DRAFT

CONTAMINATED SEDIMENT MANAGEMENT PLAN: LOS ANGELES HARBOR

In Support of

Final Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Toxic Pollutants Total Maximum Daily Loads

Submitted to

California Regional Water Quality Control Board, Los Angeles Region

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LIST OF ACRONYMS AND ABBREVIATIONS

Basin Plan Amendment	Attachment A to Resolution No. R11-008, *Amendment to the Water Quality Control Plan – Los Angeles Region*
BMP	best management practice
CCC	California Coastal Commission
CCMRP	Coordinated Compliance Monitoring and Reporting Program
CDFW	California Department of Fish and Wildlife
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIMP	Coordinated Integrated Monitoring Programs
CSM	conceptual site model
CSMP	Contaminated Sediment Management Plan
CSTF	Contaminated Sediment Task Force
cy	cubic yard
DDT	dichlorodiphenyltrichloroethane
DMMT	Dredged Material Management Team
EWMP	Enhanced Watershed Management Program
Harbor Toxics TMDL	*Final Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Toxic Pollutants Total Maximum Daily Loads*
LA	load allocation
LACFCD	Los Angeles County Flood Control District
LARE	Los Angeles River Estuary
MLOE	multiple lines of evidence
MNR	monitored natural recovery
MOA	Memoranda of Agreement
Montrose	Montrose Chemical Corporation
MOU	Memoranda of Understanding
MS4	municipal separate storm sewer system

NMFS	National Marine Fisheries Services
NPDES	National Pollutant Discharge Elimination System
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
POLA	Port of Los Angeles
POLB	Port of Long Beach
PRP	potential responsible party
RWQCB	Regional Water Quality Control Board
Shell	Shell Oil Company
SQO	Sediment Quality Objective
TDDT	total dichlorodiphenyltrichloroethane
TPCB	total polychlorinated biphenyl
TMDL	total maximum daily load
USEPA	U.S. Environmental Protection Agency
USEPA Guidance Document	*Contaminated Sediment Remediation Guidance for Hazardous Waste Sites*
WLA	waste load allocation
WMP	watershed management program
WRAP	Water Resources Action Plan

1 INTRODUCTION

The Los Angeles Harbor Contaminated Sediment Management Plan (CSMP) was developed to support the long-term recovery of sediment and water quality in the Los Angeles Harbor. The City of Los Angeles has led the development of this CSMP that addresses bedded sediment within the Los Angeles Harbor area and is submitting it on behalf of Los Angeles County Flood Control District (LACFCD). This CSMP has been developed to be consistent with other CSMPs developed for the Dominguez Channel Estuary, Long Beach Harbor, and Eastern San Pedro Bay.

Section 1 of the CSMP provides the regulatory background requiring the creation of a CSMP and a summary of the relevant information needed to support the sediment management decision process. A description of the physical setting and known contaminant-related issues, including the 303(d) listing and subsequent development of the *Final Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Toxic Pollutants Total Maximum Daily Loads* (Harbor Toxics TMDL), is also included. The Harbor Toxics TMDL compliance requirements, TMDL schedule, CSMP requirements, and integration with the stormwater programs are provided, as is a summary of regional regulatory programs and the national guidance for contaminated sediment management.

Section 2 of the CSMP describes an approach designed to form the basis for all CSMPs developed to support sediment contaminant reductions in affected waterbodies as noted in the Harbor Toxics TMDL. The process for defining actions and decisions to be implemented for each of five identified milestones to support contaminated sediment management is defined.

Section 3 of the CSMP summarizes specific actions and decisions relevant to the Los Angeles Harbor. A description of current site conditions is included along with a recommended approach for integrating the CSMP with other water quality related programs. A schedule linking CSMP milestones to the Harbor Toxics TMDL implementation schedule is also presented.

1.1 Setting: Los Angeles Harbor

The Greater Los Angeles/Long Beach Harbor Waters include waterbodies defined as Long Beach Inner Harbor, Long Beach Outer Harbor, Los Angeles Inner Harbor and Los Angeles Outer Harbor, Consolidated Slip, Fish Harbor, Cabrillo Marina, Inner Cabrillo Beach, Los Angeles River Estuary (LARE), and San Pedro Bay (RWQCB and USEPA 2011). This CSMP addresses sediments within the boundaries of the Port of Los Angeles (POLA) and includes portions of Inner and Outer Harbors, Consolidated Slip, Fish Harbor, Cabrillo Marina, and Inner Cabrillo Beach waterbodies (Figure 1).

The Los Angeles/Long Beach Harbor complex consists of approximately 15,000 acres in land and water in western San Pedro Bay, to the south of Palos Verdes peninsula. It is bounded on the landward side by the communities of San Pedro and Wilmington and the city of Long Beach, and on the seaward side by the three breakwaters that protect the port facilities. Terminal Island, which is shared by the two ports and supports a number of large cargo terminals and other port uses, comprises nearly a quarter of the total land area and is separated from the mainland by the Los Angeles Main Channel, Long Beach Back Channel, and the Cerritos Channel that links the two. A major drainage channel, the Dominguez Channel, discharges into Los Angeles Harbor via Consolidated Slip, and the Los Angeles River discharges into eastern San Pedro Bay at the east side of Long Beach Harbor.

Most of the land and water in the Los Angeles/Long Beach Harbor is owned by the cities of Los Angeles and Long Beach, acting under the Tidelands Trust Act through their respective harbor commissions, but some properties remain owned by private parties and other governmental entities (Ports 2009). POLA was founded in 1907 and encompasses 7,500 acres of land and water along 43 miles of waterfront. POLA has 270 berths, 24 cargo and passenger terminals, and 660 million square feet of warehouse and distribution facilities (POLA 2013).

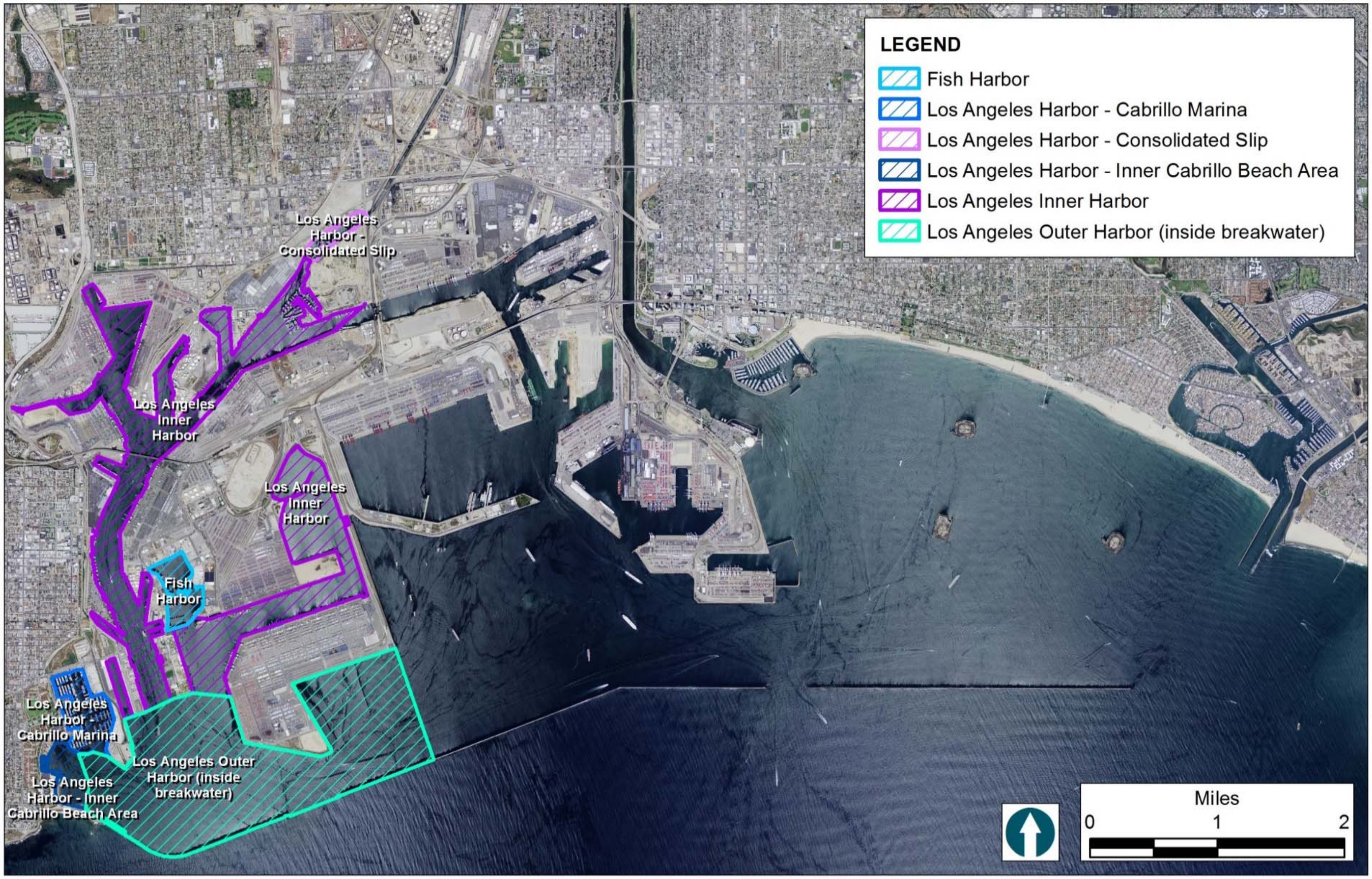

Figure 1

Los Angeles Harbor Waterbodies

The Inner Harbor has been extensively developed and consists of piers for ship loading and unloading and commercial marinas. The Outer Harbor (the greater San Pedro Bay) also contains commercial and industrial uses but has increased circulation and more open water than the Inner Harbor areas. The Los Angeles/Long Beach Harbor supports a great diversity of marine life. It is connected to the ocean at Angeles Gate, Queen's Gate, and at its eastern end. San Pedro Bay receives discharges from nearshore land uses, the Dominguez Channel, Los Angeles River, and San Gabriel River and intermittent flows to the Los Angeles Inner Harbor from Machado Lake. The Dominguez Watershed drains approximately 110 square miles and is composed of two hydrologic sub-units. The northern sub-unit drains into Dominguez Channel whereas the southern sub-unit drains directly into to the Los Angeles/Long Beach Harbor. The northern subunit drains into the Dominguez Channel, which discharges into the Los Angeles Harbor via Consolidated Slip (RWQCB and USEPA 2011). The boundaries of the harbor districts were established on the basis of legal delineations rather than natural hydrography; however, modeling results associated with the *Water Resources Action Plan* (WRAP) indicate that with the exception of the portion of the Long Beach Harbor District east of Pier H, the water of the harbors are hydrodynamically, largely separate from the eastern portion of San Pedro Bay (Ports 2009).

POLA receives stormwater from its own lands (nearshore drainage) and also from a wide area outside the port. The Dominguez Watershed drains into POLA (Ports 2009). The WRAP documents 12 major LACFCD and city storm drains that convey stormwater from more than 100 square miles of residential, commercial, and industrial areas outside POLA into the harbor. Four of these storm drains are owned and maintained by the LACFCD; the rest are owned and maintained by the City of Los Angeles. POLA itself has more than 1,000 catch basins that drain 6.7 square miles of POLA-owned and tenant-operated facilities into the harbor (Ports 2009).

In addition to stormwater, there are approximately 60 active individual National Pollutant Discharge Elimination System (NPDES) permitted discharges to the Dominguez Channel and the Los Angeles/Long Beach Harbor and approximately 50 active, general NPDES permitted discharges in the Dominguez Watershed. Two generating stations discharge directly to the

Inner Harbor areas and the Terminal Island Water Reclamation Plant discharges secondary-treated effluent[1] to the Outer Harbor (RWQCB and USEPA 2011).

The Dominguez Watershed contains the Montrose Chemical Corporation (Montrose) and the Del Amo Superfund sites. Montrose manufactured dichlorodiphenyltrichloroethane (DDT) on a 13-acre site in a light industrial/residential area in the city of Torrance from 1947 to 1982. Contaminants of concern at the Montrose site are DDT, chlorobenzene, and benzene hexachloride. DDT has been found in soils at the former plant property and surrounding areas, in sediments and soils in the historical stormwater pathway from the site (Kenwood Drain and Dominguez Channel), and in the groundwater close to the former plant property.

Shell Oil Company (Shell), Dow Chemical Company, and several other companies operated the Del Amo Synthetic Rubber Manufacturing plant from 1955 to 1972 to produce synthetic rubber for United States military operations. In 1972, the plant was dismantled, and the buildings were demolished (USEPA 1999). Contaminants of concern at the Del Amo site are volatile organic compounds, including benzene and toluene, polycyclic aromatic hydrocarbons (PAHs), and semi-volatile organic compounds (Lyons and Birosik 2007).

The definition of the Superfund boundary includes the stormwater pathway from the Montrose and Del Amo sites into Dominguez Channel Estuary and also includes Consolidated Slip. The stormwater pathway is known as Operating Unit 2.

1.2 Harbor Toxics TMDL

TMDLs are established to attain and maintain applicable water quality standards for impaired waterbodies. TMDLs provide pollutant limits that are implemented through permits (e.g., municipal separate storm sewer system [MS4] and other NPDES permits). This CSMP has been developed in response to the Harbor Toxics TMDL, which addresses localized sediment quality and regional fish tissue quality and is expected to achieve attainment of sediment,

[1] The Terminal Island Water Reclamation Plant is under a time schedule order to eliminate discharge into surface waters.

water, and fish tissue quality through source reduction, source control, management actions, and monitored natural recovery (MNR).

On March 23, 2012, the Harbor Toxics TMDL was promulgated to protect and restore fish tissue, water, and sediment quality in the Dominguez Channel and Greater Los Angeles/Long Beach Harbor Waters by managing contaminated sediments through remediation of bedded sediments and control of ongoing and future contaminated sediment loading from the Dominguez Watershed.

California's 303(d) List of Water Quality Limited Segments (SWRCB 2010) includes the following designated waterbodies within the Los Angeles Harbor: Los Angeles Inner Harbor, Los Angeles Outer Harbor (inside breakwater), Cabrillo Marina, Consolidated Slip, Inner Cabrillo Beach Area, and Fish Harbor.

1.2.1 TMDL Compliance

The Harbor Toxics TMDL set waste load allocations (WLAs) in waterbodies within the Dominguez Watershed to limit sediment-bound pollutant loadings from upstream and on-land sources. In addition, the Harbor Toxics TMDL set load allocations (LAs) in waterbodies to limit concentrations in bedded sediments believed to impact marine benthos (direct effects) and fish tissue (indirect effects). Mass-based limits for chemical constituents are provided in Table 1 and Attachment A to Resolution No. R11-008, Amendment to the *Water Quality Control Plan – Los Angeles Region* (Basin Plan Amendment; RWQCB and USEPA 2011).

Table 1
Final, Mass-Based TMDLs and Allocations for Metals, PAHs, DDT, and PCBs

Waterbody	Total Copper (kg/year)	Total Lead (kg/year)	Total Zinc (kg/year)	Total PAHs (kg/year)	TDDT (g/year)	TPCBs (g/year)
Consolidated Slip	12.1	16.6	53.3	1.43	0.56	1.14
Los Angeles Inner Harbor	76.7	105.3	338.3	9.1	3.56	7.22
Los Angeles Outer Harbor	81.6	112.1	360.1	9.7	3.79	7.68
Fish Harbor	1.04	1.43	4.59	0.123	0.048	0.098
Cabrillo Marina	1.32	1.81	5.8	0.156	0.061	0.124
Inner Cabrillo Beach	--	--	--	--	0.04	0.09

Notes:
kg = kilogram
g = gram
TDDT = total DDT
TPCB = total PCB

Compliance with sediments may be demonstrated via any one of three different means:

1. Final sediment allocations, as presented in the Basin Plan Amendment (RWQCB and USEPA 2011), are met.
2. The qualitative sediment condition of "unimpacted" or "likely unimpacted" by interpreting and integrating multiple lines of evidence (MLOE) as defined in the Sediment Quality Objective (SQO) Part 1 is met, except for chromium, which is not included in the SQO Part 1.
3. Sediment numeric targets are met in bedded sediments over a 3-year averaging period.

The SQO program provides guidance for applying the *Water Quality Control Plan for Enclosed Bays and Estuaries: Sediment Quality Plan* (SWRCB 2009). SQOs have been developed for contaminants of concern in bays and estuaries in California based on an approach that incorporates MLOE (Bay et al. 2009). These MLOE include sediment chemistry, sediment toxicity, and benthic community condition.

Compliance with fish tissues may be demonstrated via any one of four different means:

1. Fish tissue targets are met in species resident to the Harbor Toxics TMDL waterbodies.
2. Final sediment allocations, as presented in the Basin Plan Amendment (RWQCB and USEPA 2011), are met.
3. Sediment numeric targets to protect fish tissue are met in bedded sediments over a 3-year averaging period.
4. Demonstrate that the sediment quality condition protective of fish tissue is achieved per the *Water Quality Control Plan for Enclosed Bays and Estuaries: Sediment Quality Plan* (SWRCB 2009), as amended to address contaminants in resident finfish and wildlife.

Numeric targets, implementation schedules, and listed contaminants of concern may be revised during the TMDL reopener, tentatively scheduled for spring 2018.

