X		
b) Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies or regulations or by the California Department of Fish and Wildlife or U.S. Fish and Wildlife Service?		X		
c) Have a substantial adverse effect on federally protected wetlands (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?		X		
d) Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?		X		
e) Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?				X
f) Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan?				X

Background

The Project site offshore of Eden Landing supports a suite of subtidal mudflat (benthic) and shallow (less than 18 feet [ft] deep, see Goals Project 1999) open water habitats that are typical of nearshore South San Francisco Bay. Benthic habitats are dominated by younger Bay Muds with occasional lenses/deposits of silt, sand, shell, and other coarse estuarine materials. Open water habitats are dominated by near-marine salinities (about 28 to 33 parts per thousand) except during the winter when periodic pulses of freshwater from local watersheds (e.g., Old Alameda Creek, Mt. Eden Creek) enter the Bay shallows. Local turbidities are typically high due to the wave-driven resuspension of sediment from the region's shallow subtidal and intertidal mudflats and can increase seasonally in response to winter pulses of stormwater from surrounding watersheds. Suspended sediment concentrations (SSC) in SF Bay typically range from 200 milligrams per liter (mg/L) in the winter to 50 mg/L in the summer, with shallow areas and their adjacent channels having the highest SSC (Rich 2010). SSC of up to 600 mg/L have been measured in turbidity maximum zones during winter storms that flush sediment from watersheds into the Bay (O'Connor 1991). Eelgrass (*Zostera marina*) has been consistently observed in the project site and vicinity (BCDC 2022), though the precise locations and distribution of eelgrass appears to shift from year to year.

Phytoplankton, such as diatoms, dinoflagellates, and cryptophytes, form the base of the region's aquatic food web (Cloern and Dufford 2005). Common zooplankton include species of copepods, rotifers, tintinnids, and meroplankton (larval forms of gastropods, bivalves, barnacles, polychaetes [marine bristleworms], and crustaceans [shrimps, crabs, barnacles, etc.]) (Ambler et al. 1985; NOAA 2007). Macrobenthic communities in the Project vicinity are dominated by invertebrates, such as clams (e.g. non-native *Corbula*, native *Mya*), mud snails, mussels, and the native Pacific oyster *Ostrea lurida*. The shells of the latter form regionally unique habitat components as shell deposits within the region's mudflats and shell hash beaches at Whale's Tail North and South. Other common benthic invertebrate communities in the Project vicinity include polychaetes, oligochaetes (earthworms and relatives), amphipods (shrimp-like organisms), isopods (sow bugs and relatives), and crustaceans. The benthic and aquatic food webs support abundant demersal fish, including recreationally important species (e.g., California halibut, striped bass, white sturgeon), key prey species (e.g., anchovies, Pacific herring, and smelt), and federally and state-listed species (longfin smelt (*Spirinchus thaleichthys*), green sturgeon (*Acipenser medirostris*) and salmonids (*Oncorhynchus* spp.). Some demersal fish, such as bat rays, forage on mudflats at high tide. Shallow open water and mudflat habitats in the region (both within the SF Bay and Eden Landing complex) are regionally critical foraging habitat for resident and migratory shorebirds and waterfowl, and serve as a key stop on Pacific Flyway (Warnock et al. 2002). Common bird species include diving ducks (e.g., canvasback, greater and lesser scaup, surf scoter), dabbling ducks (e.g., mallards, pintail, green-winged teal, and Northern shoveler), and shorebirds (e.g., western and least sandpiper, dunlin, long- and short-billed dowitcher, long-billed curlews, whimbrels, and American avocet). Marine mammals, such as seals and sea lions, consume demersal and pelagic fish.

Landward of the Project site, the CDFW Eden Landing complex supports a mosaic of tidal and non-tidal open water, mudflat, and marsh habitats that are shifting and evolving in response to management and restoration actions undertaken as part of the South Bay Salt Pond Restoration Project. General habitat conditions in tidal open water and mudflat areas within Eden Landing tend to echo conditions in similar tidal waters and mudflats offshore, though decreased mixing and extended residence times within former salt ponds likely contribute to locally elevated temperatures and primary productivity, especially during the summer months. Legacy salt ponds that have not been restored to tidal action by the South Bay Salt Pond Restoration Project are managed by CDFW as non-tidal open water and mudflats to support especially high densities of shorebirds and waterfowl, as well as nesting of federally- and state-listed species, such as western snowy plover (*Charadrius alexandrinus nivosus*) and California least tern (*Sternula antillarum browni*). High tidal marsh within the Eden Landing complex (above MHW) is dominated by pickleweed (*Sarcocornia pacifica*) and features commonly associated species, such as salt marsh gumplant (*Grindelia stricta*), fleshy jaumea (*Jaumea carnosa*), saltgrass (*Distichlis spicata*), and salt heath (*Frankenia salina*). Low tidal marsh (between MTL-MHW) is dominated by native Pacific cordgrass (*Spartina foliosa*); non-native smooth cordgrass (*Spartina alterniflora*) is known from the area and monitored/managed by the Invasive Spartina Project (www.spartina.org). Tidal wetlands at Eden Landing are known or assumed to support numerous federally- and/or state-listed fish and wildlife species, including longfin smelt, Ridgeway's rail (*Rallus obsoletus*), black rail (*Laterallus jamaicensis*), salt marsh song sparrow (*Melospiza melodia* spp.), salt marsh yellowthroat (*Geothlypis trichas sinuosa*), and salt marsh harvest mouse (*Reithrodontomys raviventris*).

Discussion

a - d) The project would result in direct impacts to benthic habitats offshore of the CDFW Eden Landing Complex by burying these habitats with a layer of dredged sediment. Sessile organisms, including eelgrass, within the footprint of sediment placement would generally not survive large amounts of burial (e.g., Wilber et al. 2007, Kemp et al. 2011), and would primarily recover via recolonization from surrounding areas. If the properties of placed sediment differs substantially from *in situ* sediment in the placement areas, or if the residual particle size in the placement footprint differs from the original substrate after waves and tidal currents re-work the placed sediments, community shifts in species abundance and composition could occur (Bishop et al. 2006). However, any shifts would be within the natural range of variation in the region's benthic characteristics and dependent biological communities driven by tides, waves, and storms, freshwater inputs from local watersheds, seasonal shifts in fields, shoreline erosion, and actions related to salt pond management/restoration.

Though direct impacts would be limited to benthic habitats within the sediment placement footprint, a temporary reduction or shift in subtidal benthic primary producers and consumers could potentially result in indirect impacts to higher trophic levels within the estuarine food web outside the placement footprint, including special-status aquatic species, such as longfin smelt, green sturgeon, and salmonids. These impacts would be temporary, and again, would be unlikely to exceed natural background variation in the region's estuarine food webs. In addition, sediment placement is likely to drive temporary local increases in turbidity within and beyond the placement footprint, which could drive temporary impacts to eelgrass and other light-sensitive species. However, because turbidity is driven by the effects of local tidal currents and waves on the benthos, it is unlikely that turbidities will exceed background levels that are regularly experienced by local biota, especially during high-energy events such as winter storms. Modeling indicates that after dredged sediment placement, SSC adjacent to the placement footprint would most frequently range between 50 and 300 mg/L over baseline conditions, and could be elevated by as much as 500 mg/L in the most extreme case.

However, the modeling also indicates that SCC would quickly return to baseline after each placement episode, making these effects on local turbidities and biota temporary.