1.2.2 TMDL Schedule

The Harbor Toxics TMDL schedule is divided into three phases:

- Phase I, completed 5 years after effective date of the Harbor Toxics TMDL (March 2017)
- Phase II, completed 10 years after effective date of the Harbor Toxics TMDL (March 2022)
- Phase III, completed 20 years after effective date of the Harbor Toxics TMDL (March 2027)

The purpose of Phase I actions is to reduce the amount of sediment transport from point sources that directly or indirectly discharge to the Dominguez Channel and the Greater Los Angeles/Long Beach Harbor Waters. For Los Angeles Harbor, the Harbor Toxics TMDL calls for the continuation of source reduction, source control, and sediment management actions throughout the nearshore watershed. Phase I actions will include instituting watershed-wide best management practices (BMPs) actions and developing CSMPs. Actions to achieve WLAs and LAs may be implemented in phases with information from each phase being used to inform the implementation of the next phase.

As per the TMDL, pollutant reduction actions at POLA during Phase I should be developed to address different sources that contribute loadings to the Los Angeles/Long Beach Harbor, such as harbor-wide activities and associated control measures for sediment and water, control measures and to reduce discharges from various land uses in the harbor, nearshore discharges, and on-water discharges. Phase I actions should be focused on source reduction, source control, and sediment management. The WRAP was developed to summarize and prioritize activities that could be conducted to control discharges of polluted stormwater and contaminated sediments to the harbor (Ports 2009). Actions identified in the WRAP will address Phase I source reduction activities.

Standard port operations frequently result in the net improvement of sediment conditions through routine maintenance dredging, implementation of capital improvement projects such as terminal development and channel deepening, and development of habitat improvement projects. Throughout these operations, impacted sediments are encountered and removed from the environment, which improves overall water and sediment quality. The effects of these programs are evident in the marked reductions in water and sediment concentrations within the Harbor Complex over the past 20 years.

Specific proposed implementation actions listed in the Harbor Toxics TMDL that may be implemented during Phase I include:

- Removal of Contaminated Sediment within Areas of Known Concern
- Development of a Sediment Management Plan (e.g., CSMP)
- Coordination of any TMDL activities within Montrose Superfund Site Operable Units with the U.S. Environmental Protection Agency's (USEPA's) Superfund Division

Phase II should include the implementation of additional BMPs and site remedial actions in the nearshore watershed and in the Los Angeles Harbor, as determined to be effective based on the success of upstream source control, TMDL monitoring data evaluations, WRAP activities implemented during Phase I, and targeted source reduction activities as identified in Phase I (RWQCB and USEPA 2011).

Phase III should include implementation of secondary and additional remedial actions as necessary to be in compliance with the final allocations by the end of the TMDL (RWQCB and USEPA 2011).

1.2.3 Integration with MS4 Permit Requirements

The City of Los Angeles is developing an Enhanced Watershed Management Program (EWMP) and Coordinated Integrated Monitoring Plan (CIMP) for the Dominguez Watershed Management Area in cooperation with the County of Los Angeles, LACFCD, and the Cities of Hawthorne, El Segundo, and Inglewood. The EWMP/CIMP is being prepared in accordance with the Los Angeles County MS4 Permit (Order No. R4-2012-0175). The Implementation Plan for the Harbor Toxics TMDL, originally due on March 23, 2014, will be incorporated into the EWMP/CIMP timelines per communication from the Los Angeles Regional Water Quality Control Board (RWQCB). The EWMP/CIMP Work Plan are due on June 28, 2014, and the final EWMP is due on June 28, 2015. These documents will prioritize water quality issues resulting from stormwater and non-stormwater discharges from the MS4 to receiving waters. They will also identify and help implement strategies, control measures, and BMPs to achieve reductions in contaminant concentration from watersheds; execute an integrated monitoring and assessment program to determine progress; and modify strategies, control measures, and BMPs as necessary based on analysis of monitoring data collected to ensure that milestones and goals set forth in the EWMP are achieved in the required timeframes.

1.2.4 Contaminated Sediment Management Plan

Meeting goals and targets in complicated TMDLs requires a holistic approach that includes source identification and control from multiple sources within the watershed, water column, and in-place (bedded) sediments. Developing a CSMP is only one component in a larger effort to meet the goals of a TMDL focused on legacy pollutants in existing sediments. Components of a holistic approach include:

- Monitoring plans
- Watershed management programs (WMPs)
- Sediment management plans

- Special studies, such as stressor identification, source identification, BMP effectiveness, sedimentation investigations to evaluate natural recovery, and chemical fate and transport mechanisms and processes investigations
- Coordinating standard port operations such as maintenance dredging, capital improvement programs, and habitat restoration projects with the TMDL to remove areas of known contamination

The Harbor Toxics TMDL requires development of a CSMP to describe an approach for contaminated sediment management. Implementation of management actions will require coordination among stakeholders and regulators across multiple regulatory programs. Because management actions are often very costly and contaminant sources to sediment are believed to be ongoing, it is critical that source reductions are coupled with the implementation of management actions in a strategic approach to ensure those actions are effective and result in meaningful improvements to sediment, water, and fish tissue quality.

This CSMP is designed to meet requirements of the Harbor Toxics TMDL and identify, prioritize, and manage contaminated sediments for protecting and improving benthic community condition and human health from fish consumption. This risk-based approach will assess impacts and provide information on source identification and the nature and extent of impacted areas. This CSMP provides an approach for identifying potential management areas and associated alternatives based on relevant sediment and tissue data and special studies. Management alternatives will be selected based on a stakeholder and potential responsible parties (PRPs) process, while environmental and human health risks of each alternative are considered.

The Harbor Toxics TMDL encourages collaboration and coordination of monitoring, reporting, and implementation efforts. Named responsible parties with an LA to the Los Angeles Harbor include:

- LACFCD (for Consolidated Slip only)
- City of Los Angeles (including POLA)

LACFCD has agreed to this CSMP process. The City of Long Beach will be covered under a separate Long Beach Harbor CSMP.

1.3 Regional Sediment Management Regulatory Process

Management actions identified in the Harbor Toxics TMDL include targeted sediment remediation within areas of known concern, which includes the Dominguez Channel, the Dominguez Channel Estuary, Consolidated Slip, and portions of the Los Angeles/Long Beach Inner Harbor. Management actions for Consolidated Slip will consider efforts associated with the cleanup of the two Superfund sites located within the Dominguez Watershed: the Montrose site and the Del Amo site. As part of Operating Unit 2 of the Montrose Superfund site, any management actions in Consolidated Slip must be consistent with decisions made through the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process. The USEPA has not yet reached a final remedial decision for these sites.

Sediment management actions implemented for TMDL compliance must comply with state and federal regulatory authority. Like any other area of the United States, any voluntary in-water construction activities in navigable waters are regulated activities, which are subject to a variety of state and federal statutes, such as the California Environmental Quality Act, Porter-Cologne Water Quality Control Act, National Environmental Policy Act, Rivers and Harbors Act of 1899, and Clean Water Act. In addition, existing state and federal programs provide guidance on sediment management and should be the basis for CSMPs developed in response to TMDL requirements.

Guidelines for capping, dredging, disposal, and long-term management of contaminated sediments in the Los Angeles Region were developed by the Los Angeles Contaminated Sediment Task Force (CSTF). The CSTF includes representatives from the U.S. Army Corps of Engineers (USACE), USEPA, National Marine Fisheries Services (NMFS), California Coastal Commission (CCC), RWQCB, California Department of Fish and Wildlife (CDFW), Port of Long Beach (POLB), POLA, City of Long Beach, Los Angeles County Beaches and Harbors, Heal the Bay, and other interested parties. After developing the *Los Angeles Regional Contaminated Sediments Task Force: Long-Term Management Strategy* (CSTF 2005), the CSTF's role in the region shifted to that of an advisory group that convenes routinely to review and comment on procedural issues related to sediment management.

The Los Angeles Dredged Material Management Team (DMMT), led by the USACE and USEPA Region 9, is the regional regulatory group responsible for managing and authorizing sediment management programs. Participants include all state and federal permitting agencies, such as the CCC, CDFW, NMFS, and RWQCB. Using the CSTF document as its guidance, this group meets monthly to review and discuss permit applications, approve sampling plans, and provide guidance on appropriate management alternatives for contaminated and clean sediments. Strategies for managing contaminated sediment disposal are prioritized to meet regional objectives. The preferred management strategy for contaminated sediments is beneficial reuse in a port fill (nearshore confined disposal facility), temporary storage in an approved upland area (until a fill project becomes available), treatment and reuse as a marketable product (e.g., cement), other beneficial upland placement, or placement in a confined aquatic disposal site.

Implementing voluntary in-water construction activities within the jurisdiction of a port, a city, or a county would be designed, managed, and implemented by the respective staff within that port, city, or county or their representatives based on regional, state, and federal guidelines and strategies.

Involuntary sediment management actions, such as a response to a RWQCB Cleanup and Abatement Order for violating the Clean Water Act, a remedial action detailed in a Record of Decision under the CERCLA or a NPDES permit action, would be managed as directed by the lead regulatory agency for each respective program. For example, the USEPA has developed a formal process under CERCLA for assessing site risks, evaluating suitable numeric and narrative cleanup objectives, selecting a remedy that best meets the goals for the target action, and monitoring the effectiveness of the remedy. Regulatory oversight for sediment remediation activities within CERCLA or NPDES cleanup programs may only involve the DMMT and CSTF if material disposal was planned for an in-water confined disposal facility within the region, or in an advisory role.

1.4 Federal Sediment Management Guidance

Federal regulations (CERCLA, Superfund Amendments and Reauthorization Act, and Resource and Recovery Conservation Act) provide mechanisms for the USEPA to address contaminated sediments believed to impair beneficial uses of rivers and harbors. In 2005, the USEPA provided technical and policy guidance for project managers and management teams making remedy decisions for contaminated sediment sites. This guidance, *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA Guidance Document; USEPA 2005), incorporates experiences and lessons learned from more than 20 years at contaminated sediment sites and identifies 11 risk management principles that should be applied when managing contaminated sediment sites. The guidance, which remains as the primary guide for USEPA staff and project managers, also provides a formal process and is based on the following 11 principles:

- Control sources early.
- Involve the community early and often.
- Coordinate with states, local governments, Indian tribes, and natural resource trustees.
- Develop and refine a conceptual site model (CSM) that considers sediment stability.
- Use an iterative approach in a risk-based framework.
- Carefully evaluate the assumptions and uncertainties associated with site characterization data and site models.
- Select site-, project-, and sediment-specific risk management approaches that will achieve risk-based goals.
- Ensure that sediment cleanup levels are clearly tied to risk management goals.
- Maximize the effectiveness of institutional controls and recognize their limitations.
- Design remedies to minimize short-term risks while achieving long-term protection.
- Monitor during and after sediment remediation to assess and document remedy effectiveness.

The first principle of controlling sources early prior to conducting remediation is critical to the effectiveness of any sediment cleanup, because the site may become re-contaminated without source control (Nadeau et al. 2009). The other principles are designed to guide the project manager through understanding site conditions (e.g., CSM development) and identifying the site's risk drivers, which can then be used to evaluate potential remedial alternatives. Based on the CSM and risk assessments, remedial action objectives are derived and should reflect objectives that are achievable from remediation of the site. Some goals, such as lifting a fish consumption advisory, may require watershed level actions that are outside the scope of the site cleanup and may not be achievable on a short-term or even a long-term basis regardless of the subject site's remediation success (Nadeau et al. 2009).

Specific sediment remedy alternatives are identified in the USEPA Guidance Document (2005). These include MNR, capping, dredging, in situ treatments, and combining alternatives. Nadeau et al. (2009) and Bridges et al. (2008) review implementation and residual risks for various remedies. Nadeau et al. (2009) provides an overview of MNR, capping, and dredging, whereas Bridges et al. (2008) focuses on resuspension, release, residual, and risk of environmental dredging. In 2013, the Office of Superfund Remediation and Technology Innovation published *Use of Amendments for In Situ Remediation at Superfund Sediment Sites* (USEPA 2013), providing an overview of technologies to treat contaminated sediments in situ. This document introduces promising amendments for in situ remediation and summarizes some of the information on contaminated sediment sites that have employed amendments. Although this document is not intended to be a guidance or design document, the authors note that the USACE Engineer Research Development Center is developing technical guidelines for in situ sediment remediation.

2 CONTAMINATED SEDIMENT MANAGEMENT APPROACH OVERVIEW

To ensure management actions are ecologically beneficial and logistically and economically feasible, this CSMP was developed to identify, prioritize, and manage chemically impacted sediments where necessary to protect and improve benthic community condition and human health from fish consumption. This CSMP uses a risk-based approach to assess impacts due to chemically mediated effects as a means for determining the magnitude and extent of possible management actions. Overall, this approach follows guidance and lessons learned from the USEPA Guidance Document (USEPA 2005). The initial step in a CSMP is to identify impacted sediments and initiate source identification through sediment characterization and water quality measurements of inflows to the waterbody. A five step, or milestone, approach has been developed to logically assess and evaluate potential management actions. The initial step in a CSMP is to analyze available data, identify data gaps, collaborate with regional monitoring programs, conduct special studies as needed, and identify sources and the nature and extent of impacted sediments. Sediment and water quality will be evaluated as part of the required Harbor Toxics TMDL monitoring program, MS4 and NPDES permits' required monitoring programs, regional monitoring programs, and related special studies. The second milestone focuses on identification of potential management areas and includes identification of PRPs. Following this step, the next step will be reached when management alternatives will be identified for each area and will consider passive and remedial actions. The fourth step focuses on the selection of management action and approval from the RWQCB. The final milestone commences when management actions are initiated. A flowchart demonstrating each of these milestones is shown in Figure 2.

2.1 Milestone 1: Monitoring and Data Collection Program

Sediment, water, and fish tissue monitoring will be conducted through approved Coordinated Integrated Monitoring Programs (CIMP), Coordinated Compliance Monitoring and Reporting Programs (CCMRP), regional monitoring programs (e.g., Southern California Bight), MS4 and NPDES permits' required monitoring, and special studies.

Figure 2

CSMP Milestones

If multiple programs are employed within the watershed, every effort should be made to engage in a data sharing program among jurisdictional groups to ensure, where possible, data gaps are filled and that all relevant and available data are compiled and analyzed prior to making a conditional assessment on the watershed. Special study data collection programs may be implemented to fill additional data gaps, examine the spatial and temporal patterns of contaminants, establish linkage between sediment contaminant concentrations and impairment, and identify and quantify sources.

Part 1 of the *Water Quality Control Plan for Enclosed Bays and Estuaries: Sediment Quality Plan* (SWRCB 2009) provides recommendations for additional investigations to be conducted to confirm impairment and identify causative agents. Potential studies/tools may include statistical procedures (principle components analysis and multiple regression analysis), toxicity identification evaluations, bioavailability studies, and dose/response spiking studies. These data will be used to:

- Analyze available data to confirm sediments are causing impairment.
- Conduct special studies to establish linkage between sediments and impairment.
- Use the SQO tool for direct effects to assess causative agent(s).
- Conduct source investigation.
- Define nature and extent of impacted areas.

The time and effort needed to collect data to address site-specific needs is dependent on the site and the processes that influence the fate and transport of contaminants in that system. It is also dependent on the stakeholder collaboration process and the integration and concurrence of available data.

2.2 Milestone 2: Identification of Potential Management Areas

The entire waterbody or a sub-area of the waterbody may be defined as an area to be managed. The Harbor Toxics TMDL identifies certain areas as priority areas; however, through the CSMP process, sub-areas within a priority waterbody may be identified and prioritized using a similar process as the USEPA's risk-based process for evaluating contaminated sediment sites. The PRPs will be identified. PRPs include cities, agencies, and dischargers with an LA as well as current and historical dischargers of the causative agent.

The preliminary list of sites to be managed will be provided to the RWQCB during the reopener. As new information is gained, potential management areas will be identified.

2.3 Milestone 3: Identification of Management Alternatives

A range of sediment management alternatives will be summarized and their effectiveness at meeting water quality requirements within the Harbor Toxics TMDL schedule will be considered. Developing and evaluating remedial alternatives should follow the USEPA Guidance Document (USEPA 2005), which bases alternatives development on a CSM and risk assessments. Alternatives will range from passive actions (i.e., MNR and source control) to active remedial actions (i.e., treatment, capping, and/or dredging) depending on site conditions and overall rank of the impacted area relative to risks posed to the environment.

At a minimum, the following typical contaminated sediment management alternatives will be considered for each area:

- *Source Control.* Source control includes the process of identifying contaminant sources and implementing corrective actions to reduce or eliminate existing contaminants from entering the management area. Contaminants may enter the management area via one or more pathways: direct discharge from stormwater or industrial outfalls, surface runoff, sediment transport, and/or deposition. Source control actions may address the contaminant or pathway and range from passive approaches such as public education to increasingly more active approaches such as regulating or terminating discharges to the system and upgrading infrastructure to reduce contaminant loadings. Source control measures are a pre-requisite to any management alternative listed below and are most often associated with MNR and enhanced natural recovery.
- *Monitored Natural Recovery.* Natural recovery is defined as the process through which deposition of non-contaminated sediments and other natural processes (e.g., degradation, diffusion, and burial) decreases sediment contaminant concentrations over time. It is necessary to determine the rate of natural recovery in a particular area to determine its effectiveness as a remedial alternative. As recommended in the USEPA Guidance Document (USEPA 2005), MLOE are needed to establish the rate of natural recovery in a system. Typically, these lines of evidence include

demonstrating decreasing fish or invertebrate tissue chemistry concentrations, decreasing water column chemical concentrations, and decreasing surface sediment chemistry trends.