The project could result in indirect impacts to non-benthic communities, including nearby mudflat and tidal marsh communities within the Eden Landing complex. The overall project purpose is to test a novel approach to increase mudflat and salt marsh resilience to sea level rise in SF Bay via strategic placement of dredged sediment at a shallow, in-Bay location adjacent to target mudflats and tidal marshes. Holocene tidal marsh and mudflat ecosystems within the Eden Landing complex and elsewhere in SF Bay have evolved to respond to and benefit from episodic pulses of sediment from both watershed- and estuarine-derived sources; without this sediment, these systems are unlikely to be resilient to rising sea levels driven by climate change (Goals Project 2015). Modeling indicates that the project could drive modest amounts of accretion in nearby tidal areas, ranging from about 0.01 cm at the target tidal marsh to about 0.1 cm on adjacent mudflats over a two-month period. These accretion rates are similar to those observed by the U.S. Geological Survey throughout the estuary's tidal mudflats and marshes. Given this tolerance of variability in natural sediment delivery across space and time, and the relatively modest amount of accretion expected in the region's tidal systems as a result of the project, it is highly unlikely that sensitive tidal marsh communities (and their dependent special-status species) would be adversely impacted by the project.

Example taxa and species in the nearshore community potentially impacted from shallow-water placement at the project site are described in Table BIO-1. Table BIO-2 documents state and federally listed (or proposed) endangered or threatened species under the state and federal Endangered Species Acts (CESA and FESA); designated and proposed critical habitat under FESA; Essential Fish Habitat in accordance with Magnuson Stevens Fishery Conservation and Management Act (MSFCMA); marine mammals protected under the Marine Mammal Protection Act (MMPA); and avian species protected under the Migratory Bird Treaty Act (MBTA) with the potential to occur in the project action area.

Table BIO-1: Nearshore communities with potential direct and indirect impacts from shallow-water placement at the project site:

Example Species	Physical Effect	Potential Direct Effects	Potential Indirect Effects	Recovery Time
Macroalgae Green algae e.g., *Ulva spp, Gracilaria pacifica*, *Fucus gardneri*	Burial and high SSC	Light reduction: mortality or reduced growth Siltation of vegetative structures: Reduced photosynthesis Smothering of hard surfaces: Reduced habitat area		Unknown in Bay estuary Laminaria shown to rebound from burial after 3 years in other systems (Gubelit 2012)
Microphytobenthos (Subtidal) e.g., diatoms, cyanobacteria, and	Burial	Smothering: mortality, reduced growth, altered species composition	Reduction in food availability for higher trophic levels	1.6 to 2.2 years in Southern California mudflats (Janousek *et al.* 2007)

Example Species	Physical Effect	Potential Direct Effects	Potential Indirect Effects	Recovery Time
dinoflagellates			Sediment stabilization may be disrupted Reduction in microphytobenthos may increase phytoplankton growth	Burial by more than a few millimeters smothers the biofilm, and recolonization from surrounding areas would be the mechanism for recovery
Phytoplankton e.g., diatoms, microflagellates	High SSC	Light reduction: decreased primary production (Cohen 2008)	Increase in phytoplankton can occur if burial reduces microphytobenthos production (McGlathery *et al.* 2013) Increased phytoplankton blooms possible if release of nutrients from sediments elevates nutrient concentrations (Lohrer and Wetz 2003, Cardoso-Mohedano *et al.* 2016, Zhang *et al.* 2012)	Effect is probably minor and difficult to estimate due to transient nature of sediment plume; light attenuation would last only a few hours
Vegetation (Subtidal) eelgrass (*Zostera marina*)	Burial and high SSC	Light reduction: mortality or reduced growth via burial and high turbidity Reduced photosynthesis and growth via siltation of vegetative structures Habitat modification possible if substrates are changed in properties (grain size, etc.)	Reduced numbers or altered composition of eelgrass-associated species (e.g., epiphytic macroalgae, Pacific herring, halibut, Canada geese) if eelgrass beds were to be significantly altered or reduce	In general, eelgrasses recover from burial in 2 to 5 years (Cabaco *et al.* 2008, Preen et al. 1995, Birch and Birch 1984, Onuf 1991, Blake and Ball 2001, Frederiksen *et al.* 2004, Sheridan 2004) Eelgrasses are sensitive to burial by around 2 to 5 cm, or to about 20 percent of total plant height (Cabaco *et al.* 2008, Munkes *et al.* 2015)

Example Species	**Physical Effect**	**Potential Direct Effects**	**Potential Indirect Effects**	**Recovery Time**
Invertebrates (Benthic) Macrobenthos: benthic epifauna and infauna, including worms, amphipods, etc.	Burial and high SSC	Smothering: mortality or reduced growth resulting in decreased species number, population density, and biomass of benthic organisms can result from burial and high turbidity	Reduction in food via changes in macrobenthos abundance and composition Habitat modification possible if substrates are changed in properties (grain size, etc.)	3 months to 5 years (Borja *et al.* 2010) Rates of recovery are highly variable depending on the substrate, community type, burial depth, and the extent to which the affected communities adapt to high levels of sediment disturbance
Invertebrates (Pelagic) Zooplankton e.g., copepods and amphipods	Burial and high SSC	Siltation: clogging of physical structures	Decreased primary production via burial or increased turbidity can lead to decreased food availability	Unknown
Invertebrates Native oysters (*Ostrea lurida*) and other bivalves	Burial and high SSC	Smothering: adult mortality or morbidity Siltation and high SSC: disruption of larval dispersal and settling	Reduction in food, via decreased proportion of food items compared to sediments for filter feeding Reduction of habitat by burial of hard surfaces where larva attach	Unknown Zabin *et al.* (2009) found that oysters permanently buried by mud suffered mortality, but survived temporary burial of less than one month
Invertebrates Dungeness crab (*Metacarcinus magister*)	Burial	Smothering: mortality of juveniles if they are unable to excavate from burial by dredge-material placement	Reduction of food via burial of benthic feeding grounds	Areas affected by dredge disposal repopulate with crabs in about 3 weeks (Roegner and Fields 2015) Crabs generally avoid sediment plume and burial, and can dig themselves out of about ~10 cm of material (Roegner and Fields 2015)
Ground Fishes leopard shark (*Triakis semifaciata*) green sturgeon (*Acipenser medirostris*)	Burial	Smothering: mortality of juveniles if they are unable to avoid burial by dredge-material placement	Reduction of food via burial of benthic feeding grounds	Unknown

Example Species	Physical Effect	Potential Direct Effects	Potential Indirect Effects	Recovery Time
Pelagic Fishes (use of near-benthic habitats) Pacific herring (*Clupea pallasi*), longfin smelt (*Spirinchus thaleichthys*) (spawning habitat)	High SSC	Siltation: morbidity and mortality of eggs, delays in hatching via increased SSC, which can adhere to eggs	For Pacific herring, limitation of spawning habitat if eelgrass or other structures, where eggs adhere, are buried or reduced For longfin smelt, Moyle (2002) states that spawning occurs in fresh water over sand, gravel, rocks, and aquatic plants so spawning habitat could be impacted as well if project effects extend into more fresh water areas	Jabusch *et al*. (2008) concluded that effects of elevated SSC from Bay dredging were lower than those experienced by herring during natural tidal cycles, specific effects of actions unknown Longfin smelt expected to be similarly affected
Pelagic Fishes e.g., salmonids, smelt, herring, anchovy	High SSC	Siltation: gill impairment, stress response, morbidity or mortality if SSC is very high Responses vary by species	Decreased food availability for demersal fishes if benthic prey is affected Reduced spawning habitat If eelgrass beds or other breeding surfaces are disrupted	Varies by species, most studies are from lab settings (see details in *Appendix A, Literature Review*)
Birds (Dabbling Ducks) e.g., mallard (*Anas platyrhynchos*), green-winged teal (*Anas carolinensis*), Northern shoveler (*Anas clypeata*)	Burial		Reduced food availability if subtidal vegetation is matted or killed, resulting in reduced seed production, an important dietary element for dabbling ducks (Joint Venture 2006) Reduced cover and nesting habitat if marsh vegetation is matted or buried (Enright n.d.)	Unknown Invertebrate (i.e., food) recovery from burial is 3 months to 7 years Vegetation (i.e., food, cover) recovery from burial is 6 months to 7 years