- *Enhanced Natural Recovery.* Enhanced natural recovery typically refers to the activity of placing a thin-layer clean cap of sediments over the contaminated surface to enhance the natural recovery process through mixing via bioturbation or currents. This clean layer is not intended to provide complete containment of the underlying contaminated sediments but generally provides for a cleaner substrate and sufficient initial isolation that, along with future deposition of new material, will reduce contaminant migration. The degree of improvement depends on surface sediment conditions prior to placing the clean material and rate of mixing. In general, the clean material reduces average surface sediment concentrations and levels of exposure to organisms.
- *Capping.* Engineered capping involves placing clean material on top of contaminated sediments to effectively isolate the sediments in perpetuity. Engineered caps typically are 3 to 5 feet thick to account for potential erosion, contaminant mobility, and bioturbation. At sites where propeller wash or high current velocities or waves may impact the stability of the cap, an armor layer may be required to prevent cap erosion. Similarly, in areas where potential groundwater upwelling may occur, a reactive treatment layer using products such as activated carbon can be applied to filter the porewater as it fluxes up through the thin-layer clean cap.
- *In Situ Treatment.* In situ treatment of sediments refers to technologies that immobilize, transform, or destroy contaminants of concern while leaving sediments in place (i.e., without first removing sediments). In situ treatment technologies are effective for broad categories of contaminants. Carbon amendment (alone or in conjunction with other technologies) is an innovative technology that has been explored for application with organic compounds, including polychlorinated biphenyls (PCBs). Bench- and pilot-scale studies are likely required to demonstrate that the technology will be effective for specific compounds in specific areas.
- *Dredging.* Physically removing contaminated sediments is the most common method of sediment remediation. Removal typically involves dredging, using either mechanical or hydraulic dredging equipment. Land-based excavation equipment can sometimes be used if contaminated sediments are located within reach of the shore.

Removal is always combined with some form of disposal option (e.g., upland landfill, port fill, aquatic containment, or ocean disposal). Depending on the nature of the material being removed (grain size, chemistry, etc.), dredge residuals may be a concern that will require additional management through measures, such as thin layer capping of the dredge footprint.

Further information on evaluating remedial options for contaminated sediments is provided in Appendix A. Nadeau et al. (2009) highlights key risk-based, decision-making factors necessary to realistically evaluate risk reduction associated with each remedial option. This paper is based upon the decision-making process recommended by the USEPA Guidance Document (USEPA 2005).

For each potential management alternative, the following should be considered:

- Technical, logistical, and economic feasibility
- Social and environmental impacts
- Estimated cost
- Estimated time to complete
- Predicted load reduction to sediment and fish

2.4 Milestone 4: Selection of Management Alternatives

Once an area is designated for some form of remediation and available management alternatives are summarized, the relevant stakeholder group can evaluate and select the appropriate action. The makeup of the stakeholder group, and the memoranda of agreement (MOAs) or memoranda of understanding (MOUs) between the stakeholders, will define the process for selecting of one or more management alternatives. The MOA or MOU will likely detail the communication process, cost-share agreements, and roles and responsibilities of each agency or stakeholder.

Environmental and human health risk levels may be considered to assist in selecting the most appropriate remediation target. The nature and extent of contaminants—including their potential to bioaccumulate, the potential for the area to scour and contribute to contaminant mobility, the presence of sensitive habitats and/or species, and the potential for the area to be re-contaminated—can be considered during selection of an appropriate management action. When possible, management activities may be coupled with other infrastructure and maintenance programs to increase economic and logistic efficiencies. These opportunities may reprioritize management actions.

The timing of the selection of management alternatives is dependent on stakeholder involvement and site-specific actions.

2.5 Milestone 5: Commence Management Action

Once all parties agree to the selected management approach and funding mechanisms are secured, the management action can be scheduled and implemented. When a sediment management action is required to meet a specific objective, post-construction verification that the action was successful in meeting cleanup objectives is required by the regulatory agencies. Methods for determining the effectiveness of the chosen action will be will be agreed upon prior to the management action being implemented to confirm the success of the action.

3 DEFINED PRIORITY SITES: LOS ANGELES HARBOR

Historical activities in the Dominguez Watershed have contributed to the current elevated sediment concentrations observed throughout Los Angeles Harbor. Watershed discharge limitations required under state and federal laws have significantly reduced inputs to the Los Angeles Harbor, and these programs are expected to continue improving sediment quality in the coming years. POLA and POLB engage in routine maintenance dredging programs, capital improvement programs, and habitat improvement projects that frequently remove contaminated sediment and improve surface conditions. POLA and POLB dredge approximately 30 percent of the Inner Harbor surface area every 10 years and a large percentage of that material is chemically impacted. This approach has resulted in millions of cubic yards of material being removed and managed by POLA and POLB, and these activities have contributed significantly to the overall reduction of contaminants in sediment throughout Los Angeles/Long Beach Harbor the past 30 years. Maintenance dredging programs return sediment elevations to design depths to support improved navigation. The effectiveness of maintenance dredging programs in reducing contaminated sediments continues to improve as ongoing sources continue to decline. Capital dredging programs deepen waterways to allow for expanded commerce and bring sediment surface layers to pre-industrial chemical concentrations. Habitat improvement programs are propelled through mitigation requirements for improvements that result in loss of marine habitat or unavoidable impacts. Habitat improvement programs often place clean material in an area to create a shallow water habitat that supports higher valued marine life, like nursery grounds and essential fish habitat. In summary, maintenance dredging, capital improvement dredging, and habitat enhancement programs currently managed by POLA and POLB will continue to serve as the major mechanism for the continued reduction in surface sediment contaminant concentrations. These activities are tied to port operations and will need to be implemented along with port business driven mechanisms. It is recognized that additional management strategies may be required to further improve surface sediment condition. These management actions will be implemented through this CSMP.

Attaining water, sediment, and fish tissue quality will likely be achieved through a combination of source reduction, source control, sediment removal, and MNR. The Harbor Toxics TMDL and the recent Los Angeles County MS4 Permit (Order No. R4-2012-0175) prescribe specific components that are to inform and enhance water and sediment management. These components include establishing regional monitoring coalitions, coordinated monitoring plans, WMPs, EWMPs, CSMPs, and special studies. This CSMP is being developed to provide a mechanism for determining and prioritizing one or more sediment management alternatives predicated on the information and data collection obtained from the monitoring efforts of the responsible stakeholder group(s).

CSMP milestones are summarized in Figure 2. Sediment quality will be evaluated as part of the required monitoring program. Impacts of sediment-bound contaminants will be evaluated through the SQO process developed by the State Water Resource Control Board (SWRCB 2009). If chemicals within sediments are contributing to impairment, then causative agent(s) will be determined using SQO recommended procedures. Impacted sediments will then be included in the list of sites to be managed. This process will prioritize management efforts at sites that have the greatest impact to the overall health of the benthic community and risk to humans from fish consumption. The prioritization process will allow sites with lower risks to be addressed in later phases of the implementation plan. The site will then be managed and improvements confirmed through a sediment monitoring program. For areas where sediment has been demonstrated to cause impairment, activities and key questions to be addressed in each milestone shown in Figure 2 are summarized below.

3.1 Monitoring and Data Collection Program

Sediment, water, and fish tissue monitoring will be conducted through approved CIMP, CCMRP, regional monitoring programs (e.g., Southern California Bight), Los Angeles County MS4 Permit (Order No. R4-2012-0175),[2] and NPDES permits' required monitoring, and special studies. If multiple programs are employed within the watershed, every effort should be made to engage in a data sharing program among jurisdictional groups to ensure, where

[2] The Los Angeles County MS4 Permit (Order No. R4-2012-0175), adopted November 8, 2012, incorporated Harbor Toxics TMDL stormwater WLAs. This permit requires WMPs to be developed either collaboratively or individually to prioritize water quality issues resulting from MS4 Permit discharges to receiving waters, to identify and implement control measures, and to execute an integrated monitoring program and assessment program.

possible, data gaps are filled and that all relevant and available data are compiled and analyzed prior to making a conditional assessment on the watershed.

The CCMRP has been submitted to the Executive Officer of the RWQCB for approval. Briefly, the CCMRP will include sediment, water, and fish tissue sampling for the Los Angeles Harbor, Long Beach Harbor, LARE, San Gabriel River Estuary, and Eastern San Pedro Bay as is defined in the Harbor Toxics TMDL, Los Angeles County MS4 Permit (Order No. R4-2012-0175), and City of Long Beach MS4 Permit (Order No. R4-2014-0024). The PRPs identified in the effective metals TMDLs for the Los Angeles and San Gabriel rivers are responsible for conducting water and sediment monitoring above LARE and at the mouth of the San Gabriel River, respectively, to determine the rivers' contribution to the impairments in the Greater Los Angeles/Long Beach Harbor Waters.

A thorough data review of harbor sediments and fish tissue has been conducted and validated data are included in the POLA and POLB sediment chemistry database. The database also includes an extensive compilation of data collected by a variety of agencies as part of other characterization and monitoring studies conducted between 1980 and 2011. Data from the Los Angeles/Long Beach Harbor, Eastern San Pedro Bay, Dominguez Channel Estuary, and nearshore areas along the Southern California Bight were also included in the compilation.

In addition to monitoring programs, POLA (with POLB) is engaged in developing a series of special studies examining the fate and effect of chemicals of concern in the Greater Los Angeles and Long Beach Harbor Waters area to determine the cause and source of observed impairments. These studies include identifying stressors and sources to benthic impairments and sources and linkage to fish tissue impairments. Identifying the sources of fish tissue impairments is the first critical step in evaluating potential remedies directed at reducing fish tissue concentrations. It is necessary to establish the causes of elevated fish tissue concentrations (i.e., harbor sediments, ongoing sources, and off-site regional sources) and determine the necessary reductions of these sources that will effectively reduce fish tissue concentrations prior to developing management strategies. To establish these causes, scientific- and data-based models of the conditions in the harbor and the food web are necessary. Integrating hydrodynamic, sediment transport, chemical fate, and bioaccumulation processes through site-specific models will allow POLA to evaluate the limitations of background concentrations, effectiveness of specific remedial actions including MNR, and the impact of out-of-harbor sources (e.g., Palos Verdes Shelf). These studies are using the WRAP Model and expanding it to incorporate chemical fate of PCBs and DDTs. The expanded WRAP Model will then be linked to a site-specific bioaccumulation model. The bioaccumulation model will be used to evaluate the relative contribution of water column and sediment sources to the fish receptors of concern.

3.2 Identification of Potential Management Areas

The areas recommended for potential management will be better defined after data gaps are fulfilled. Identifying these areas will be informed by data collection efforts as well as information from WMPs within the Dominguez Watershed. Meeting the sediment targets in the Harbor Toxics TMDL requires a watershed-based approach that includes both land-side and sediment-based programs that focus on identifying sources and source reduction alternatives

Two sites have been identified thus far for priority management by the RWQCB in the Harbor Toxics TMDL: Consolidated Slip and Fish Harbor. The advancement of management alternatives for these two sites will be provided in site-specific detail within each of the five milestones below. Additional sites requiring potential management will be identified during the reopener tentatively scheduled for 2018.

3.2.1 Consolidated Slip

Sediment and fish tissue data are summarized in Appendix B and maintained in POLA and POLB's chemistry database, an extensive compilation of data collected by a variety of agencies as part of characterization and monitoring. Data from the Los Angeles/Long Beach Harbor, Eastern San Pedro Bay, Dominguez Channel Estuary, and nearshore areas along the Southern California Bight are included in the compilation.

For Consolidated Slip, the contaminants of concern in the Harbor Toxics TMDL include the following for sediment:

- Metals: cadmium, chromium, copper, lead, mercury, and zinc
- Pesticides and PCBs: chlordane, TDDT, and total PCB (TPCB)

- PAHs: benzo[a]pyrene, 2-methylnapthalene, phenanthrene, benzo[a]anthracene, chrysene, and pyrene

The contaminants of concern for fish tissue include chlordane, dieldrin, toxaphene, TDDT, and TPCB.

Consolidated Slip sits at the terminus of the Dominguez Channel drains a highly industrialized area and contains remnants of persistent legacy pesticides and PCBs resulting in poor sediment quality both within the channel and in adjacent Inner Harbor areas. The loadings of organochlorine pesticides, PCBs, PAHs, and metals to Dominguez Channel reflect inputs from urban runoff and multiple NPDES permitted and stormwater permitted discharges within the watershed.

Data collected from several sediment investigations conducted since 2000 provide reasonable spatial coverage for most TMDL-listed contaminants for both surface and subsurface sediments. The results of previous investigations indicate that TMDL-listed contaminants were elevated at levels greater than their respective screening targets at the majority of stations.

Special studies are ongoing to address specific data gaps and support a site-specific tissue bioaccumulation model currently in development. Specific objectives include fish tissue linkage to sediment contaminant concentrations, fish usage patterns, sediment transport and contaminant fate processes, and potential for recontamination.

3.2.2 Fish Harbor

Sediment and fish tissue data are summarized in Appendix C and maintained in the Ports' chemistry database, an extensive compilation of data collected by a variety of agencies as part of characterization and monitoring. For Fish Harbor, the contaminants of concern in the Harbor Toxics TMDL include the following for sediment:

- Metals: copper, lead, and zinc
- Pesticides and PCBs: chlordane, TDDT, and TPCB

- PAHs: benzo[a]pyrene, phenanthrene, benzo[a]anthracene, chrysene, pyrene, and dibenz[a,h]anthracene

The contaminants of concern for fish tissue include TDDT and TPCB.

Recent investigations within Fish Harbor determined a preliminary spatial (horizontal and vertical) extent of contaminated sediments. These investigations included regional monitoring programs (SCCWRP 2003, 2007), sediment characterization studies in the vicinity of the Al Larson Boat Shop (Weston 2005), studies conducted to support development of the WRAP (Weston 2008), and studies in support of data gap analyses (Anchor QEA 2012). These studies identified several contaminants of concern within surface and subsurface sediments, including metals, DDTs, PAHs, PCBs, and tributyltin. Based on these investigations, almost 1 million cubic yards of sediment as deep as 10 feet below the mudline are at concentrations above the Harbor Toxics TMDL numeric targets. Additional studies are needed to better define the extent of the contaminated sediments and confirm no ongoing sources of contamination are present in the area.

Special studies are ongoing to address specific data gaps in support of developing a site-specific tissue bioaccumulation model. Specific objectives include fish tissue linkage to sediment contaminant concentrations, fish usage patterns, sediment transport and contaminant fate processes, and potential for recontamination.

3.3 Identification of Management Alternatives

For each potential management area, a range of alternatives will be summarized and their effectiveness at meeting the target water quality requirements within the TMDL schedule will be considered. As recommended by the USEPA Guidance Document (USEPA 2005), and described above in Section 2, the first step in selecting an appropriate management alternative for a priority site is to implement an effective source control program. None of the available alternatives can be successful if the potential for recontamination is still present; therefore, the effectiveness of source control for inputs to the Los Angeles Harbor must be evaluated prior to other sediment management actions. Once management actions are identified and implemented to reduce pollutants in effluent and stormwater inputs to the Los Angeles Harbor, these management actions will be incorporated into the CSMP.

POLA and POLB are implementing source reduction strategies through the WRAP (Ports 2009). These actions have been developed to address sources of pollutants related to port land use discharges, watershed discharges, and legacy pollutants in sediments. The WRAP was developed by the POLA and POLB in cooperation with the RWQCB, USEPA, and other stakeholders to establish programs and control measures to improve water and sediment quality within the Los Angeles/Long Beach Harbor. The WRAP is currently being implemented as a living document and will be updated as needed.

Structural BMPs and non-structural BMPs are being evaluated. In addition, POLA and POLB plan to develop and implement port-specific guidance manuals for design of new and redeveloped facilities, including design criteria and appropriate structural BMPs for differing land uses and potential contaminants of concern. POLA and POLB are developing approaches to expand upon existing stormwater/dust control programs for vacant/undeveloped property. Control measures may include introducing sustainable landscaping, using swales and berms, and appropriate re-grading to reduce erosion and levels of suspended solids and other pollutants in stormwater. Street and parking lot sweeping is currently conducted by POLA and POLB throughout the Harbor District; however, debris is still present. POLA and POLB plan to enhance and expand these programs based on an evaluation of the current sweeping/cleaning activities and inspecting all sites to assess debris levels and problem areas. POLA and POLB plan to evaluate the construction permitting process and procedures to determine areas for improvement in permitting compliance that would reduce pollutant runoff from such sites.

As discussed in above, maintenance dredging, capital dredging, and habitat improvement programs result in improvement in surface condition. These programs are implemented through the CSTF process where it is necessary to demonstrate that post-dredge surfaces are better quality, chemically, than pre-dredge conditions.

3.3.1 Consolidated Slip

The following management alternatives have been initially identified as potential options for consideration in remediating Consolidated Slip sediments.