Example Species	Physical Effect	Potential Direct Effects	Potential Indirect Effects	Recovery Time
Birds (Diving Ducks) e.g., surf scoter (*Melanitta perspicillata*), bufflehead (*Bucephala albeola*)	High SSC	Reduced ability to forage if SSC is too high for visual hunting	Reduced foraging and prey availability if actions affect mollusks, bivalves, crustaceans, aquatic invertebrates, fish roe, and if submerged aquatic vegetation is reduced (Lovvorn et al. 2013)	Unknown Invertebrate (i.e., food) recovery from burial is 3 months to 7 years Eelgrass beds' (i.e., food) recovery is 2 to 5 years
Birds (Piscivorous) e.g., California least tern (*Sternula antillarum browni*)	High SSC	Reduced ability to forage if SSC is too high for visual hunting	Reduced prey availability if fish species are negatively affected by increased SSC, reductions of eelgrass beds or food resources (USACE 1998, USFWS 1998)	Unknown Recovery will depend on fish response and nesting success

Table BIO-2. Special-status species and critical habitats potentially occurring in and adjacent to the proposed action area.

Scientific Name	Common Name	Status	Statutory Protection
Spirinchus thaleichthys	longfin smelt	Threatened	California Endangered Species Act (CESA)
Sterna antillarum browni	California least tern	Endangered	Federal Endangered Species Act (FESA)
Rallus obsoletus obsoletus	Ridgway's rail	Endangered	FESA
Laterallus jamaicensis coturniculus	California black rail	Threatened, Fully Protected	CESA
Charadrius alexandrinus nivosus	western snowy plover	Threatened	FESA
Acipenser medirostris	North American green sturgeon, Southern DPS	Threatened with Critical Habitat Present	FESA
Onchorhynchus mykiss	Steelhead, Central California Coast with Critical Habitat present and Central Valley DPS	Threatened	FESA
Reithrodontomys raviventris raviventris	Southern salt marsh harvest mouse	Endangered	FESA
Zalophus californianus	California sea lion	Protected	MMPA
Phoca vitulina	Pacific harbor seal	Protected	MMPA
	Pacific Groundfish Fisheries Management Plan (FMP)	Essential Fish Habitat	MSFCMA
	Coastal Pelagic FMP	Essential Fish Habitat	MSFCMA
	Pacific Salmon FMP	Essential Fish Habitat	MSFCMA
	Eelgrass beds	Habitat of Particular Concern (HAPC)	MSFCMA
	Olympia oyster beds	HAPC	MSFCMA
	Pacific Groundfish FMP Estuary	HAPC	MSFCMA

Impacts from the project to sensitive estuarine habitats (including tidal wetlands, mudflats, and open waters) other than eelgrass would be temporary, and within the range of natural physical and biological variability experienced by these ecosystems. This includes impacts to habitats presumably used as migratory corridors by anadromous fish, such as salmonids, and catadromous fish, such as green sturgeon. The project would not interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites. None of the threatened or endangered species in Table BIO-2 are sessile benthic species that will be smothered by placed sediment, therefore, they are not expected to be adversely impacted by the project. USACE, as federal lead for the project, is consulting with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service to ensure compliance with the federal Endangered Species Act. These consultations are expected to result in provisions that will further ensure the protection of the special-status species and communities listed in Table BIO-2, including marine mammals and state-listed longfin smelt. Implementation of these provisions through mitigation measure BIO-1 would ensure that impacts to habitats, communities and species other than eelgrass would be less than significant.

Impacts from the project to eelgrass habitats offshore of Eden Landing are potentially significant, due to multiple factors including the sensitivity of these communities and their dependent food webs to burial and turbidity, and the uncertain rate and extent of recolonization, growth, and recovery post-burial. The San Francisco Bay Conservation and Development Commission's website has a web-based application, San Francisco Bay Eelgrass Impact Assessment Tool (Tool), for assessing the potential impacts of dredging projects on eelgrass. The Tool, which is located at San Francisco Bay Eelgrass Impact Assessment Tool | BCDC Open Data Portal (arcgis.com), shows 1) the maximum extent of eelgrass beds that have been surveyed in San Francisco Bay as of 2021; 2) a 45-meter growth buffer for potential bed expansion (direct impact buffer zone); and 3) a 250-meter turbidity buffer around eelgrass for determining indirect impacts (indirect impact buffer zone). Using the Tool to map the location of the project relative to the location of eelgrass beds and adjacent buffer zones shows that most areas of the project are within the 45-meter direct impact buffer zone and 250-meter indirect impact buffer zone. Implementation of mitigation measures BIO-1 and BIO-2, below, would reduce impacts to sensitive habitats and species (including eelgrass communities) to **less than significant with mitigation.**

Mitigation Measure BIO-1: The Permittee shall comply with the provisions of the U.S. Fish and Wildlife Service and the National Marine Fisheries Service in the project's Endangered Species Act consultations.

Mitigation Measure BIO-2:

a. Consistent with the June 9, 2011, Programmatic Essential Fish Habitat Consultation Agreement (Agreement) between the U.S. EPA, USACE, and the National Marine Fisheries Service (NMFS), the Permittee shall conduct pre- and post-dredge surveys of eelgrass areal coverage and density within the dredge footprint where it overlaps the 45-meter direct impact buffer zone.

b. Consistent with the Agreement, the Permittee shall implement operational control best management practices (BMPs) to protect eelgrass beds within 250 meters of dredging activity from adverse impacts due to excess turbidity in the water column.

c. The permittee shall mitigate for potentially significant impacts in accordance with the California Eelgrass Mitigation Policy and Implementing Guidelines (noaa.gov). In accordance with the policy, monitoring will be performed to assess potential impacts to eelgrass, and if found, eelgrass impacts will be mitigated to less than significant by creating, restoring, and/or enhancing eelgrass habitat at a minimum ratio of 1.2:1 acres. If the Project adversely impacts eelgrass, the Permittee shall submit and implement a mitigation plan and schedule, acceptable to Water Board staff. A NMFS-approved mitigation plan and schedule shall be considered acceptable to Water Board staff.

e) No trees would be removed as a result of the project. Therefore, **no impact** would occur.

f) The project site is not covered by any federal, state, or local conservation plan. Therefore, the project would have **no impact** with respect to habitat conservation plan compliance.