- *Source Control.* It is anticipated that the CIMP and CCMRP will provide data to more accurately quantify sources to Consolidated Slip. Once these sources are characterized, their potential to aid in natural recovery or to re-contaminate Consolidated Slip will be evaluated. As with any remediation site, effective source control is vital prior to implementing any other form of management alternative.
- *Monitored Natural Recovery.* Once source control measures in Dominguez Watershed are increased, the flow of cleaner sediments will begin to work its way through the system, eventually depositing within the Consolidated Slip and adding to the natural recovery process. As recommended in the USEPA Guidance Document (USEPA 2005), MLOE are needed to establish the rate of natural recovery potential within a system. Several special studies are ongoing to examine the potential for MNR to contribute to the overall reduction of contaminated sediments in the surface of Consolidated Slip. An implementation plan for Consolidated Slip will rest on a weight of evidence that incorporates both data-based analyses (e.g., estimates of natural recovery from sediment and biological tissue contaminant data and comparison of concentrations with regional background) and model-based estimates of future contaminant concentrations in sediments, water, and biota given an estimate of ongoing burial.
- *Enhanced Natural Recovery.* The ability to place a thin-layer clean sediment cap within Consolidated Slip as a mechanism for increasing the rate of recovery will be evaluated. Due to the high flow through this area, it is not believed to be sufficient for long-term management, but it will be assessed to determine if interim management actions provide sufficient value to warrant this type of management.
- *Capping.* As with enhanced natural recovery, this area is subject to high flows and high levels of disposition. Capping may only provide temporary reductions in surface contaminant concentrations if upstream sources are ongoing.
- *In Situ Treatment.* As with enhanced natural recovery and capping, any amendment added to the surface sediment in this high flow area may not provide meaningful long-term reductions in surface contaminant concentrations. In addition, the

contaminants are both organic and inorganic; in situ treatment technologies are most effective when only one type of contaminant requires management.

- *Dredging.* Current estimates predict that up to 500,000 cubic yards (cy) of impacted material may need to be removed to bring surface sediments to levels below the Harbor Toxics TMDL numeric targets. Removing sediments from Consolidated Slip would require the identification of a disposal site to accommodate that volume. Upland disposal at a commercial or private landfill is cost prohibitive and would impact air quality and social impacts from truck trips; therefore, a disposal option within POLA would need to be identified. As with many of the proposed management strategies, unless current inputs from upstream sources are eliminated, the effectiveness of removing the contaminated sediment is temporary and will likely result in further management actions in the future. The requirements necessary to demonstrate appropriateness of funds will not be met. Additionally, dredging alone is not likely to achieve target TMDL concentrations in surface sediments due to dredge residuals generated during material removal. Typically, dredging is a bulk removal tool and a secondary alternative like thin layer capping must be used in conjunction to meet target numerical thresholds.

Additional management actions or interim actions may also be considered. During the TMDL reopener, a summary of each potential management alternative for remediating Consolidated Slip sediments along with a conceptual feasibility evaluation for each option against a range of topics will be provided. Included in that evaluation will be a consideration of the following topics:

- Technical, logistical, and economic feasibility
- Social and environmental impacts
- Estimated cost
- Estimated time to complete
- Predicted load reduction to sediment and fish
- Potential for recontamination (despite best attempts at controlling sources)

3.3.2 Fish Harbor

The following management alternatives have been initially identified as potential options for consideration in remediating Fish Harbor sediments.

- *Source Control.* Ongoing sources in Fish Harbor have not been fully assessed. Special studies will be developed to confirm ongoing sources are stopped prior to any remedial actions.
- *Monitored Natural Recovery.* Fish Harbor is a relatively enclosed water area within the Los Angeles/Long Beach Harbor and is believed to have very little deposition; therefore, MNR is unlikely to be sufficient for the degree of change that is needed.
- *Enhanced Natural Recovery.* The effectiveness of a thin-layer cap to dilute surface contaminant concentrations in Fish Harbor will be evaluated. Because of its location, sediment mixing in the upper levels as a result of currents is not likely to occur; therefore, future studies will need to focus on the potential for significant bioturbation-induced mixing.
- *Capping.* The effectiveness of an engineered sediment cap to isolate surface and subsurface contaminant concentrations in Fish Harbor will be evaluated. Current and future harbor uses would need to be carefully considered before shallowing the harbor with a cap.
- *In Situ Treatment.* Available technologies will be evaluated for use at Fish Harbor; but like with Consolidated Slip, these are heavily influenced by the nature of the contaminants of concern (metals versus organics) and the potential for future navigation in the area.
- *Dredging.* It is estimated that up to 1,000,000 cy of material may need to be removed to bring surface sediments to levels below the Harbor Toxics TMDL numeric targets. Removing the sediments from Fish Harbor would require the identification of a disposal site to accommodate that volume. To reduce the volume of material to be handled off site, partial dredging with capping will also be evaluated. As with many of the proposed management strategies, current inputs from upstream sources will limit the effectiveness of removing the contaminated sediment.

Additional management actions or interim actions may also be considered. During the TMDL reopener, a summary of each potential management alternative for remediating Fish

Harbor sediments along with a conceptual feasibility evaluation for each option against a range of topics will be provided. Included in that evaluation will be a consideration of the following topics:

- Technical, logistical, and economic feasibility
- Social and environmental impacts
- Estimated cost
- Estimated time to complete
- Predicted load reduction to sediment and fish
- Potential for future recontamination

3.4 Selection of Management Alternatives

Once an area has been identified for remediation and available management alternatives are summarized, the relevant stakeholder group can select the appropriate management action for the area. The makeup of the stakeholder group and agreements between the stakeholders will define the process for selecting management alternatives. As stated above, the maintenance dredging, capital improvement dredging, and habitat enhancement programs will serve as the major mechanism for the continuation of reduction in surface sediment contaminant concentrations. These activities coincide with port operations and will need to be implemented along with port business-driven mechanisms.

3.4.1 Consolidated Slip

The USEPA is the regulatory agency with respect to the two Superfund sites within Consolidated Slip subarea. The USEPA has not yet reached a final remedial decision to several operable units that remain contaminated with DDT. For any management actions considered for Consolidated Slip, it is recommended that those actions be consistent with the final remedial decision. In addition, any efforts proposed for Consolidated Slip should consider the timing of Superfund activities when setting schedules and commencing with the Los Angeles Harbor sediment management actions. Any voluntary actions considered in advance of the superfund remedial actions that are within a designated operable unit must be approved by the USEPA's Superfund Division in advance of such action.

3.4.2 Fish Harbor

When Milestone 1 is complete and the contaminants of concern driving the management actions are determined, the stakeholder group will be defined. The stakeholder group will then select the management action and plan to commence management action when resources and opportunities align.

3.5 Commence Management Actions

The selected management action can be scheduled for implementation only after all the parties agree to the management approach and funding mechanisms.

3.6 CSMP Schedule

The CSMP schedule is outlined in Table 2.

Table 2
CSMP Schedule

Deliverables to RWQCB	Task	Date	Alignment with Basin Plan Amendment	Alignment with TMDL and MS4 Permit Requirements
CSMP	Submit CSMP for Los Angeles Harbor to RWQCB for consideration by Executive Director	March 23, 2014 (2 years after effective date of TMDL)	Meets required submittal timeline	WRAP: Continue to implement source reduction practices EWMP: Identify opportunities to incorporate management actions (e.g., BMPs and their effectiveness into CSMP process [see Section 3.3]) CCMRP: Outline monitoring program to be used to identify areas to be managed (see Section 3.1) Special Studies: Through the Harbor Technical Work Group special studies will be implemented to characterize the impairment and appropriate management actions.
CSMP Stakeholder Meetings	Conduct stakeholder meetings as needed	Meeting agendas and minutes to stakeholders as needed	Demonstrates coordination and cooperation of stakeholders	EWMP: Annual review of EWMP management strategies, actions, and special studies that may inform change of conditions in the Los Angeles Harbor.

Deliverables to RWQCB	Task	Date	Alignment with Basin Plan Amendment	Alignment with TMDL and MS4 Permit Requirements
CSMP Update	Submit CSMP Update for Los Angeles Harbor to RWQCB	March 23, 2017 (5 years after effective date of TMDL)	Provides updated list of sites to be managed submitted to RWQCB during TMDL reopener	
CSMP Update	Submit CSMP Update for Los Angeles Harbor to RWQCB	March 23, 2022 (10 years after effective date of TMDL)	Demonstrates progress toward sediment management actions and provides updated list of sites to be managed	
CSMP Update	Submit CSMP Update for Los Angeles Harbor to RWQCB	March 23, 2027 (15 years after effective date of TMDL)	Demonstrates progress toward sediment management actions and provides updated list of sites to be managed	
CSMP Update	Submit CSMP Update for Los Angeles Harbor to RWQCB	March 23, 2032 (20 years after effective date of TMDL)	Demonstrates attainment of LAs using the means identified in Basin Plan Amendment	

4 SUMMARY

This CSMP is designed to meet requirements of the TMDL schedule for the Harbor Toxics TMDL, which states that responsible parties in the Dominguez Watershed develop a CSMP to address contaminated sediments in Los Angeles Harbor. This CSMP is based on established guidance and is consistent with other CSMPs being developed for Dominguez Channel Estuary, Long Beach Harbor, Eastern San Pedro Bay, and LARE.

The objective of this CSMP is to establish specific steps to identify, prioritize, and implement sediment management actions. Initial steps were designed to inform subsequent technical and decision-making tasks and include:

- Data collection and evaluation (including source investigations and defining the nature and extent of impacts)
- Identification of potential management areas (including identifying PRPs)
- Identification of management alternatives
- Selection of management alternatives (considering ecological and human health risks and net benefits)
- Commencement of management actions

This approach encourages collaboration with regional monitoring programs, WMPs, and existing sediment remediation programs (e.g., Montrose Superfund site) to inform management alternatives and schedules. Source identification and reduction is included in the first step in the management plan and will be completed through data evaluation, data gap identification, and data collection and analyses prior to identifying and implementing remedies. A schedule of deliverables is included in this CSMP to reflect requirements set forth in the TMDL for submitting the CSMP and providing annual reports and updates to the RWQCB. This CSMP is an adaptive plan that provides for stakeholder and RWQCB review and interaction and provides a plan for protecting and improving benthic community condition and human health from fish consumption.

5 REFERENCES

AMEC (AMEC Earth & Environmental, Inc.), 2003. Supplemental Report: Consolidated Slip Restoration Project Concept Plan. Prepared for Los Angeles Regional Water Quality Control Board and Port of Los Angeles. October 2003.

AMEC, 2012. Port of Los Angeles Dominguez Channel and Consolidated Slip Erosion Study. 2011 Excel files. Provided to Anchor QEA, L.P., on behalf of the Port of Los Angeles.

Anchor QEA, 2012. Technical memorandum: Sampling and Analysis of Sediments within Fish Harbor at the Port of Los Angeles. September 2012.

Bay, S.M., D.J. Greenstein, J.A. Ranasinghe, D.W. Diehl, and A.E. Fetscher, 2009. *Sediment Quality Assessment Draft Technical Support Manual*. Technical Report 582. Southern California Coastal Water Research Project. May 2009.

Bridges, T.S., P. Schroeder, S. Ells, D. Hayes, D. Mount, S. Nadeau, M. Palermo, C. Patmont, 2008. *The Four Rs of Environmental Dredging: Resuspension, Release, Residual, and Risk*. Prepared for U.S. Army Corps of Engineers. ERDC/EL TR-08-4. January 2008.

CSTF (Contaminated Sediment Task Force), 2005. *Los Angeles Regional Contaminated Sediments Task Force: Long-Term Management Strategy*.

Lyons, J.M., and S. Birosik, 2007. *Water Quality in the Dominguez Channel and Los Angeles/Long Beach Harbor Watershed Management Area Under the Surface Water Ambient Monitoring Program Fiscal Year 2002-2003*. California Regional Water Quality Control Board, Los Angeles Region.

MEC (MEC Analytical Systems, Inc.), 2002. Ports of Long Beach and Los Angeles Year 2000 Biological Baseline Study of San Pedro Bay. Prepared for the Port of Long Beach Planning Division, Long Beach, California. June 2002.

Nadeau, Steven C., Megan C. MuCulloch, and T.S. Bridges, 2009. Principles for Evaluating Remedial Options for Contaminated Sediment Sites. 5th International Conference on Remediation of Contaminated Sediments, Jacksonville, Florida. 2009.

POLA (Port of Los Angeles), 2013. Sustainability Report July 2011 – June 2013. Los Angeles, California, 2013.

Ports (Ports of Los Angeles and Long Beach), 2009. Water Resources Action Plan, Final Report. August 2009.

RWQCB and USEPA (Los Angeles Regional Water Quality Control Board and U.S. Environmental Protection Agency), 2011. *Final Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Toxic Pollutants Total Maximum Daily Loads*. May 2011.

SAIC (Science Applications International Corporation), 2010. Final Sediment Quality Report. Submitted to Port of Los Angeles. April 2010.

SCCWRP (Southern California Coastal Water Research Project), 2003. Southern California Bight 1998 Regional Monitoring Program. Technical Report.

SCCWRP, 2007. Southern California Bight 2003 Regional Monitoring Program. Technical Report.

SCCWRP, 2012. California Sediment Quality Objectives Database. Available from: http://www.sccwrp.org/Data/SearchAndMapData/DataCatalog/CaliforniaSedimentQualityObjectivesDatabase.aspx.

SWRCB (State Water Resources Control Board), 2009. *Water Quality Control Plan for Enclosed Bays and Estuaries: Sediment Quality Plan*. Final Staff Report. August 2009.

SWRCB, 2010. Integrated Report (Clean Water Act Section 303(d) List / 305(b) Report. Available from: http://www.waterboards.ca.gov/water_issues/programs/tmdl/integrated2010.shtml.

USEPA (U.S. Environmental Protection Agency), 1999. Record of Decision: Dual Site Groundwater Operable Unit Montrose Chemical and Del Amo Superfund Sites. EPA Region IX.

USEPA, 2005. *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites*. USEPA-540-R-05-012. Office of Solid Waste and Emergency Response OSWER 9355.0-85. December 2005.

USEPA, 2013. *Use of Amendments for In Situ Remediation at Superfund Sediment Sites. Office of Superfund Remediation and Technology Innovation*. OSWER 9200.2-128FS. April 2013.

Weston Solutions, Inc., 2005. *Los Angeles County 1994-2005 Integrated Receiving Water Impacts Report*. August 2005.

Weston, 2008. Draft Report Sediment Characterization in Support of the Water Resources Action Plan, Port of Los Angeles. September 2008.

APPENDIX A
PRINCIPLES FOR EVALUATING REMEDIAL OPTIONS FOR CONTAMINATED SEDIMENT SITES

Principles for Evaluating Remedial Options for Contaminated Sediment Sites

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ABSTRACT: The complexity inherent in contaminated sediment sites requires that they undergo a detailed evaluation of site conditions and sediment management options in order to optimize the effectiveness of their potential remediation and risk reduction. Experiences gained at numerous sediment sites over the last 20 years can be tapped by Project Managers in the form of lessons learned. This knowledge should be integrated into the decision-making process as recommended by the U.S. EPA Contaminated Sediment Remediation Guidance For Hazardous Waste Sites (2005). This paper will review risk management principles for complex contaminated sediment sites and several of the key risk-based decision-making factors necessary to realistically evaluate the potential risk reduction associated with each remedial option.

INTRODUCTION

Contaminated sediment is pervasive across the United States. In 2004, U.S. EPA identified 96 watersheds as containing "areas of probable concern," defined as areas where fish and benthic organisms may be frequently exposed to contaminated sediment (U.S. EPA 2004). As of September 2005, through U.S. EPA's Superfund program, remedies have been selected for over 150 contaminated sediment sites, of which over 65 are large enough to be tracked at the national level (U.S. EPA 2008). Investigations are on-going at over 50 other contaminated sediment sites (U.S. EPA 2008).

Sediment sites pose challenging technical problems and addressing these problems consumes an enormous amount of resources. There are over 11 Superfund "mega" sites where the cost of the sediment remedy exceeded $50 million (U.S. EPA 2008). A number of other sites are expected to become "mega" sites as site investigations are completed and remedies are selected for them. An example of the high cost of remediating contaminated sediment is the Fox River's Operable Units 2 – 5, where the sediment remedy was estimated to cost $390 million in the Amended Record of Decision (U.S. EPA and WDNR 2007). Moreover, the cost estimate for remediating approximately 75 million cubic yards of contaminated sediment within Great Lakes Areas of Concern ranged from $1.5 billion to $4.5 billion, depending on the types of remedies selected (Great Lakes Regional Collaboration 2005).

Due to the number, size, and high cost of sediment sites across the U.S., efficient and effective remediation of these sites will require a decision-making process that integrates the key lessons learned from the remediation efforts at numerous sediment sites over the last 20 years and the application of risk-management principles in a comprehensive remedy evaluation process. Key considerations in remedy evaluation and selection are discussed and key questions to consider when evaluating and selecting remedies are presented.

RISK MANAGEMENT PRINCIPLE #1: SOURCE CONTROL

The first principle for managing risks associated with contaminated sediment sites is to "Control Sources Early" (U.S. EPA 2002). Identifying and controlling sources prior to conducting remediation is critical to the effectiveness of any sediment cleanup (U.S. EPA 2005). Without source control, the site may become recontaminated.