V. Cultural Resources

Would the project:

Environmental Issue	Potentially Significant Impact	Less Than Significant with Mitigation	Less Than Significant Impact	No Impact
a) Cause a substantial adverse change in the significance of a historical resource pursuant to Section 15064.5?			X	
b) Cause a substantial adverse change in the significance of an archaeological resource pursuant to Section 15064.5?				X
c) Disturb any human remains, including those interred outside of dedicated cemeteries?				X

Background

Section 15064.5 of the State CEQA Guidelines establish the definition of historical resource for the purposes of CEQA. Assembly Bill (AB) 52 became effective for all projects, including this one, with CEQA documents prepared after July 1, 2015. The bill added a definition of "tribal cultural resource," which is separate from the definitions for "historical resource" and "archaeological resource" (California Public Resource Code (PRC) Section 21074; 21083.09). Section XVIII of this checklist describes the project's impacts to tribal cultural resources. Under both Section 15064.5 and Section 106 of the National Historic Preservation Act (NHPA), the area of potential effects (APE) for the project includes the offshore placement site (about 138 acres) and the marsh and mudflats within the western extent of the Eden Landing Ecological Reserve (about 2,500 acres). The vertical APE is a minimum depth of 2 inches and maximum depth of 10 inches below the surface of the Bay. The APE for indirect effects includes access routes to monitoring sites located within the Eden Landing Ecological Reserve, and a large buffer around both the placement and replacement site.

To assess compliance with Section 15064.5 of the State CEQA Guideline, a records search was completed at the Northwest Information Center located in Sonoma State University. Records were also reviewed online for results from underwater surveys at NOAA's Automated Wreck and Obstruction Information System, in addition to T-Charts from the U.S. Coast Survey located at https://historicalcharts.noaa.gov/. Four archaeological survey reports, a Master of Arts thesis, and an Memorandum of Agreement between the US Fish and Wildlife Service (USFWS) and SHPO, were reviewed within a one-mile radius of the APE. The entire study area has gone through extensive reconnaissance as well as archival research. Surveys have been funded by government agencies, including the USFWS and CalTrans, since the early 1980s. The results of the records search show there is one eligible historic district within the APE – the Eden Landing Salt Works landscape (HALS-CA-91) – and ten cultural resources are located within or contributing to HALS-CA-91. Additionally, the San Mateo Bridge is an eligible historic property within the APE.

The offshore placement site was surveyed for cultural resources beginning in 1996, when a seismic retrofit for the San Mateo Bridge was first proposed. Numerous other inventories were completed for ecological restoration work at Eden Landing as part of the South Bay Salt Pond Restoration Project, which resulted in the identification of the Eden Landing Ecological Reserve Historic District located in the southern end of San Francisco Bay. The Historic District encompasses 6,612 acres divided into 23 ponds that is gradually being restored by the South Bay Salt Pond Restoration Project into a mosaic of tidal, managed tidal, and non-tidal estuarine habitats.

Eden Landing was placed on the NRHP because it is the birthplace of SF Bay's solar salt industry, which grew to be one of the world's largest salt producers. Beginning in the 1850s, Eden Landing's natural conditions of shallow tidelands, relatively dry summers, and navigable creeks that provided shipping points were critical features for developing the salt industry. The Eden Landing Salt Works landscape encompasses elements that include archaeological features, salt ponds, and water control structures from three of the original salt company operations that provide an essential link to the earliest period of this important industry.

Ten cultural resources have been recorded within HALS-CA-91, all of which are related to the historic period of salt manufacturing. Four sites have been determined eligible, five sites have been determined ineligible, and one site is unevaluated. And, one architectural resource, the Archimedes Screw Windmills, has been determined to be a contributing element of the HALS-CA-91.

Discussion

a) The only historic resources within HALS-CA-91 that would be affected by the project are tidal wetlands and tidally restored salt ponds within the Eden Landing complex. As previously discussed under Section IV, modeling indicates that the project could drive modest amounts of accretion in tidal areas near the shallow water placement site, including within tidal marshes and restored salt ponds at Eden Landing, ranging from about 0.01 cm at the target tidal marsh to about 0.1 cm on adjacent mudflats over a two-month period. These accretion rates are similar to those observed by the U.S. Geological Survey throughout the estuary's tidal mudflats and marshes, and do not represent a substantial adverse impact to these resources. The impacts on cultural resources would therefore be **less than significant.**

b) There are no archeological resources within the project's APE, therefore there would be **no impact** from the project on archeological resources.

c) The shallow water placement site is more than two miles offshore and is not known to contain human remains, therefore there would be **no impact** from the project on human remains.

VI. Energy

Would the Project:

Environmental Issue	Potentially Significant Impact	Less Than Significant with Mitigation	Less Than Significant Impact	No Impact
a) Result in potentially significant environmental impact due to wasteful, inefficient, or unnecessary consumption of energy resources, during project construction or operation?				**X**
b) Conflict with or obstruct a state or local plan for renewable energy or energy efficiency?				**X**

Discussion

a), b) The project would not result in wasteful, inefficient, or unnecessary consumption of energy, and would not conflict with or obstruct state or local plans for renewable energy or energy efficiency. The project would not require substantially more energy than USACE's historic and current maintenance dredging operations in San Francisco Bay. The project is designed to maximize transportation of sediment from the placement location to target tidal wetlands and mudflats using natural tidal currents and waves, instead of more energy-intensive transport methods such as direct placement. Therefore, the project would have **no impact** on energy.

VII. Geology and Soils

Would the Project:

Environmental Issue	Potentially Significant Impact	Less Than Significant with Mitigation	Less Than Significant Impact	No Impact
a) Directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death involving:				
i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map, issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.				X
ii) Strong seismic ground shaking?				X
iii) Seismic-related ground failure, including liquefaction?				X
iv) Landslides?				X
b) Result in substantial soil erosion or the loss of topsoil?			X	
c) Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse?			X	
d) Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial direct or indirect risks to life or property?				X
e) Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of wastewater?				X
f) Directly or indirectly destroy a unique paleontological resource or site, or unique geologic feature?			X	

Background

Soil and Geologic Conditions

The project site is located on subtidal (below Mean Lower Low Water [MLLW]) quarternary Bay Muds about 2 miles offshore of Eden Landing. These sediments were deposited during high stands of sea level in the post-Wisconsin (less than 10,000 years ago) period, and have undergone some tectonic and possibly isostatic subsidence since their deposition (Atwater et al. 1977). Local Bay Muds likely also experience ongoing subsidence due to sediment and aquifer-system compaction (Shirzaei and Burgmann 2018). The project's location in the Bay shallows (less than 18 ft deep, see Goals Project 1999) means that local Bay Muds and associated lenses of coarser sediment (e.g., estuarine-derived shell, fluvial-derived silts, sands, and gravels) are regularly exposed to tidal currents and waves that sort, re-work, and transport nearshore sediments. When these sediments are advected into the water column during a flood tide, they can be transported into and deposit within adjacent tidal water bodies, including tidal wetlands and tidally restored former salt ponds within the Eden Landing complex. Depending on conditions, such as wave height, direction, and tidal state, waves can contribute to erosion and retreat of the shoreline, and/or deposit sediment onto shoreline tidal wetlands (such as Whale's Tail North and South).

Seismic Conditions

The site is located in the seismically active Bay Area. It is located about 12.2 miles northeast of the San Andreas fault, 20 miles northeast of the San Gregorio fault, 6.25 miles southwest of the Hayward fault, and 14.3 miles southwest of the Calaveras fault. The probability of a major (6.0 Richter Magnitude or above) earthquake occurring on one or more of these faults by 2043 is 98 percent. During such an earthquake, strong seismic shaking is likely to occur at the site. No faults are mapped as crossing or within a half mile of the site, and the site is not in a fault rupture hazard zone as identified by the California Geological Survey.

Discussion

a) The project site is not located within an area that has been identified as an Alquist-Priolo Earthquake Fault Zone, though it is located in an area that is vulnerable to strong ground shaking, liquefaction, and landslides (California Geological Survey 2018). However, the project does not involve the construction of any structure meant for human use or habitation, and would not influence geological, geotechnical, or seismic conditions near any such structures. Therefore, the project would not directly or indirectly cause potential substantial adverse effects, including the risk of loss, injury, or death, so there is **no impact** with respect to seismic risk.

b) The purpose of the project is to increase sediment delivery to tidal mudflats and marshes within and offshore of the Eden Landing Complex. Though the placed sediment is likely to erode into the water column and be advected into adjacent tidal waters, sediment placement is unlikely to influence the erosion of *in situ* benthic sediment elsewhere in the vicinity. There is therefore a **less than significant** impact to soil erosion or the loss of topsoil.

c) Saturated Bay Muds are inherently unstable and vulnerable to subsidence, lateral spreading, liquefaction, and related geotechnical risks. The project proposes to place 100,000 cubic yards of dredged sediment (mostly Bay Muds) in a thin layer on top of in situ Bay Muds roughly two miles offshore of Eden Landing. By placing this sediment as evenly as feasible over the 138-acre placement footprint, the average thickness of sediment deposits would be around half a foot deep. It is possible, but unlikely, that thicker deposits would result from operational variability; especially thick deposits could potentially lead to very limited localized compaction, spreading, and displacement of *in situ* Bay Muds. The impact would be **less than significant**.

d) The project would be located on expansive soil, but would not involve the construction of any structure meant for human use or habitation, and would not influence geological, geotechnical, or seismic conditions near any such structures that would result in substantial direct or indirect risks to life or property. There would therefore be **no impact** with respect to expansive soils.

e) The proposed project does not involve installation of a septic system. Therefore, **no impact** would occur with respect to adequacy of site soils for septic systems.

f) The project would not involve deep excavation, therefore potential impacts to paleontological resources are unlikely and would be considered **less than significant**.

VIII. Greenhouse Gas Emissions

Would the Project:

Environmental Issue	Potentially Significant Impact	Less Than Significant with Mitigation	Less Than Significant Impact	No Impact
a) Generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment?			X	
b) Conflict with an applicable plan, policy or regulation adopted for the purpose of reducing the emissions of greenhouse gases?			X	

Background

This section describes construction greenhouse gas (GHG) emissions impacts associated with the proposed project and is consistent with the methods described in the BAAQMD *CEQA Air Quality Guidelines* (May 2017).

"Global warming" and "global climate change" are terms typically used to describe the increase in the average temperature of the earth's near-surface air and oceans since the mid-20th century and its projected continuation. Warming of the climate system is now considered to be unequivocal, with global surface temperature increasing approximately 1.33 degrees Fahrenheit (°F) over the last 100 years. Continued warming is projected to increase global average temperature between 2 and 11°F over the next 100 years.

Gases that trap heat in the atmosphere are referred to as GHG because they capture heat radiated from the sun as it is reflected back into the atmosphere, much like a greenhouse does. The accumulation of GHG has been implicated as the driving force for global climate change. The primary GHG are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), ozone, and water vapor.

While the presence of the primary GHG in the atmosphere are naturally occurring, CO_2, CH_4, and N_2O are also emitted from human activities, accelerating the rate at which these compounds occur within earth's atmosphere. Emissions of CO_2 are largely by-products of fossil fuel combustion, whereas methane results from off-gassing associated with agricultural practices, coal mines, and landfills. Other GHG, such as hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride, are generated in certain industrial processes.

CO_2 is the reference gas for climate change because it is the predominant GHG emitted. The effect that each of the aforementioned gases can have on global warming is a combination of the mass of their emissions and their global warming potential (GWP). GWP indicates, on a pound-for-pound basis, how much a gas is predicted to contribute to global warming relative to how much warming would be predicted to be caused by the same mass of CO_2. CH_4 and N_2O are substantially more potent GHG than CO_2, with GWP of a 27 to 30 and 273 times that of CO_2, respectively (USEPA 2022).

In emissions inventories, GHG emissions are typically reported in terms of pounds or metric tons of CO_2 equivalents (CO_2e). CO_2e are calculated as the product of the mass emitted of a given GHG and its specific GWP. While CH_4 and N_2O have much higher GWP than CO_2, CO_2 is emitted in such vastly higher quantities that it accounts for the majority of GHG emissions in CO_2e.

Appendix A-5 of the EA-MND describes the details of the greenhouse gas analysis. The results of this analysis are summarized in Table GHG-1:

Table GHG-1. Greenhouse gas analysis of the proposed project.

Redwood City Sediments taken to Eden Landing Placement Site	
Total CO2eq (lbs/day)	1382.78
Total Project CO2eq (Tons)	45.63
Council on Environmental Quality Yearly GHG Threshold (CO2eq) (Tons)	None
Project Exceeds Council on Environmental Quality Yearly GHG Threshold?	N/A
Project is Significant With Respect to Regional Output?	NO

Discussion

a) See Section 4.1.11 and Appendix A-5 of the EA-MND for information about the model used to quantify GHG emissions associated with project construction activities. The proposed project's estimated construction related GHG emissions would be approximately 108.3 tons of CO_2e. There is no BAAQMD CEQA significance threshold for construction-related GHG emissions. However, this value would be below the 2030 bright line GHG significance threshold of 660 metric tons per year. Therefore, this impact would be **less than significant**.

b) California passed the California Global Warming Solutions Act of 2006 (AB 32; California Health and Safety Code Division 25.5, Sections 38500 - 38599). AB 32 established regulatory, reporting, and market mechanisms to achieve quantifiable reductions in GHG emissions and establishes a cap on statewide GHG emissions. AB 32 required that statewide GHG emissions be reduced to 1990 levels by 2020. The state achieved 1990 levels in 2016 and the levels remained below 1990 levels through 2020 (CARB 2021). In September of 2016, SB 32 extended the goals of AB 32 and set a goal to achieve reductions in GHG of 40 percent below 1990 levels by 2030. In 2017, CARB adopted the 2017 Scoping Plan, which identifies how the state can reach the 2030 climate target to reduce GHG emissions by 40 percent from 1990 levels, and substantially advance toward the state's 2050 climate goal to reduce GHG emissions by 80 percent below 1990 levels.

The project has been reviewed relative to the climate change policies and measures in CARB's *2017 Climate Change Scoping Plan* (CARB 2017) and it has been determined that the Project would not conflict with State GHG reduction goals. Therefore, impacts would be **less than significant**.