The risk of recontamination is not theoretical. A 2007 survey of recently completed contaminated sediment remedial actions identified 20 sites in which sediment had become recontaminated (Nadeau and Skaggs 2007). Common sources of recontamination are combined sewer overflows, storm sewer outfalls, other point sources, other sediment sources, including upstream sources and unremediated nearby sediments, runoff, atmospheric deposition, and contaminated groundwater advection (U.S. EPA 2002; U.S. EPA 2005; Nadeau and Skaggs 2007). Thus, prior to initiating any sediment cleanup, project managers should identify and control existing sources, consider whether there is a potential for recontamination and factor that potential into the remedy selection process. Table 1 identifies key questions to consider regarding source control.

TABLE 1. Key source control questions to consider during site evaluation and remedy evaluation and selection (from Evison 2008).

- What steps have been taken to identify sources and are these steps sufficient?
- Have continuing sources been identified?
- Will all continuing sources be controlled prior to remediation?
- If not, should remediation proceed and what accommodations/expectations/plans exist about those sources?

A VALUABLE TOOL: CONCEPTUAL SITE MODEL

A conceptual site model (CSM) represents the current understanding of the site conditions by incorporating information about contaminant sources, transport pathways, exposure pathways and receptors (U.S. EPA 2005). The CSM not only summarizes much of the information related to site risks to human and ecological receptors, it identifies the nature and source of the risk. This identification of the site's risk drivers can be used to evaluate which of the proposed remedial alternatives would effectively mitigate site risks to human and ecological receptors by addressing the site elements that are creating the risks (U.S. EPA 2005). Therefore, the value of a CSM for evaluating the potential effectiveness of remedial alternatives should not be underestimated. Table 2 identifies key questions to consider regarding the CSM.

TABLE 2. Key CSM questions to consider during site evaluation and remedy evaluation and selection (adapted from Evison 2008).

- Have the following data been collected and evaluated in developing the conceptual site model?
  -- Sources of contaminants of concern
  -- Human exposure pathways
  -- Human receptors
  -- Biota exposure pathways
  -- Ecological receptors
  -- Contaminant transport pathways
- If not, why not?
- What are the principal contaminants of concern and exposure pathways driving unacceptable risk at the site?
- Which exposure pathways are relatively unimportant and can be excluded from further consideration?

STABILITY OF CONTAMINANTS IN SEDIMENT

A key component of the CSM is its representation of the stability of contaminants in sediment (U.S. EPA 2002; U.S. EPA 2005). Although sediment moves over time in most aquatic environments, the most important consideration is whether movement of the contaminants in sediment is occurring at a scale and rate that poses risks to human health and ecological receptors (U.S. EPA 2005). Thus, it is important to evaluate the stability of contaminants in sediment and how it affects risk rather than just the movement and/or stability of sediment without reference to risk. Table 3 identifies key questions to consider regarding the stability of contaminants in sediment.

TABLE 3. Key stability of contaminants in sediment questions to consider during site evaluation and remedy evaluation and selection (adapted from Evison 2008).

- Have the appropriate lines of evidence been evaluated on the potential stability of the contaminants present in the sediment (as opposed to sediment stability per se)?
- Does contaminant fate and transport through in-place sediment potentially pose an unacceptable risk to human health and ecological receptors? Is movement of contaminated sediment (surface and subsurface) or of contaminants alone occurring or may occur at scales and rates that will significantly change their current contribution to human health and ecological risk?
  -- Are they contributing to risk now?
  -- Are they likely to contribute to risk in the future?
- If yes, can in-situ remedies (e.g., capping, MNR) be designed to adequately reduce risk to human health and ecological receptors?

EVALUATING REMEDIAL ALTERNATIVES AND SELECTING A REMEDY

There are several key concepts that should be applied when evaluating remedial alternatives and selecting a remedy. These concepts are discussed below.

Remedial Action Objectives. To develop and evaluate remedial alternatives, a description should be developed of what risk reduction the cleanup is expected to accomplish (U.S. EPA 2005). These general statements, remedial action objectives (RAOs), are derived from the understanding of exposure pathways, receptors, and risks gained during development of the CSM and from risk assessments. RAOs should reflect objectives that are achievable from remediation of the site. Some goals, such as lifting a fish consumption advisory, may require watershed level actions that are outside the scope of the site cleanup and may not be achievable on a short-term or even a long-term basis regardless of the subject site's remediation success (U.S. EPA 2005). From the RAOs, contaminant-specific risk-based remediation goals and sediment cleanup levels should be developed (U.S. EPA 2002; U.S. EPA 2005).

Comparative Net Risk. U.S. EPA recommends using a risk management process "to select a remedy designed to reduce the key human and ecological risks" (U.S. EPA 2005). Considerations in the risk management process for contaminated sediment sites include (U.S. EPA 2005; Nadeau 2008):

- There is no presumptive remedy for any contaminated sediment site, regardless of the contaminant or level of risk;
- Risks must be characterized over appropriate timeframes;
- Management goals must be framed within a realistic time period;
- Risk management actions must be linked to reduction of significant human and ecological risks;

- Ecological risks are characterized at a level of assessment appropriate for the site;
- All implementation and residual risks of the remedial alternatives must be considered.

An approach recommended by U.S. EPA and the National Academy of Sciences Committee on Remediation of PCB-Contaminated Sediments that incorporates these considerations is comparative net risk evaluation (CNRE) (NRC 2001; U.S. EPA 2005). Use of CNRE ensures that on a site-specific basis decision-makers consider, at the remedy selection stage, not only the benefits of a remedial approach, but also the residual risks associated with the approach and the risks associated with implementing the remedial approach (U.S. EPA 2005; Nadeau 2008). This differs from the traditional approach of either considering implementation risks at the remedy implementation stage or assuming that remedial approaches will be 100% effective on implementation thereby bypassing any consideration of residual risk. CNRE is consistent with the National Oil and Hazardous Substances Pollution Contingency Plan's (NCP) 9 criteria (40 CFR §300.430(e)(9)(iii)), which require evaluation and balancing of short-term and long-term risks and benefits, including residual risk. Failure to account for implementation risks and residual risk during the remedy evaluation stage can skew remedy selection and result in a less effective and less protective remedy than anticipated, a result neither regulators nor the responsible parties should find acceptable.

Specific Remedy Implementation Risks. Each remedy has its own uncertainties and potential implementation risks. For MNR, the risk present at the time of remedy selection should decrease with time (U.S. EPA 2005). The implementation risks associated with MNR are mostly related to continued exposure to contaminants while natural processes work to reduce contaminant bioavailability. Institutional controls may be useful to address risks to human health during MNR implementation (e.g., fish consumption advisories) (U.S. EPA 2005).

For capping, the risk due to direct exposure to contaminated sediment should decrease rapidly as the cap is placed (U.S. EPA 2005). Implementation risks may include contaminant releases during placement of the cap, impacts on the community (e.g., noise, accidents, residential or commercial disruption), construction-related risks to workers during transport and placement of cap materials, and disruption of the benthic community (U.S. EPA 2005). Cap design and placement techniques may be useful in mitigating some construction-related implementation risks (U.S. EPA 2005).

During dredging, risks to human health and ecological receptors may increase due to increased exposure to contaminants resuspended and released to the surface water (U.S. EPA 2005; NRC 2007; Bridges *et al.* 2008). For example, during the 1995 Non-Time Critical Removal Action (NTCRA) in the Grasse River, caged fish deployed along the perimeter of a set of 3 silt curtains for 6 weeks showed several-fold increases in PCB concentrations compared to those observed in the pre-dredging period (NRC 2007). Lessons learned from the 1995 NTCRA and dredging projects at other sites over 10 additional years did not prevent a similar impact to Grasse River fish during the 2005 Remedial Options Pilot Study dredging (NRC 2007). PCB concentrations increased substantially in fish during the 2005 dredging pilot (NRC 2007).

In addition to the effects of releases at the site, resuspended and released contaminants may be transported downstream from the site. For example, at the Fox River Deposit 56/57 dredging project, 2.2% of the mass of contaminants dredged were released downstream (Steuer 2000).

Although there are no standardized best management practices for environmental dredging, lessons learned from other similar sites may yield some useful techniques for reducing resuspension and releases during dredging (U.S. EPA 2005; NRC 2007). Of late, the effectiveness of silt curtains in controlling releases has been questioned (Bridges *et al.* 2008), as evidenced by the Grasse River fish examples. Because some contaminant release and transport during dredging is inevitable, it must be considered during the alternatives evaluation (U.S. EPA 2005).

Other dredging implementation risks may include impacts on the community (e.g., noise, accidents, residential or commercial disruption), construction-related risks to workers during sediment removal and handling, and disruption of the benthic community (U.S. EPA 2005). Implementation risks are site-specific and remedy-specific and must be considered during remedy evaluation and selection (U.S. EPA 2005). Failure to adequately consider implementation risks may skew remedy selection and result in a less protective remedy than anticipated.

Residual Risk. Residual risk is the risk to human health and ecological receptors from contaminated materials or residuals that remain after remedial action has been concluded (U.S. EPA 2005). All remedial approaches leave some contaminants in place after remedial actions are complete (U.S. EPA 2005). The source of residual risk varies for each remedial approach and should be evaluated on a site-specific basis.

For MNR, residual risk is generally related to the possibility that clean sediment overlying buried contaminants may move to such an extent that unacceptable risk is created or that groundwater flow, bioturbation, or other mechanisms may move buried contaminants to the surface in an amount and at a rate that could cause unacceptable risk to human health or ecological receptors (U.S. EPA 2005). Institutional controls and monitoring may be used to address residual risk. Table 4 identifies key questions to consider regarding residual risk following a MNR remedy.

TABLE 4. Key questions to evaluate residual risk from a MNR remedy (adapted from Evison 2008).

- What evidence is there that the system is recovering? Is the pattern of recovery expected to change in the future? If so, how will it change? Will the change result in unacceptable risk?
  -- If the change may result in an unacceptable risk, can institutional controls reduce human health risks?
- Is the rate of recovery sufficient to reduce risk within an acceptable time frame?
  -- If no, can the recovery process be accelerated by engineering means?
  -- If no, can human health risks be addressed by institutional controls?
- Are groundwater flow, bioturbation, or other mechanisms likely to move contaminants to the surface at a rate and concentration that may pose an unacceptable risk?
- Can a monitoring plan be designed to evaluate risk reduction and protectiveness?

For capping, residual risk is generally related to (1) the possibility of cap erosion or disruption exposing contaminants; (2) the potential for contaminants to migrate through the cap; and (3) risks from contaminants remaining in uncapped areas (U.S. EPA 2005). As with MNR, whether erosion or contaminant migration through the cap poses an unacceptable risk depends on the amount and rate of contaminant exposure due to those processes (U.S. EPA 2005). Cap monitoring, maintenance, and design and institutional controls may be used to address residual risk. Table 5 identifies key questions to consider regarding residual risk following capping.

TABLE 5. Key questions to evaluate residual risk from a capping remedy (adapted from Evison 2008).

- Is erosion or disruption of the cap likely to occur in a way that may pose an unacceptable risk?
  -- If likely, can cap design, maintenance, or institutional controls reduce risk to an acceptable level?
- Is contaminant migration through the cap likely to occur at a rate that may pose an unacceptable risk?
  -- If likely, can activated carbon or other material be incorporated into the cap to reduce risk to an acceptable level?
- Is NAPL migration through the cap likely to occur at a rate that may pose an unacceptable risk?
  -- If likely, can an impervious material or reactive material be incorporated into the cap to reduce risk to an acceptable level?
- Is gas migration through the cap likely to occur at a rate that may pose an unacceptable risk?
  -- If likely, can the cap be designed to reduce risk to an acceptable level?
- Can the monitoring plan be designed to detect significant erosion or contaminant movement before unacceptable risk occurs?

For dredging, residual risk is primarily related to residuals, i.e., contaminated sediments remaining in the aquatic environment after the completion of dredging. (U.S. EPA 2005; NRC 2007; Bridges *et al*. 2008). Because residuals will occur to some degree with every dredging project (NRC 2007), they should be considered during remedy evaluation and selection (U.S. EPA 2005). There are two types of residuals, undisturbed and generated, both of which are important. Undisturbed residuals are contaminated sediments found at the post-dredge sediment surface that have been uncovered, but not fully removed as a result of the dredging operation (Patmont and Palermo 2007; Bridges *et al*. 2008). Generated residuals are contaminated sediments that are dislodged or suspended by the dredging operation and are subsequently redeposited on the bottom either within or adjacent to the dredging footprint (Patmont and Palermo 2007; Bridges *et al*. 2008). A series of dredging project results has shown that generated residuals ranged from 2 to 9% of the contaminant mass from the last production pass (Patmont and Palermo 2007). Lessons learned from previous dredging projects indicate that residuals are likely to be higher in areas where there are debris, rocks, bedrock, and/or hardpan as well as in areas with low dry density sediment (e.g., "fluff") (U.S. EPA 2005; NRC 2007).

Residuals are not inconsequential. For example, during the 2005 Remedial Options Pilot Study at the Grasse River, the average surficial concentration of PCBs increased substantially immediately following dredging (NRC 2007). The increase occurred despite removing approximately 80% of the PCB mass in the dredging footprint (NRC 2007). Thus, mass removal did not equate to risk reduction in this more modern-day pilot (NRC 2007). Table 6 identifies key questions to consider regarding residual risk from dredging.

TABLE 6. Key questions to evaluate residual risk from a dredging remedy (adapted from Evison 2008).

- Is it likely that resuspension will pose an unacceptable risk?
- Is it likely that releases will pose an unacceptable risk?
- Is it likely that residuals will pose an unacceptable risk?
- If residuals are estimated to exceed cleanup levels, should an engineered cap be considered as an alternative to dredging?
- If residuals are estimated to exceed cleanup levels, can cleanup levels be achieved with backfill? If so,

how is the backfill intended to function?
-- If it is intended as a dilution layer
- Is the added material going to change the amount of contaminant mass that is bioavailable?
- Would thin layer placement without dredging be more appropriate?
-- If it is intended as a cap
- Has it been evaluated for erosion potential?
- Has it been evaluated for the effects of groundwater advection?
- Would engineered capping be more appropriate?

- Can the monitoring plan be designed to ensure the backfill is functioning as designed?

Selecting A Remedy. Once the remedial alternatives have been evaluated, a risk-based decision-making process should be applied to select a remedy or combination of remedies that will effectively reduce risks to human health and ecological receptors (U.S. EPA 2005). This risk-based decision-making process includes the 9 criteria from the NCP and complies with the NCP (U.S. EPA 2005; Evison 2008). Table 7 identifies key remedy selection considerations.

TABLE 7. Key remedy selection principles (adapted from U.S. EPA 2005 and Evison 2008).

- There is no presumptive remedy for any contaminated sediment site, regardless of the contaminant or level of risk.
- Risk management goals should be developed that can be evaluated within a realistic time period, acknowledging that it may not be practical to achieve all goals in the short term.
- Evaluate uncertainties concerning the predicted effectiveness of various remedial alternatives and the time frames for achieving cleanup levels, remedial goals, and remedial action objectives.
- Use realistic time frames for remedy design, implementation and completion, and incorporate risks associated with remedy implementation when comparing on-going risks
- The effectiveness of in-situ (capping and MNR) and ex-situ (dredging) alternatives should be evaluated under the conditions present at the site. There should not be a presumption that removal of contaminated sediments from a water body will be more effective or permanent than capping or MNR.
- Contaminants that are deeply buried, have no significant migration pathway to the surface, and are unlikely to be exposed in the future may not need removal because they do not necessarily contribute to site risks.
- No remedy is perfect. A combination of sediment management options may be the most effective way to manage risk.
- Developing accurate cost estimates is an essential part of evaluating alternatives. An important risk management function is to compare and contrast the cost and benefits of various remedies.

CONCLUSION

Contaminated sediment sites pose difficult challenges due to complex technical issues. Addressing these sites requires applying risk-management principles within a risk-management framework to remedy evaluation and selection. To be effective, this risk management framework must include consideration of implementation risks and residual risk at the remedy evaluation and selection phase. U.S. EPA's "Contaminated Sediment Remediation Guidance for Hazardous Waste Sites" provides such a framework.

REFERENCES

Bridges, T., S. Ells, D. Hayes, D. Mount, S. Nadeau, M. Palermo, C. Patmont, and P. Schroeder. 2008. *The Four Rs of Environmental Dredging: Resuspension, Release, Residual, and Risk*. ERDC/EL TR-08-4. U.S. Army Corps of Engineers, Engineer Research and Development Center. February 2008.

Evison, L. 2008. "Decision Tool for Remedy Evaluation". Presented at *Optimizing Decision-Making and Remediation at Complex Contaminated Sediment Sites Conference*, January 8-10, 2008, New Orleans, Louisiana. Conference jointly sponsored by U.S. Environmental Protection Agency, U.S. Navy Space and Naval

Warfare Systems Center, U.S. Army Corps of Engineers – Engineer Research and Development Center, and Sediment Management Work Group.

Great Lakes Regional Collaboration. 2005. *Strategy To Restore And Protect The Great Lakes*. December 2005.

Nadeau, S. and M. Skaggs. 2007. "Analysis of Recontamination of Completed Sediment Remedial Projects." Paper D-050 in *Proceedings, 4th International Conference on Remediation of Contaminated Sediments*, January 22-25, 2007, Savannah, GA. Battelle Press, Columbus, OH:

Nadeau, S. 2008. "Applying the Principles of Comparative Net Risk and Risk Management to Sediment Sites." Presented at *Optimizing Decision-Making and Remediation at Complex Contaminated Sediment Sites Conference*, January 8-10, 2008, New Orleans, LA. Conference jointly sponsored by U.S. Environmental Protection Agency, U.S. Navy Space and Naval Warfare Systems Center, U.S. Army Corps of Engineers – Engineer Research and Development Center, and Sediment Management Work Group.