IX. Hazards and Hazardous Materials

Would the Project:

Environmental Issue	Potentially Significant Impact	Less Than Significant with Mitigation	Less Than Significant Impact	No Impact
a) Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?				X
b) Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?				X
c) Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?				X
d) Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, would it create a significant hazard to the public or the environment?				X
e) For a Project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the Project result in a safety hazard or excessive noise for people residing or working in the Project area?				X
f) Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?				X
g) Expose people or structures, either directly or indirectly, to a significant risk of loss, injury or death involving wildland fires?				X

Discussion

a-c) Sediment delivered to the project site for subtidal placement would be tested and approved for placement by the Dredged Material Management Office, which bans the in-Bay disposal of any sediment that could be classified as hazardous material. Project construction would not involve the routine transport, use, or disposal of hazardous materials. There is therefore **no impact** with respect to hazards to the public and the environment.

d) The project site is not included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5. There is therefore **no impact** with respect to hazards to the public and the environment.

e) The project site is not within an airport land use plan nor is it within two miles of a public airport or public use airport. The project would not present a hazard to air safety, and **no impact** would occur.

f) Construction of the project is not expected to interfere with the City of Hayward's emergency response because the project site is more than two miles offshore of the City. **No impact** would occur.

g) The project site is within San Francisco Bay, so therefore the project would have **no impact** with respect to wildfire hazards.

X. Hydrology and Water Quality

Would the Project:

Environmental Issue	Potentially Significant Impact	Less Than Significant with Mitigation	Less Than Significant Impact	No Impact
a) Violate any water quality standards or waste discharge requirements or otherwise substantially degrade surface or groundwater quality?			X	
b) Substantially decrease groundwater supplies or interfere substantially with groundwater recharge such that the project may impede sustainable groundwater management of the basin?				X
c) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river or through the addition of impervious surfaces, in a manner which would: i) result in substantial erosion or siltation on- or off-site; ii) substantially increase the rate or amount of surface runoff in a manner which would result in flooding on-or off-site; iii) create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems orprovide substantial additional sources of polluted runoff; or iv) impede or redirect flood flows?			X	
d) In flood hazard, tsunami, or seiche zones, risk release of pollutants due to project inundation?				X
e) Conflict with or obstruct implementation of a water quality control plan or sustainable groundwater management plan?				X

Background

The project site offshore of Eden Landing is located within shallow (less than 18 ft deep, see Goals Project 1999) tidal waters typical of nearshore South San Francisco Bay. Tides at the site are mixed semi-diurnal, with roughly two daily low tides and high tides of unequal height. Tidal datums at the nearby NOAA San Mateo Bridge West station (941-4458) are as follows:

Datum	Elevation (ft NAVD)
MHHW	6.92
MHW	6.29
MSL	3.31
MTL	3.34
MLW	0.39
MLLW	-0.80

Tidal waters are dominated by near-marine salinities (about 28 to 33 parts per thousand) except during the winter when periodic pulses of freshwater from local watersheds (e.g., Old Alameda Creek, Mt. Eden Creek) enter the Bay shallows. These freshwater pulses can temporarily decrease local salinities into brackish ranges, particularly during periods of sustained high flows from the Alameda Creek Flood Control Channel to the south. Water temperatures are typically between 46 and 74°F, with warmer temperatures experienced during the summer months. Local pH in the Bay is relatively constant, and typically ranges from 7.8 to 8.2 (LTMS 1998; SFEI 2013). Tidal waters at the project site are generally well oxygenated (above 5 mg/L); typical concentrations of dissolved oxygen (DO) in most of the Bay range from 9 to 10 mg/L during high periods of river flow, 7 to 9 mg/L during moderate river flow, and 6 to 9 mg/L during the late summer months, when flows are lowest (SFEI 2008). Local turbidities are typically high (above 50 Nephelometric Turbidity Units, or NTUs) due to the wave-driven resuspension of sediment from the region's shallow subtidal and intertidal mudflats, and can increase seasonally in response to winter pulses of stormwater from surrounding watersheds. Suspended sediment concentrations (SSC) typically range from 200 mg/L in the winter to 50 mg/L in the summer, with shallow areas and their adjacent channels having the highest SSC (Rich 2010). SSC of up to 600 mg/L have been measured in turbidity maximum zones during winter storms that flush sediment from watersheds into the Bay (O'Connor 1991). Wind-waves along the shoreline are consistent but moderate during the summer months; winter storms drive a more variable wave climate that typically features the largest annual wave heights.

Discussion

a) Water quality objectives and beneficial uses (i.e., standards) for the project site are described in the Water Quality Control Plan for the San Francisco Bay Basin (Basin Plan) adopted by the San Francisco Bay Regional Water Quality Control Board (Water Board). Beneficial uses of mudflats and tidal marshes in the region include providing estuarine habitat (EST), habitat for special-status and/or rare organisms (RARE), fish migration (MIGR), and recreation (REC-1 and REC-2). Climate change threatens these beneficial uses via rising sea levels, which can drown mudflats and tidal wetlands and convert them to shallow open water habitats (Goals Project 2015). The project is intended to result in beneficial environmental impacts, by augmenting the local supply of sediment available to support accretion in mudflats and tidal wetlands, and help them keep pace with rising sea levels. The water quality objectives at issue for the project are sediment and turbidity. The water quality objective for sediment provides that the sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect beneficial uses. Similarly, the turbidity water quality objective states that waters shall be free of turbidity changes that cause nuisance or adversely affect beneficial uses and increases in turbidity from discharges shall not be greater than 10 percent where background turbidity is greater than 50 NTU. During periods of sediment placement, nearby tidal waters would likely experience temporary increases in sediment and turbidity due to placed material settling on the Bay mudflats and dispersing into the water column. Modeling indicates that after dredged sediment placement, SSC adjacent to the placement footprint would most frequently range between 50 and 300 mg/L over baseline conditions, and could be elevated by as much as 500 mg/L in the most extreme case. However, the modeling also indicates that SCC would quickly return to baseline after each placement episode. Once the material is placed, tidal currents and waves are expected to re-work these sediments, and disperse additional sediment into the water column to support accretion in nearby mudflats and tidal marshes (see [c] below). Given the naturally turbid nearshore environment in the project vicinity, temporary local increases in turbidity would not violate any water quality standards or waste discharge requirements or otherwise substantially degrade surface or groundwater quality, so this impact would be **less than significant**. Moreover, in permitting the discharge, the Regional Water Board will have to ensure the discharge meets water quality standards, including antidegradation requirements, further ensuring impacts remain less than significant.

b) The project site is located in San Francisco Bay, two miles offshore of Eden Landing, and will have **no impact** on groundwater resources.

c) The project will not alter any existing drainage patterns in the area, and does not propose any new impervious surfaces or other features that could alter local runoff/flooding patterns. The project proposes to place a thin (average depth of less than half a foot) layer of sediment across roughly 138 acres along the bottom of San Francisco Bay offshore of Eden Landing, to augment local nearshore sediment supplies and support accretion (siltation) on nearby tidal mudflats and marshes to help them keep pace with rising sea levels. Modeling indicates that the project could drive modest amounts of accretion in nearby tidal areas, ranging from about 0.01 cm at the target tidal marsh to about 0.1 cm on adjacent mudflats over the first two months during and after placement. These accretion rates are similar to those observed by the U.S. Geological Survey throughout the estuary's tidal mudflats and marshes. Neither the sediment placement nor the resulting siltation in the project vicinity is expected to substantially influence local wave or tidal dynamics. This impact is therefore **less than significant**.

d) See Section (IX); any sediment delivered to the project site for subtidal placement would be tested and approved for placement by the Dredged Material Management Office, which bans the in-Bay disposal of any sediment that could be classified as hazardous or polluted material. Therefore, even though the project site is within San Francisco Bay, there would be **no impact** with respect to the risk of releasing pollutants due to project inundation.

e) The project is consistent with the Basin Plan and will not influence local groundwater, therefore there is **no impact**.