NRC. 2001. *A Risk-Management Strategy for PCB-Contaminated Sediments*. National Research Council. National Academies Press, Washington, DC.

NRC. 2007. *Sediment Dredging at Superfund Megasites: Assessing the Effectiveness*. National Research Council. National Academies Press, Washington, DC.

Patmont, C., and M. Palermo. 2007. "Case Studies of Environmental Dredging Residuals and Management Implications." Paper D-066 in *Proceedings, 4th International Conference on Remediation of Contaminated Sediments*, January 22-25, 2007, Savannah, GA. Battelle Press, Columbus, OH.

Steuer, J. 2000. *A Mass-Balance Approach for Assessing PCB Movement During Remediation of a PCB-Contaminated Deposit on the Fox River, Wisconsin*. USGS Water Resources Investigation Report 00-4245.

U.S. EPA. 2002. *Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites*. OSWER Directive 9285.6-08. February 2002.

U.S. EPA. 2004. *The Incidence and Severity of Sediment Contamination in Surface Waters of the U.S., National Sediment Quality Survey: Second Edition*. EPA-823-R-04-007. November 2004.

U.S. EPA. 2005. *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites*. OSWER Directive 9355.0-85.

U.S. EPA and WDNR. 2007. *Record of Decision Amendment, Lower Fox River and Green Bay Superfund Site*. U.S. Environmental Protection Agency and Wisconsin Department of Natural Resources. June 2007.

U.S. EPA. 2008. "Contaminated Sediments in Superfund." http://www.epa.gov/superfund/health/conmedia/sediment/index.htm. Website last visited January 14, 2009.

APPENDIX B
CONSOLIDATED SLIP SEDIMENT AND FISH DATA

1 INTRODUCTION

This appendix provides a summary of available sediment and fish chemistry data from Consolidated Slip to support development of a Contaminated Sediment Management Plan (CSMP). Characterizing current and historical contaminant levels in sediment and fish tissue data will aid in the evaluation of management alternatives for long-term compliance with the *Final Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Toxic Pollutants Total Maximum Daily Loads* (Harbor Toxics TMDL; RWQCB and USEPA 2011). Data are summarized and compared to total maximum daily load (TMDL) targets.

For Consolidated Slip, contaminants of concern in the Harbor Toxics TMDL include the following:

- Sediment
  - Metals: cadmium, chromium, copper, lead, mercury, and zinc
  - Pesticides and polychlorinated biphenyls (PCBs): chlordane, total dichlorodiphenyltrichloroethane (TDDT), and total PCB (TPCB)
  - Polycyclic aromatic hydrocarbons (PAHs): benzo[a]pyrene, 2-methylnapthalene, phenanthrene, benzo[a]anthracene, chrysene, and pyrene
- Fish
  - Pesticides and PCBs: chlordane, dieldrin, toxaphene, TDDT, and TPCB

2 EXISTING DATA REVIEW

The data reviewed herein are primarily from Ports of Long Beach and Los Angeles' (Ports') sediment and fish databases. Initially assembled in April 2013, the Ports' sediment physical and chemical databases and fish tissue chemistry database are extensive compilations of data collected by a variety of agencies as part of characterization and monitoring studies between 1980 and 2012 (Ports 2013; see Tables 1 and 2 of Ports 2013 for summaries by study and year). They include data from the Los Angeles/Long Beach Harbor, Eastern San Pedro Bay, Dominguez Channel, and nearshore areas along the Southern California Bight. The original data compilation focused on dichlorodiphenyltrichloroethane (DDTs), PCBs, and physical parameters (i.e., grain size). Only data meeting basic data quality requirements were included in the data compilation.

Since April 2013, data from additional sediment studies dating from 1998 to 2001 and 2006 to 2012 as well as data from additional fish studies dating from 1990 to 2012 (collected primarily from the Palos Verde Shelf) were acquired and added to the sediment and fish data compilations. In addition, the contaminants of concern summarized in the database were expanded to include metals and PAHs. These new data were included in the database following the same data handling and treatment procedures for consistency with the original compilations (Ports 2013). In addition to incorporating new data, sediment and fish compilations were modified with new duplicate and coordinate information. The fish data compilation included further standardization of fish and tissue names.

Where applicable, sediment chemistry data were compared against the Harbor Toxics TMDL direct effects targets for sediments (based on effects range low [ERL] criteria) and indirect effects targets for sediment and fish tissue (based on fish contaminant goal [FCG] criteria and assumed fish-sediment relationship), and, in comparison, the listing criteria for sediment (based on effects range median [ERM] criteria; Table B-1).

Reports for each study, where available, were reviewed and are summarized in the following subsections.

2.1 Sediment

The Ports' sediment physical and chemical databases contain data from Consolidated Slip from the following studies (see sampling locations illustrated in Figure B-1):

- Biological baseline studies in 2000 (MEC 2002) and 2008 (SAIC 2010)
- Bay Protection and Toxic Cleanup Program (BPTCP) from 1992, 1994, and 1996 (SCCWRP 2012)
- Southern California Bight 2003 Regional Monitoring Program (Bight '03; SCCWRP 2012)
- Port of Los Angeles Special Studies (AMEC 2003a; AMEC 2012; Weston 2013)

Table B-2 reports data counts of DDTs, PCBs, PAHs, and metals per study for Consolidated Slip sediment. The following sections include summaries for each study based on review of study reports and evaluations using the Ports' databases.

2.1.1 Biological Baseline Studies

In 2000, MEC performed a biological baseline study of the Los Angeles/Long Beach Harbor (MEC 2002). As part of this study, surface sediment was collected from one station (LA-14[1]) within Consolidated Slip for grain size and benthic macrofauna analysis. Surface sediment (0 to 2 centimeters [cm]) was predominantly fine-grained materials (silt and clay). Benthic community results indicated low abundance, low diversity, and a low number of species at this station (MEC 2002). In addition, the benthic community was dominated by pollution indicator species (MEC 2002).

As part of the 2008 Port of Los Angeles (POLA) Biological Baseline Study, SAIC collected surface sediment (0 to 10 cm) at station LA-14 for Sediment Quality Objective (SQO) assessment using multiple lines of evidence (LOE; SAIC 2010). Elevated concentrations of contaminants resulted in a chemistry LOE score of high exposure. High toxicity was observed to amphipods in acute exposure tests (15 percent survival relative to the control), while no toxicity was observed to polychaetes in chronic exposure tests. Benthic community results indicated high disturbance, which is consistent with the results of the previous biological baseline study in 2000 (MEC 2002). Based on these results, this station was categorized as clearly impacted (SAIC 2010).

The 2008 data indicate elevated metals, DDTs, PCBs, and PAHs (Table B-3). Sediment chemistry data indicate ERM exceedances for zinc and exceedances of ERL values and TMDL indirect effects sediment targets for cadmium, chromium, copper, lead, mercury, zinc, TDDT, TPCB, phenanthrene, chrysene, and pyrene. No data were available for chlordane.

2.1.2 Regional Studies

Thirteen samples were collected within Consolidated Slip as part of regional programs, including BPTCP (SCCWRP 2012) and Bight ’03 (SCCWRP 2007). Station locations are presented in Figure B-1.

[1] This location was also sampled in 2008 as part of the Port of Los Angeles Biological Baseline Study (SAIC 2010); in Figure B-1, it is shown as part of that program.

From 1992 to 1996, surface sediment (0 to 2 cm or 0 to 30 cm) was collected at 11 stations within Consolidated Slip as part of BPTCP (SCCWRP 2012). At all stations, surface sediment was predominantly fine-grained materials (silt and clay). The BPTCP monitoring results indicate elevated concentrations of metals, DDTs, PCBs, and PAHs in surface sediment (Table B-3). Levels for all six metals of concern (i.e., cadmium, copper, chromium, lead, zinc, and mercury) were exceeded ERL values. In 1992 and 1994, levels of zinc also exceeded ERM values. In 1996, at least one sample from the 0 to 30 cm depth interval exceeded ERM values for copper, chromium, and zinc. TDDT exceeded ERL values and TMDL indirect effects sediment targets in all samples. Data were not available for chlordane. TPCB exceeded ERL values and TMDL indirect effects sediment targets in all samples, with the majority of samples also exceeding ERM values. Regarding the individual PAHs of concern (i.e., benzo[a]pyrene, 2-methylnaphthalene, phenanthrene, benzo[a]anthracene, chrysene, and pyrene), concentrations in all samples exceeded ERL values except for 2-methylnaphthalene, which exceeded ERL values in one sample.

Surface sediment (0 to 2 cm) was collected at one station within Consolidated Slip for Bight '03 (SCCWRP 2007). Surface sediment was predominantly fine-grained materials (silt and clay). Metals were measured at elevated concentrations; cadmium, chromium, copper, lead, and mercury concentrations were greater than ERL values, and zinc was greater than the ERM value (Table B-3). Concentrations of TDDT, TPCB, and individual PAHs of concern were less than ERL, ERM, and TMDL indirect effects sediment values. In addition to sediment chemistry, bioassay testing and benthic macrofauna analyses were performed. High toxicity was observed to amphipods (48 percent survival relative to the control). Benthic community results indicated moderate disturbance.

2.1.3 Port of Los Angeles Special Studies

2.1.3.1 Consolidated Slip Restoration Project Concept Plan

In 2002, CH2M Hill and Kinnetic Laboratories, Inc., collected sediment cores in the storm water pathway that leads from the former Montrose facility in Torrance to Consolidated Slip (AMEC 2003b). Sediment cores were collected at 15 locations within Consolidated Slip to a maximum depth of 20 feet. Cores were segmented into the following feet intervals for chemical analysis: 0 to 0.5, 0.5 to 3, 3 to 6, 6 to 9, 9 to 12, 12 to 15, 15 to 18, and below 18. Depth profiles for contaminants of concern are presented in Figures B-2a through B-2n.

Metals concentrations were elevated relative to ERL and ERM values in at least one depth interval for all 15 locations, with a few exceptions (Figures B-2a through B-2f). At stations CS-1 and CS-15 (at the northeast and southwest ends of Consolidated Slip, respectively), cadmium, chromium, copper, lead, mercury, and zinc were less than ERL and ERM values. At station CS-9, chromium and copper concentrations were less than the ERM value. At station CS-13, chromium was less than the ERM value. All concentrations were less than ERL and ERM values in the bottom core segment, with the exception of CS-5, CS-7, CS-10, and CS-11.

Pesticide concentrations were elevated relative to ERL and ERM values in at least one depth interval at almost all 15 locations (Figures B-2g and B-2h). The exceptions were that TDDT did not exceed the ERL value at CS-15, and TPCB did not exceed the ERL value at stations CS-1 and CS-15. Chlordane was not analyzed during this study. Generally, TDDT and TPCB concentrations decreased with depth or spiked mid-depth and then decreased. All concentrations were less than ERL and/or ERM values in the bottom core segment, with the exception of CS-5, CS-7, CS-10, and CS-11.

PAH concentrations were elevated relative to ERL or ERM values in at least one depth interval at the majority of locations (Figures B-2i through B-2n). Concentrations of all PAH contaminants of concern (i.e., benzo[a]pyrene, 2-methylnaphthalene, phenanthrene, benzo[a]anthracene, chrysene, and pyrene) did not exceed ERL values at stations CS-1 and CS-15. In addition, 2-methylnaphthalene did not exceed ERL values at CS-9. Generally, concentrations decreased with depth or spiked mid-depth and then decreased. All concentrations were less than ERL values in the bottom core segment, with the exception of CS-5, CS-7, and CS-10; concentrations of 2-methylnapthalene, phenanthrene, chrysene, and pyrene also exceeded ERL values in the bottom segment at CS-11.

2.1.3.2 Dominguez Channel/Consolidated Slip Erosion Study

In 2011, AMEC performed an erosion study within Dominguez Channel and Consolidated Slip. Sediment core and grab samples were collected at three stations within Consolidated Slip (Figure B-1). Cores were collected using a vibracore or push core. The top 2 feet were segmented into 1-foot intervals and analyzed for grain size, while the entire 2 feet were analyzed for contaminants. Grabs were collected using a double Van Veen or petite ponar, and the top 0.5 foot was analyzed for contaminants.

Core and grab samples were predominantly fine-grained materials (silt and clay). Metals, pesticides, PCBs, and PAHs were measured at concentrations greater than ERL, ERM, and/or TMDL indirect effects sediment values. Cadmium, chromium, copper, lead, zinc, and mercury concentrations were almost always greater than ERL values at all stations; zinc levels were also greater than the ERM value at all stations (Table B-3). Chlordane, TDDT, and TPCB exceeded ERL, ERM, and TMDL indirect effects sediment values at all stations. Regarding the PAHs of concern, concentrations in all samples exceeded ERL values except for phenanthrene at one site, pyrene at one site, and 2-methylnaphthalene at all sites.

2.1.3.3 Port of Los Angeles Sediment Quality Objective Phase II 2012

In 2012, Weston collected surface sediment (0 to 5 cm) at six locations within Consolidated Slip as part of a larger study that evaluated Consolidated Slip and Outer Harbor contaminant concentrations in sediment and fish tissue (Weston 2013). In Consolidated Slip, levels of pesticides and PCBs were found to be elevated (Table B-3); all TDDT and TPCB concentrations exceeded ERL, ERM, and TMDL indirect effects sediment values. All chlordane measurements exceeded the ERL value, all but one exceeded the TMDL indirect effects sediment target, and half exceeded the ERM value. No data were available for metals or PAHs in sediment from Consolidated Slip.

2.2 Fish

The Ports' fish chemistry database[2] contains data from part of a port-wide sediment and fish tissue investigation and a follow-up study conducted by Weston in 2011 and 2012, respectively (Weston 2012, 2013). The mid-point of the trawl line is shown in Figure B-1. Table B-4 shows the average TMDL-listed contaminant concentrations for each of the four fish species collected from Consolidated Slip as part of the Weston studies: California halibut (*Paralichthys californicus*; 2011 only), white croaker (*Genyonemus lineatus*), queenfish (*Seriphus politus*), and topsmelt (*Atherinops affinis*). The percent of samples exceeding TMDL fish tissue targets is also provided in Table B-4.

Average total chlordane concentrations varied by species and ranged from 3.9 micrograms per kilogram (µg/kg) for California halibut (n=1), which is below the fish target, to 16.7 µg/kg for white croaker (n=6) in 2011. Average total chlordane concentrations in 2012 were on the same order of magnitude as those in 2011 for queenfish, topsmelt, and white croaker. Exceedances of the fish chlordane target ranged from 0 percent for California halibut and topsmelt to 100 percent for white croaker in 2011; queenfish (n=4) total chlordane concentrations exceeded the target concentration in 75 percent of the tissue samples in 2011. Fewer total chlordane exceedances were measured in 2012, with 0 percent for queenfish, 14 percent for topsmelt, and 50 percent for white croaker.

In 2011, average TDDT concentrations varied by species and ranged from 39.4 µg/kg for California halibut (n=1) to 156 µg/kg for white croaker (n=7; more than seven times the fish target for TDDT). In 2012, the average TDDT concentrations for queenfish and topsmelt were similar to average concentrations measured in 2011. Exceedances of the fish TDDT target ranged from 50 to 100 percent for all species.

In 2011, average TPCB congener concentrations varied by species and ranged from 26.3 µg/kg for topsmelt (n=2) to 754 µg/kg for white croaker (n=7; more than two orders of magnitude greater than the fish target for TPCB). In 2012, average TPCB congener

[2] Older studies—a 2002 study by AMEC and from BPTCP—also analyzed fish tissues for key legacy contaminants. Fish tissue chemistry data from these studies are summarized in the Harbor Toxics TMDL but are not discussed here because they are not likely to be representative of current fish contamination levels. Data from these studies are not in the Ports' database.

concentrations ranged from 289 μg/kg for topsmelt (n=7) to 566 μg/kg for white croaker (n=7). Exceedances of the fish target for TPCB were 100 percent for all species collected from Consolidated Slip in 2011 and 2012.

In 2011, dieldrin was below the detection limit for all fish species; however, the method detection limit was higher than the TMDL target. In 2012, dieldrin was below the detection limit for all queenfish; the detection limit for dieldrin for this study was below the TMDL target. In addition, average dieldrin concentrations in 2012 were below the fish dieldrin target for topsmelt and white croaker. Exceedances of the fish target for dieldrin were 14 percent for topmelt and 0 percent for white croaker.

3 SUMMARY

Recent investigations within Consolidated Slip have defined the preliminary spatial (horizontal and vertical) extent of contamination in sediments. These investigations included biological baseline studies (MEC 2002; SAIC 2010), regional programs (SCCWRP 2007, 2012), and sediment characterization studies (AMEC 2003a; Weston 2012). These studies identified several contaminants of concern within surface and subsurface sediments, including metals, DDTs, PAHs, and PCBs; concentrations exceeded TMDL targets at many stations. Contaminated sediment extended beyond 18 feet below the mudline in some locations. Based on these investigations, approximately 500,000 cubic yards of sediment are considered contaminated by at least one TMDL-listed constituent occurring at concentrations greater than the corresponding sediment Harbor Toxics TMDL numeric targets.