XI. Land Use and Planning

Would the Project:

Environmental Issue	Potentially Significant Impact	Less Than Significant with Mitigation	Less Than Significant Impact	No Impact
a) Physically divide an established community?				X
b) Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the Project (including, but not limited to the general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?				X
c) Conflict with any applicable habitat conservation plan or natural community conservation plan?				X

Discussion

a) The project is located within San Francisco Bay and will have **no impact** on established communities.

b) The project site is over two miles offshore of Eden Landing and is not included in any applicable land use plan, general plan, specific plan, local coastal program, or zoning ordinance. The project would not change the existing land use on site and would therefore have **no impact** on plan conformance.

c) The project site is not located within the boundaries of a habitat conservation plan or a natural community conservation plan; therefore, the project would not conflict with any habitat plans and there would be **no impact**.

XII. Mineral Resources

Would the Project:

Environmental Issue	Potentially Significant Impact	Less Than Significant with Mitigation	Less Than Significant Impact	No Impact
a) Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?				**X**
b) Result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan?				**X**

Discussion

a, b) The project site is within San Francisco Bay and is not identified within any plans as a site containing mineral resources that would be of local, regional, or statewide importance. Therefore, the project would not have any impacts on mineral resources. The project site is also outside of any areas designated by the State Mining and Geology Board as containing regionally significant construction-grade aggregate resources (used in concrete). The project site does not contain any known mineral deposits or active mineral extraction operations. Therefore, the project would have **no impact** on mineral resources.

XIII. Noise

Would the Project result in:

Environmental Issue	Potentially Significant Impact	Less Than Significant with Mitigation	Less Than Significant Impact	No Impact
a) Generation of a substantial temporary or permanent increase in ambient noise levels in vicinity of the project in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?			X	
b) Generation of excessive groundborne vibration or groundborne noise levels?				X
c) For a Project within the vicinity of a private airstrip or an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the Project expose people residing or working in the project area to excessive noise levels?				X

Discussion

a) Noise from dredging equipment such as a dredging ship can generate noise levels from 55 to 87dBA (Joint Guam 2010), or 62 to 80 dBA (Epsilon 2006), which are below the construction noise thresholds in the Federal Transit Administration (FTA) guidelines of 90 dBA during daytime hours. It does not fall below the nighttime hours threshold; however, the project is over 4 miles from a residential receptor (USACE 2021). The placement site is over open waters, and there are no sensitive receptors nearby. Short-term noise impacts may occur during placement at the placement site. However, sediment management (including the excavation and placement of dredged materials) has occurred in the past at this location, and ongoing noise from sediment management activities and ambient noise from existing vessel traffic are part of the existing condition. In this context, noise impacts specific to placement of dredged materials from the federal navigation channels would be **less than significant**.

b) The project does not involve use of ground vibratory equipment, so there is **no impact**.

c) The Project site is not within the vicinity of a private airstrip or an airport land use plan, or within 2 miles of a public use airport. Therefore, the Project would have **no impact** on cumulative airport noise**.**

XIV. Population and Housing

Would the Project:

Environmental Issue	Potentially Significant Impact	Less Than Significant with Mitigation	Less Than Significant Impact	No Impact
a) Induce substantial population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)?				**X**
b) Displace substantial numbers of existing people or housing, necessitating the construction of replacement housing elsewhere?				**X**

Discussion

a) The project would not build new housing or businesses, nor build any infrastructure that could indirectly support new housing or businesses. Therefore, the project would not induce new development on nearby lands, and **no impact** would occur.

b) The project site is within San Francisco Bay and would not displace existing housing or people, so there would be **no impact**.

XV. Public Services

Would the project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for any of the following public services:

Environmental Issue	Potentially Significant Impact	Less Than Significant with Mitigation	Less Than Significant Impact	No Impact
a) Fire protection?				**X**
b) Police protection?				**X**
c) Schools?				**X**
d) Parks?				**X**
e) Other public facilities?				**X**

Discussion

a-e) The project does not propose any public facilities or activities that would require public services; therefore there would be **no impact** on public services.

XVI. Recreation

Environmental Issue	Potentially Significant Impact	Less Than Significant with Mitigation	Less Than Significant Impact	No Impact
a) Would the Project increase the use of existing neighborhood and regional parks or other recreational facilities such that physical deterioration of the facility would occur or be accelerated?				**X**
b) Does the Project include recreational facilities or require the construction or expansion of recreational facilities which might have an adverse physical effect on the environment?				**X**

Discussion

a-b) The project site is located more than two miles offshore of existing recreational facilities at Eden Landing, and does not propose any new public facilities or activities. Therefore there would be **no impact** on recreation.

XVII. Transportation/Traffic

Would the Project:

Environmental Issue	Potentially Significant Impact	Less Than Significant with Mitigation	Less Than Significant Impact	No Impact
a) Conflict with a program, plan, ordinance or policy addressing the circulation system, including transit roadways, pedestrian and bicycle facilities?				X
b) Conflict or be inconsistent with CEQA Guidelines Section 15064.3, subdivision (b) (vehicle Miles traveled)?				X
c) Substantially increase hazards due to design features (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?				X
d) Result in inadequate emergency access?				X

Discussion

a-d) The project site is more than two miles offshore of Eden Landing within San Francisco Bay, and would be constructed by equipment and personnel that are barged to the project site. No equipment or personnel would be transported to the project site on local surface roads or freeways. Therefore, the project would have **no impact** on traffic and transportation.

XVIII. Tribal Cultural Resources

Would the project:

Environmental Issue	Potentially Significant Impact	Less Than Significant with Mitigation	Less Than Significant Impact	No Impact
a) Would the project cause a significant adverse change in the significance of a tribal cultural resource defined in Public Resource Code Section 21074 as either a site, feature, place cultural landscape that is geographically defined in terms of the size and scope of the landscape, sacred place, or object with cultural value to a California Native American tribe, and that is:				
i) Listed or eligible for listing in the California Register of Historical Resources, or in a local register of historical resources as defined in Public Resources Code section 5020.1(k), or				X
ii) A resource determined by the lead agency, in its discretion and supported by substantial evidence, to be significant pursuant to criteria set forth in subdivision (c) of Public Resources Code section 5024.1. In applying criteria set forth in subdivision (c) of Public Resources Code section 5024.1, the lead agency shall consider the significance of the resource to a California Native American tribe.				X

Background

Section 21084.1 of CEQA and Section 15064.5 of the State CEQA Guidelines establish the definition of historical resource for the purposes of CEQA. Assembly Bill (AB) 52 became effective for all projects, including this one, with CEQA documents prepared after July 1, 2015. The bill added a definition of “tribal cultural resource,” which is separate from the definitions for “historical resource” and “archaeological resource” (California Public Resource Code (PRC) Section 21074; 21083.09). The bill also added requirements for lead agencies to engage in additional consultation procedures with respect to California Native American tribes (PRC Sections 21080.3.1, 21080.3.2, 21082.3). Specifically, PRC Section 21084.3 states: “a. Public agencies shall, when feasible, avoid damaging effects to any tribal cultural resource. b. If the lead agency determines that a project may cause a substantial adverse change to a tribal cultural resource, and measures are not otherwise identified in the consultation process provided in Section 21080.3.2, the following are examples of mitigation measures that, if feasible, may be considered to avoid or minimize the significant adverse impacts: 1) Avoidance and preservation of the resources in place, including, but not limited to, planning and construction to avoid the resources and protect the cultural and natural context, or planning greenspace, parks, or other open space, to incorporate the resources with culturally appropriate protection and management criteria." California Register of Historical Resources California PRC Section 5024.1 and 14 California Code of Regulations Section 4850 establishes the CRHR, the "authoritative listing and guide to be used by state and local agencies, private groups, and citizens in identifying the existing historical resources of the state and to indicate which resources deserve to be protected, to the extent prudent and feasible, from substantial adverse change."