Recent fish data have been collected within Consolidated Slip (Weston 2012, 2013). Almost all contained elevated PCB, DDT, and chlordane concentrations relative to respective TMDL fish targets.

Special studies are ongoing to address specific data gaps that will support the development of a site-specific bioaccumulation model. Specific objectives include understanding the fish tissue linkage to sediment contaminant concentrations, fish usage patterns, sediment transport and contaminant fate processes, and potential for sediment recontamination.

4 REFERENCES

AMEC (AMEC Earth & Environmental, Inc.), 2003a. ToxScan Montrose Pathways Database. Excel file. Provided to Anchor QEA, LLC, by AMEC on December 12, 2013.

AMEC, 2003b. *Supplemental Report: Consolidated Slip Restoration Project Concept Plan*. Prepared for Los Angeles Regional Water Quality Control Board and Port of Los Angeles. October 2003.

AMEC, 2012. Port of Los Angeles Dominguez Channel and Consolidated Slip Erosion Study. 2011 Excel files. Provided to Anchor QEA, LLC, on behalf of the Port of Los Angeles.

MEC (MEC Analytical Systems, Inc.), 2002. *Ports of Long Beach and Los Angeles Year 2000 Biological Baseline Study of San Pedro Bay*. Prepared for the Port of Long Beach Planning Division, Long Beach, California. June 2002.

Ports (Ports of Long Beach and Los Angeles), 2013. Compilation of Sediment, Fish Tissue, and Mussel Tissue Datasets for the TMDL Support Program. April 2013.

RWQCB and USEPA (Los Angeles Regional Water Quality Control Board and U.S. Environmental Protection Agency), 2011. *Final Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Toxic Pollutants Total Maximum Daily Loads*. May 2011.

SAIC (Science Applications International Corporation), 2010. *Final 2008 Biological Surveys of the Los Angeles and Long Beach Harbors*. Submitted to Port of Los Angeles. April 2010.

SCCWRP (Southern California Coastal Water Research Project), 2007. *Southern California Bight 2003 Regional Monitoring Program*. Technical Report.

SCCWRP, 2012. California Sediment Quality Objectives Database. Available from: http://www.sccwrp.org/Data/SearchAndMapData/DataCatalog/CaliforniaSedimentQualityObjectivesDatabase.aspx.

Weston (Weston Solutions, Inc.), 2012. POLA POLB SQO Part II data from 2011. Excel Files. Provided to Anchor QEA on behalf of the Ports of Los Angeles and Long Beach.

Weston, 2013. Fish and sediment chemistry data from 2012. Excel Files. Provided to Anchor QEA on behalf of the Ports of Los Angeles and Long Beach.

TABLES

Table B-1
TMDL Targets for Sediment and Fish

Parameter	Units	Sediment: Direct Effects Criteria (ERL) [1]	Sediment: Indirect Effects Target [2]	Sediment: Effects Range Median (ERM) [3]	Fish: Indirect Effects Criteria (FCG) [2]
Metals					
Cadmium	mg/kg	1.2	---	---	---
Chromium	mg/kg	81	---	370	---
Copper	mg/kg	34	---	270	---
Lead	mg/kg	46.7	---	---	---
Mercury	mg/kg	0.15	---	---	---
Zinc	mg/kg	150	---	410	---
Pesticides and PCBs					
Chlordane	µg/kg	0.5	1.3	6	5.6
Dieldrin	µg/kg	0.02	---	8	0.46
Toxaphene	µg/kg	0.1	0.1	---	6.1
Total PCBs	µg/kg	22.7	3.2	180	3.6
Total DDTs	µg/kg	1.58	1.9	---	21
PAHs					
Benzo[a]anthracene	µg/kg	261	---	---	---
Benzo[a]pyrene	µg/kg	430	---	---	---
Chrysene	µg/kg	384	---	---	---
Pyrene	µg/kg	665	---	---	---
2-Methylnaphthalene	µg/kg	201	---	---	---
Dibenzo[a,h]anthracene	µg/kg	260	---	---	---
Phenanthrene	µg/kg	240	---	---	---
High Molecular Weight PAHs	µg/kg	1700	---	---	---
Low Molecular Weight PAHs	µg/kg	552	---	---	---
Total PAHs	µg/kg	4022	---	---	5.47

Notes:
1 Direct effects criteria are from Table 3-7 of Harbor Toxics TMDL (RWQCB and USEPA 2011).
2 Indirect effects criteria are from Table 3-8 of Harbor Toxics TMDL (RWQCB and USEPA 2011).
3 ERM criteria are from Table 2-4 of Harbor Toxics TMDL (RWQCB and USEPA 2011) for marine and estuarine sediments.

µg/kg = micrograms per kilogram
mg/kg = milligrams per kilogram
DDT = dichlorodiphenyltrichloroethane
ERL = effects range low
FCG = fish contaminant goal
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
TMDL = total maximum daily load

Table B-2
Summary of Sediment Data Collected within Consolidated Slip

Source	Sample Year	Type	Depth	Number of Samples	Number of Samples Per Analyte				
					DDT	PCB		PAH [2]	Metals [2]
						Aroclor	Congener		
BPTCP	1992	Grab	0-2 cm	2	2	---	2	1	2
BPTCP	1994	Grab	0-2 cm	3	3	3	3	1	3
BPTCP	1996	Grab	0-2 cm, 0-30 cm	6	6	6	6	6 [4]	6
AMEC [3]	2002	Core	0-0.5 ft, 0.5-3 ft, every 3 ft until 18 ft, below 18 ft	15	15	15	---	15	15
SCC_B03	2003	Grab	0-2 cm	1	1	---	1	1	1
POLA BIOBASELINE 2008	2008	Grab	0-10 cm	1	1	---	1	1	1
AMEC	2011	Grab	0-0.5 ft	3	3	3	3	3	3
		Core	0-2 ft, 2 ft up to 3.6 ft	3	3	3	3	3	3
WESTON	2012	Grab	0-5 cm	6	6	---	6	---	---

Notes:

1 Counts are based on data contained in the Ports of Long Beach and Los Angeles sediment chemistry database.

2 For simplicity, counts reflect those for one PAH or one metal.

3 Counts are the numbers of cores collected.

4 Only five measurements were available for some individual PAHs.

AMEC = AMEC Earth & Environmental, Inc.

BPTCP = Bay Protection and Toxic Cleanup Program

cm = centimeters

DDT = dichlorodiphenyltrichloroethane

ft = feet

PAH = polycyclic aromatic hydrocarbon

PCB = polychlorinated biphenyl

POLA BIOBASELINE 2008 = Port of Los Angeles Biological Baseline Study 2008

SCC_B03 = Bight Regional Monitoring Program 2003

WESTON = Weston Solutions, Inc.

Table B-3
Summary of Consolidated Slip Sediment Chemistry Results

Parameter	1992 BPTCP			1994 BPTCP			1996 BPTCP			2002 AMEC			2003 SCC_B03			2008 POLA BIOBASELINE			2011 AMEC						2012 Weston		
	Grab: 0-2 cm			Grab: 0-2 cm			Grab: 0-2 cm, 0-30 cm			Core: 0-0.5 ft, 0.5-3 ft, every 3 ft until 18 ft, below 18 ft			Grab: 0-2 cm			Grab: 0-10 cm			Grab: 0-0.5 ft			Core: 0-2 ft			Grab: 0-5 cm		
		% exceeding			% exceeding			% exceeding			% exceeding			% exceeding			% exceeding			% exceeding			% exceeding			% exceeding	
Parameter	Samples	ERL	ERM	Samples	ERL	ERM	Samples	ERL	ERM	Samples	ERL	ERM	Samples	ERL	ERM	Samples	ERL	ERM	Samples	ERL	ERM	Samples	ERL	ERM	Samples	ERL	ERM
Metals																											
Cadmium	2	100	---	3	100	---	6	100	---	114	63	---	1	100	---	1	100	---	3	100	---	3	100	---	0	---	---
Chromium	2	100	0	3	100	0	6	100	17	114	55	17	1	100	0	1	100	0	3	67	0	3	100	0	0	---	---
Copper	2	100	0	3	100	0	6	100	17	114	76	18	1	100	0	1	100	0	3	100	0	3	100	0	0	---	---
Lead	2	100	---	3	100	---	6	100	---	114	67	---	1	100	---	1	100	---	3	100	---	3	100	---	0	---	---
Mercury	2	100	---	3	100	---	6	100	---	114	70	---	1	100	---	1	100	---	3	100	---	3	100	---	0	---	---
Zinc	2	100	100	3	100	100	6	100	50	114	65	61	1	100	100	1	100	100	3	100	100	3	100	100	0	---	---
Pesticides and PCBs																											
Chlordane	0	---	---	0	---	---	0	---	---	0	---	---	0	---	---	0	---	---	3	100	100	3	100	100	6	100	50
Total PCBs - Aroclor	0	---	---	3	100	67	6	100	83	113	62	57	0	---	---	0	---	---	3	100	100	3	100	100	0	---	---
Total PCBs - congener	2	100	100	3	100	100	6	100	100	0	---	---	1	0	0	1	100	0	3	100	100	3	100	100	6	100	100
Total DDTs	2	100	---	3	100	---	6	100	---	113	67	---	1	0	---	1	100	---	3	100	---	3	100	---	6	100	---
PAHs																											
Benzo[a]anthracene	1	100	---	1	100	---	5	100	---	114	57	---	1	0	0	1	0	---	3	100	---	3	100	---	0	---	---
Benzo[a]pyrene	1	100	---	1	100	---	5	100	---	114	53	---	1	0	0	1	0	---	3	100	---	3	100	---	0	---	---
Chrysene	1	100	---	1	100	---	5	100	---	114	62	---	1	0	0	1	100	---	3	100	---	3	100	---	0	---	---
Pyrene	1	100	---	1	100	---	5	100	---	114	65	---	1	0	0	1	100	---	3	100	---	3	67	---	0	---	---
2-Methylnaphthalene	1	100	---	1	100	---	5	20	---	114	34	---	1	0	---	1	0	---	3	0	---	3	0	---	0	---	---
Phenanthrene	1	100	---	1	100	---	5	100	---	114	64	---	1	0	0	1	100	---	3	100	---	3	67	---	0	---	---

Notes:

1 Harbor Toxics TMDL direct effects targets for sediments (based on ERL), indirect effects targets for sediment and fish tissue (based on fish contamination goal), and for comparison, the listing criteria for sediment (based on ERM) are listed in Table B-1.

2 The following parameters have numeric targets in the Harbor Toxics TMDL, but are not listed constituents for Consolidated Slip waterbody and therefore were not evaluated: dieldrin, toxaphene, dibenzo[a,h]anthracene, high molecular weight PAHs, low molecular weight PAHs, and total PAHs.

3 Exceedances are based on data contained in the Ports of Long Beach and Los Angeles sediment chemistry database.

AMEC = AMEC Earth & Environmental, Inc.

BPTCP = Bay Protection and Toxic Cleanup Program

cm = centimeters

DDT = dichlorodiphenyltrichloroethane

ERL = effects range low

ERM = effects range medium

ft = feet

PAH = polycyclic aromatic hydrocarbon

PCB = polychlorinated biphenyl

POLA BIOBASELINE = Port of Los Angeles Biological Baseline Study 2008

SCC_B03 = Bight Regional Monitoring Program 2003

TMDL = Total Maximum Daily Load

WESTON = Weston Solutions, Inc.

Table B-4
Summary of Consolidated Slip Fish Tissue Chemistry Results

		2011				2012		
		California Halibut	Queenfish	Topsmelt	White Croaker	Queenfish	Topsmelt	White Croaker
Total Chlordane (ND = 0)	Number of Samples	1	4	2	6	5	7	6
	Mean (µg/kg)	3.90	8.90	4.30	16.7	2.48	3.63	5.71
	Standard Deviation	N/A	6.3	1.56	10.8	1.44	1.16	3.70
	% Exceeding Fish Target (5.6 µg/kg)	0%	75%	0%	100%	0%	14%	50%
Dieldrin	Number of Samples	1	4	2	6	4	7	7
	Mean [µg/kg]	<1	<1	<1	<1	<0.21	0.414	0.175
	Standard Deviation	N/A	N/A	N/A	N/A	N/A	0.130	0.109
	% Exceeding Fish Target (0.46 µg/kg)	--	--	--	--	0%	14%	0%
Total DDTs (ND = 0)	Number of Samples	1	3	2	7	7	7	7
	Mean (µg/kg)	39.4	152	60.9	156	90.4	43.0	112
	Standard Deviation	N/A	95.4	60.5	68.8	75.1	50.4	80.5
	% Exceeding Fish Target (21 µg/kg)	100%	100%	50%	100%	86%	100%	100%
Total PCB Congeners (ND = 0)	Number of Samples	1	3	2	7	7	7	7
	Mean (µg/kg)	205	262	26.3	754	393	289	566
	Standard Deviation	N/A	115	19.3	943	526	412	722
	% Exceeding Fish Target (3.6 µg/kg)	100%	100%	100%	100%	100%	100%	100%

Notes:

Fish were collected by Weston in 2011 and 2012 (Weston 2012, 2013).

Units are in wet weight.

Non-detects were assumed to be zero in the summing of DDT derivatives or PCB congeners.

Total chlordane was calculated using the following compounds: alpha-chlordane, gamma-chlordane, oxychlordane, cis-nonachlor, and trans-nonachlor.

Skin-off fillets were analyzed from California halibut, queenfish, and white croaker for chemical constituents.

Whole topsmelt were analyzed for chemical constituents.

< = less than method detection limit

µg/kg = micrograms per kilogram

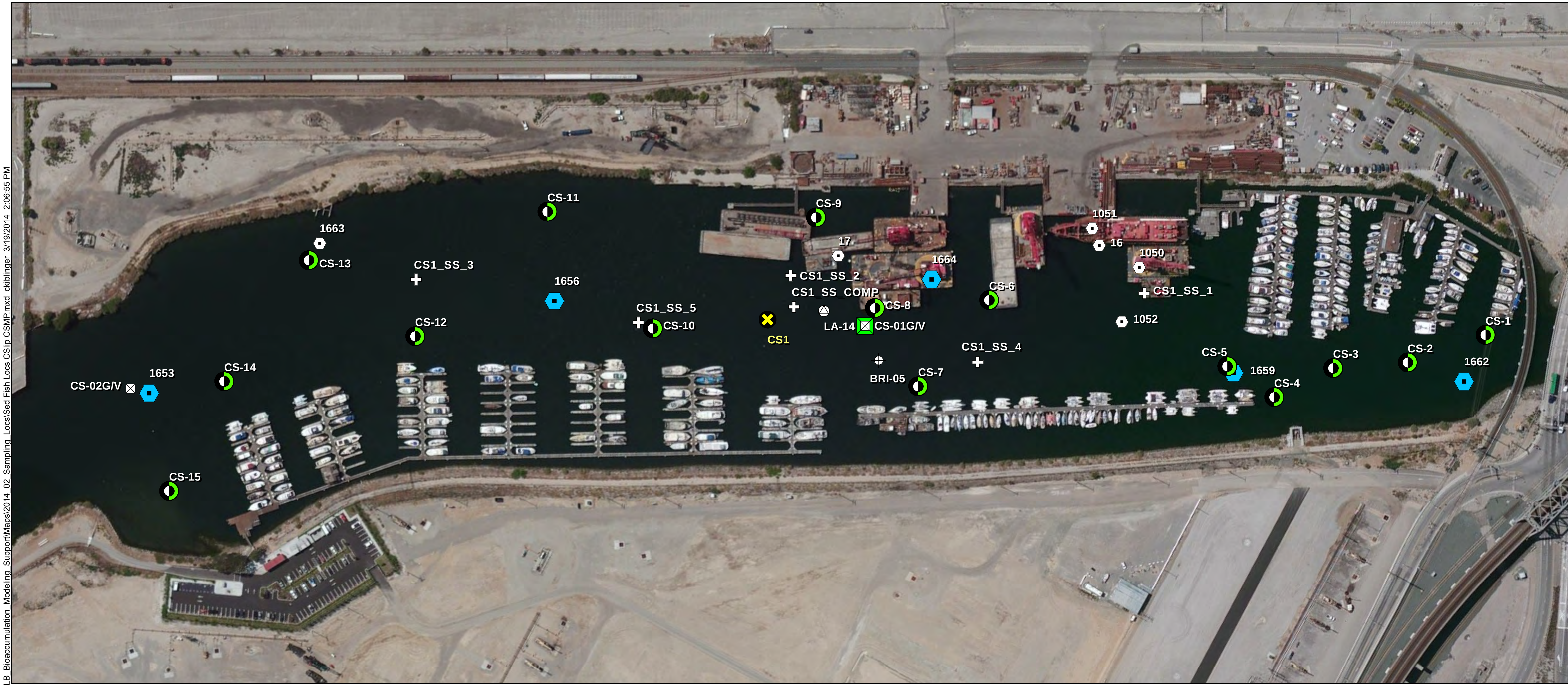
DDT = dichlorodiphenyltrichloroethane

N/A = not applicable

ND = non-detect

PCB = polychlorinated biphenyl

FIGURES



LEGEND

Surface Sediment (top 0.5 ft or less)
- BPTCP 1992, 1994, 1996
- AMEC 2002
- Bight '03
- POLA Biobaseline 2008
- AMEC 2011
- Weston 2012

Subsurface Sediment (> 0.5 ft)
- BPTCP 1996
- AMEC 2002
- AMEC 2011

Fish Sampling Location - 2011

NOTES:
Surface sediment data were defined as data collected within the top 0.5 ft or less. Subsurface sediment data were defined as data collected below the top 0.5 ft, including samples with intervals starting at the surface and extending beyond 0.5 ft.