The USACE and Water Board contacted the Native American Heritage Commission (NAHC) requesting an updated Native American tribal consultation list for the Project. The Sacred Lands File search was negative. USACE obtained a tribal consultation list from the NAHC on 14 April 2020. The following Ohlone Tribes were identified as tribal consulting parties under Section 106 of NHPA and the National Environmental Policy Act (NEPA): The Amah Mutsun Tribal Band, Amah Mutsun Tribal Band of Mission San Juan Bautista, Costanoan Ohlone Rumsen-Mutsun Tribe, Indian Canyon Mutsun Band of Costanoan, and the Muwekma Ohlone Indian Tribe of the SF Bay Area.

On June 1, 2022, a virtual, informal Tribal consultation meeting was held with the Confederated Villages of Lisjan (CVL). The CVL is interested in the project and wishes to be involved in the monitoring of plants and the effectiveness of the study. The Tribe identified tidal marshes near the sediment placement site as a cultural resource, would like access to the monitoring data that is collected, and are interested in learning whether the Pilot Project is successful. As previously discussed under (V) Cultural Resources, the existing tidal marshes in the area are considered a historic resource under the NHPA. No additional historical resources, archaeological resources, or tribal cultural resources were identified in addition to those already analyzed under the NHPA.

Discussion

a) As previously discussed under (IV) Biological Resources, modeling of the proposed project indicates that tidal systems in the area (including existing tidal marshes at Eden Landing) would experience accretion ranging from about 0.01 cm at the target marsh to about 0.1 cm on the mudflats over a three-month period during and after placement. This is similar to natural accretion rates observed by the U.S. Geological Survey in tidal marshes and mudflats throughout the estuary. As such, USACE recommends the Pilot Project will constitute a "No Historic Properties Affected", due to the limited deposition potential of strategic placement. USACE, the federal sponsor, and the Water Board are consulting with SHPO and Tribes on our determination of effect. Therefore, implementation of the proposed project would have **no impacts** on cultural resources.

XIX. Utilities and Service Systems

Would the Project:

Environmental Issue	Potentially Significant Impact	Less Than Significant with Mitigation	Less Than Significant Impact	No Impact
a) Require or result in the relocation or construction of new or expanded water, wastewater treatment or storm water drainage, electric power, natural gas, or telecommunications facilities, the construction or relocation of which could cause significant environmental effects?				X
b) Have sufficient water supplies available to serve the project and reasonably foreseeable future development during normal, dry and multiple dry years?				X
c) Result in a determination by the waste water treatment provider, which serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments?				X
d) Generate solid waste in excess of state or local standards, or in excess of the capacity of local infrastructure, or otherwise impair the attainment of solid waste reduction goals?				X
e) Comply with federal, state, and local management and reduction statutes and regulations related to solid waste?				X

Discussion

a-e) The project does not propose any facilities or structures that require public utilities; therefore, there are **no impacts** with respect to utilities.

XX. Wildfire Hazards

If located in or near state responsibility areas or lands classified as very high fire hazard severity zones, would the Project:

Environmental Issue	Potentially Significant Impact	Less Than Significant with Mitigation	Less Than Significant Impact	No Impact
a) Substantially impair an adopted emergency response plan or emergency evacuation plan?				X
b) Due to slope, prevailing winds, and other factors,exacerbate wildfire risks, and thereby expose project occupants to pollutant concentrations from a wildfire or the uncontrolled spread of a wildfire?				X
c) Require the installation or maintenance of associated infrastructure (such as roads, fuel breaks, emergency water sources, power lines or other utilities) that may exacerbate fire risk or that may result in temporary or ongoing impacts to the environment?				X
d) Expose people or structures to significant risks, including downslope or downstream flooding or landslides, as a result of runoff, post-fire slope instability, or drainage changes?				X

Discussion

a-d) The project site is within San Francisco Bay, so therefore the project would have **no impact** with respect to wildfire hazards, associated hazards, and equipment /infrastructure needs.

I. MANDATORY FINDINGS OF SIGNIFICANCE

Environmental Issue	Potentially Significant	Less Than Significant with Mitigation	Less Than Significant	No Impact
a) Does the Project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, substantially reduce the number or restrict the range of an endangered, rare or threatened species or eliminate important examples of the major periods of California history or prehistory?		X		
b) Does the Project have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of a Project are considerable when viewed in connection with the effects of past Projects, the effects of other current Projects, and the effects of probable future Projects)?		X		
a) Does the Project have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly?				X

a) The purpose of the project is to support native and special-status plants, fish, and wildlife by supporting the health, diversity, and resilience of sensitive estuarine habitats in the vicinity of Eden Landing and within restoring former salt ponds that are part of the South Bay Salt Pond Restoration Project. The project will result in temporary impacts to estuarine habitats and dependent fish and wildlife communities (including special-status species) offshore of Eden Landing, primarily via burial of sessile organisms in the benthos at the sediment placement site and localized temporary increases in turbidity. Buried portions of the Bay bottom are expected to be recolonized by nearby populations of benthic organisms, and turbidity is not expected to increase beyond levels naturally experienced in nearshore habitats. Impacts to eelgrass and water quality from the proposed project are potentially significant, and would be reduced to **less than significant with the incorporation of mitigation** measures AQ-1, BIO-1, and BIO-2.

b) Table 12 in Chapter 5 of the EA-MND lists related past, present, and reasonably foreseeable future projects in the vicinity of this proposed project. All of these projects are currently in the planning phases, with the exception of the South Bay Salt Pond Restoration Project and the South San Francisco Bay Shoreline Protection Project. Phase 1 of the South Bay Salt Pond Restoration Project restored roughly 1,700 acres of tidal habitat within the CDFW Eden Landing complex north of Old Alameda Creek; construction of Phase 2, which will restore an additional 2,200 acres to tidal action south of Old Alameda Creek, is expected to begin in 2023. The South San Francisco Bay Shoreline Protection Project will restore roughly 2,900 acres of former salt ponds near the community of Alviso to tidal action; the first phase is currently under construction. All of these projects are designed, permitted, and implemented such that the temporary adverse environmental impacts from construction are anticipated to be offset by longer-term beneficial environmental impacts (improved habitat for native and special-status species, improved flood control, improved recreation, etc.). The only potential cumulatively considerable adverse environmental impacts from the project and those other related projects is from cumulative greenhouse gases resulting from the construction of all these projects. However, with the implementation of mitigation measure AQ-1, and considering the short time span of the project's duration (~25 days), it is unlikely the project, when viewed in connection with other related projects, will result in cumulatively considerable impacts. The proposed project would therefore result in cumulative impacts that are **less than significant with mitigation**.

c) The proposed project would result in no environmental impacts that would drive adverse effects on human beings; therefore, there is **no impact.**

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Appendix H – AGENCY AND PUBLIC PARTICIPATION

Agency and public comments to be included after review period. For public outreach and participation see main body of EA/IS/MND Section 7.