Feet
0 250 500

Q:\Jobs\120711-01.01_Port_of_Los_Angeles\POLA_POLB_Bioaccumulation_Modeling_Support\Maps\2014_02_Sampling_Locs\Sed Fish Locs CSlip CSMP.mxd ckiblinger 3/19/2014 2:06:55 PM

ANCHOR QEA

Figure B-1
Consolidated Slip Sediment and Fish Sampling Locations
Los Angeles Harbor

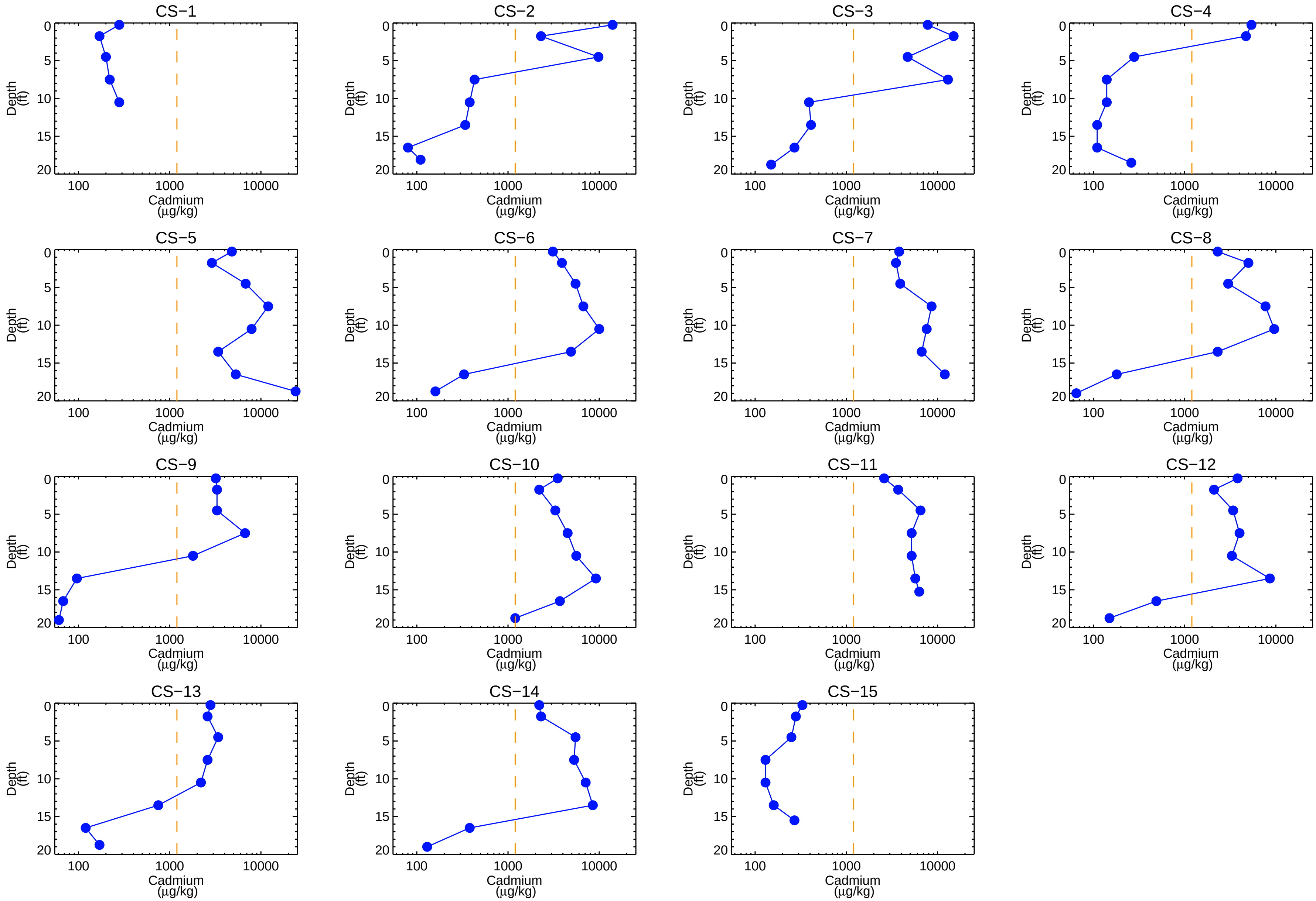


Figure B−2a

Cadmium Concentrations in Sediment Cores from Consolidated Slip

Data collected in 2002. Values plotted at mid−depths.
Vertical lines show ERLs (orange), ERMs (red), and TMDL indirect effects sediment targets (purple) where applicable.
Duplicates from original sample results were averaged. Data source: AMEC

ANCHOR QEA

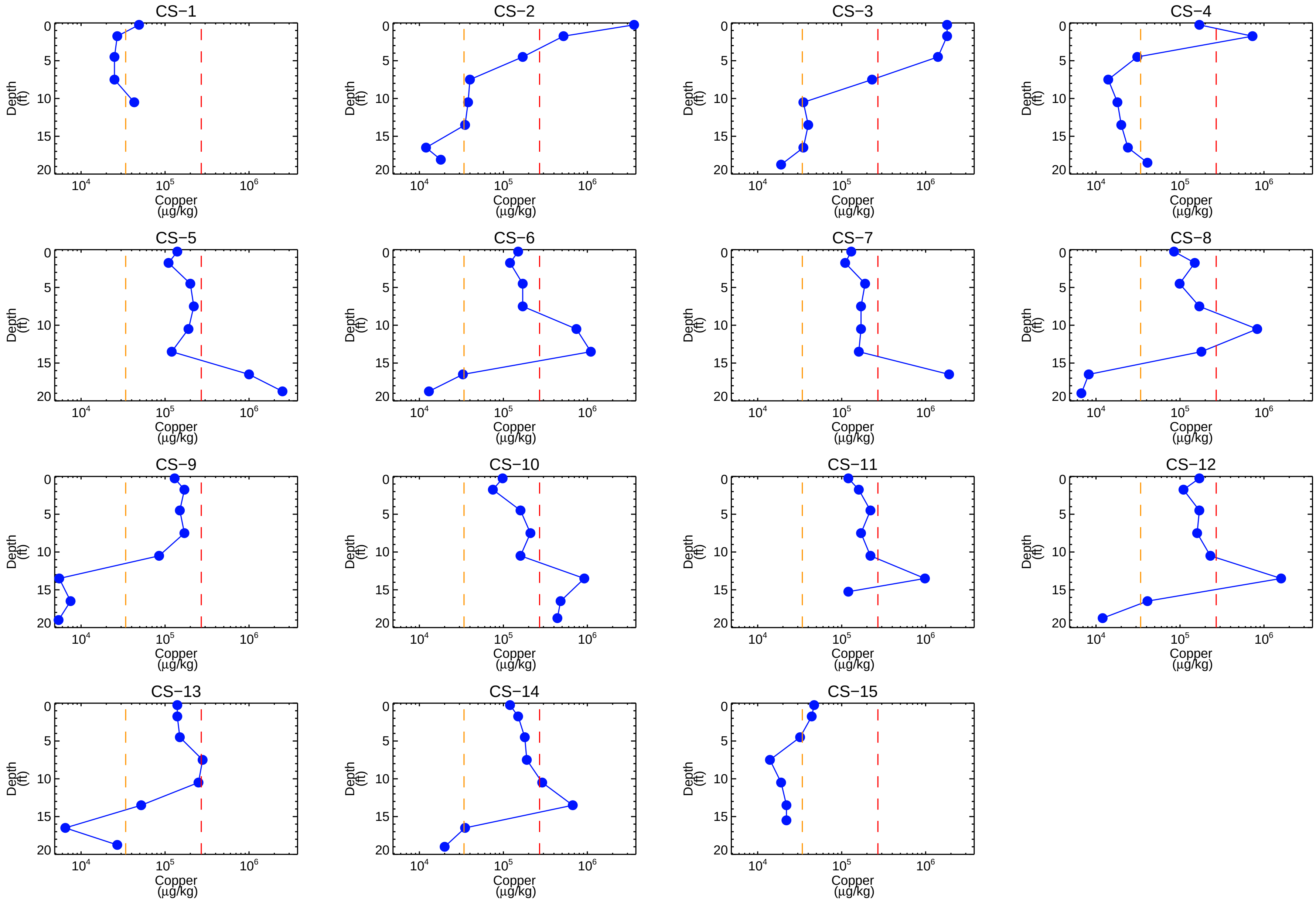


Figure B−2b

Copper Concentrations in Sediment Cores from Consolidated Slip

Data collected in 2002. Values plotted at mid−depths.
Vertical lines show ERLs (orange), ERMs (red), and TMDL indirect effects sediment targets (purple) where applicable.
Duplicates from original sample results were averaged. Data source: AMEC

ANCHOR QEA

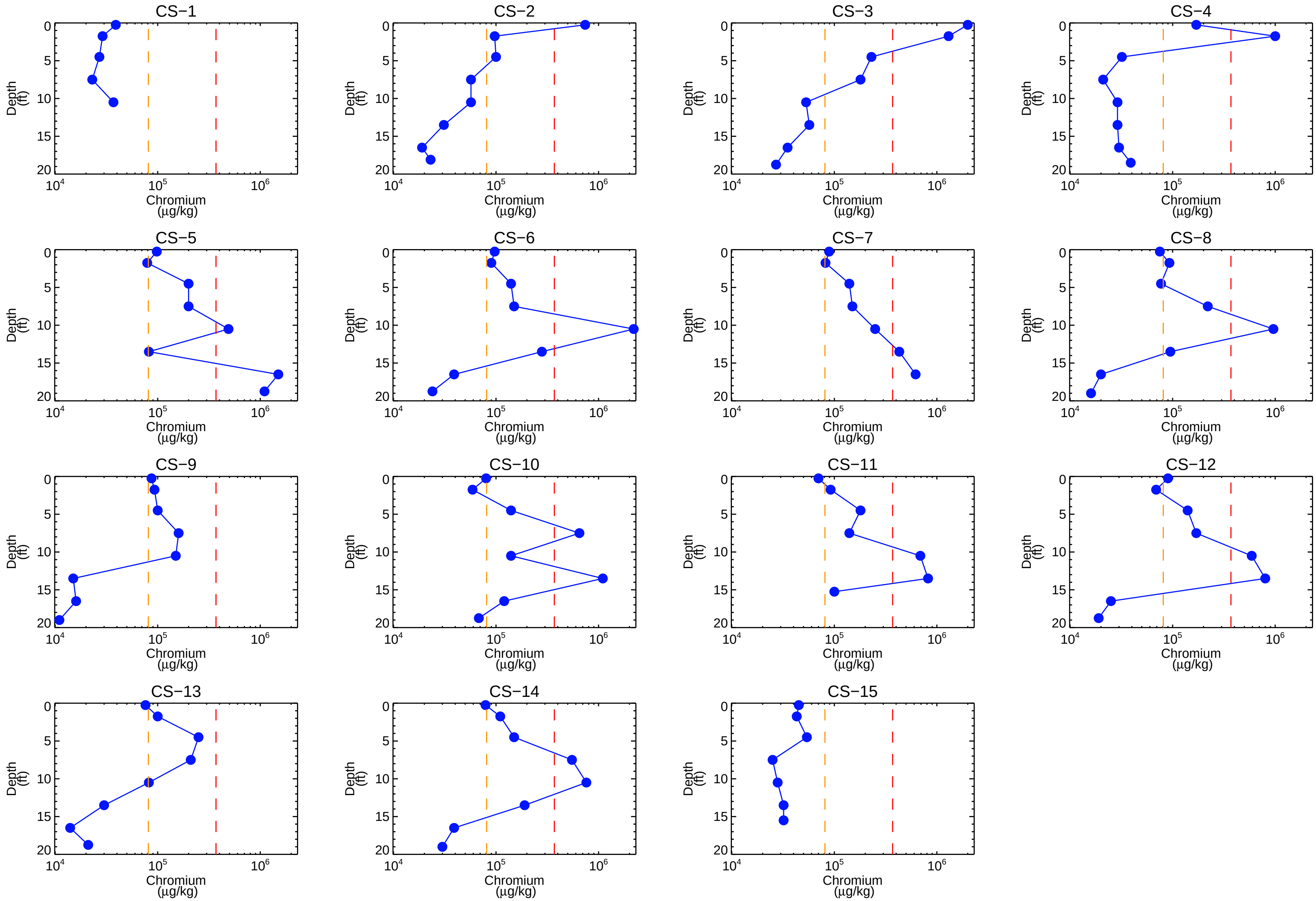


Figure B−2c

Chromium Concentrations in Sediment Cores from Consolidated Slip

Data collected in 2002. Values plotted at mid−depths.
Vertical lines show ERLs (orange), ERMs (red), and TMDL indirect effects sediment targets (purple) where applicable.
Duplicates from original sample results were averaged. Data source: AMEC

ANCHOR QEA

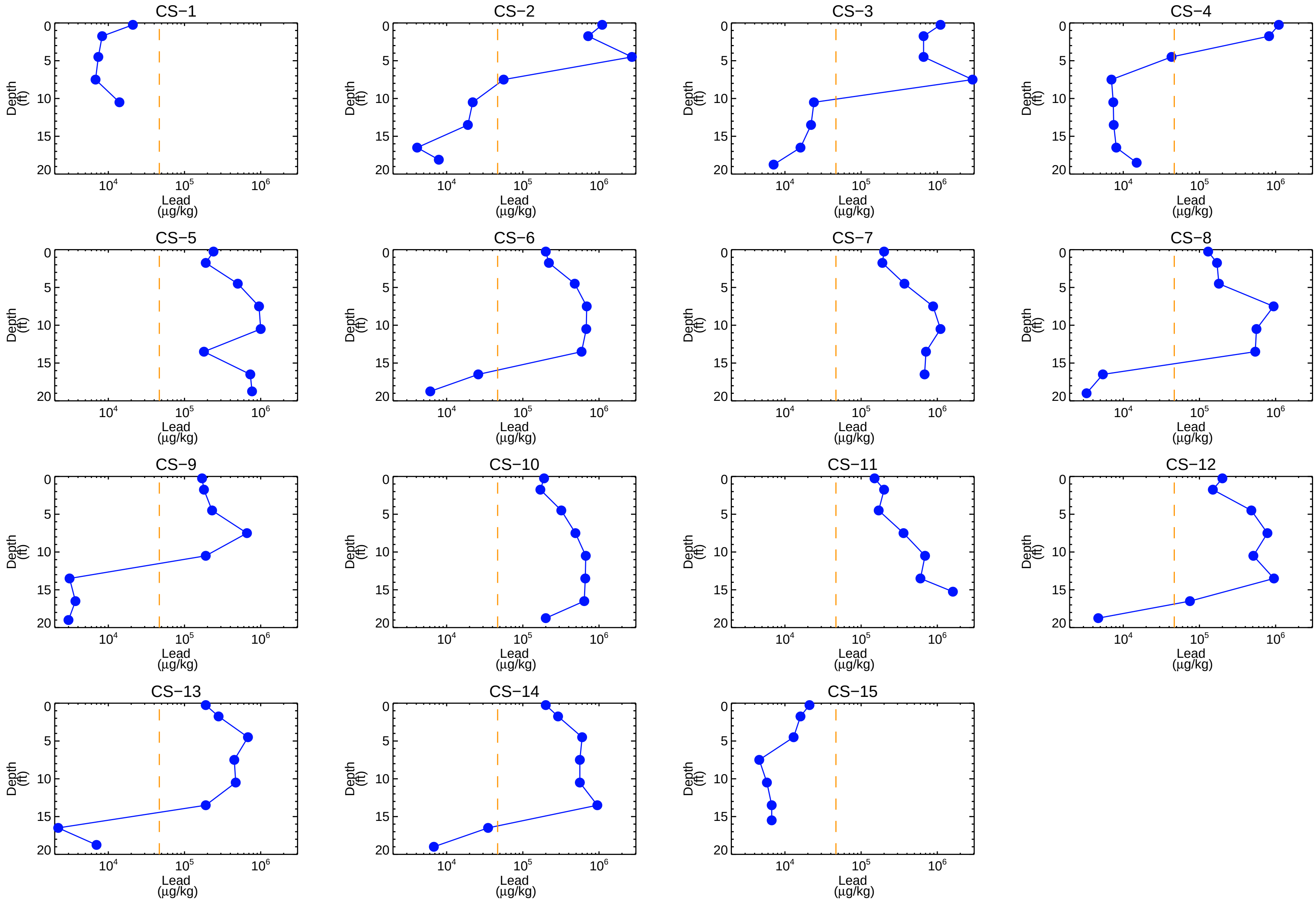


Figure B−2d

Lead Concentrations in Sediment Cores from Consolidated Slip

Data collected in 2002. Values plotted at mid−depths.
Vertical lines show ERLs (orange), ERMs (red), and TMDL indirect effects sediment targets (purple) where applicable.
Duplicates from original sample results were averaged. Data source: AMEC

ANCHOR QEA

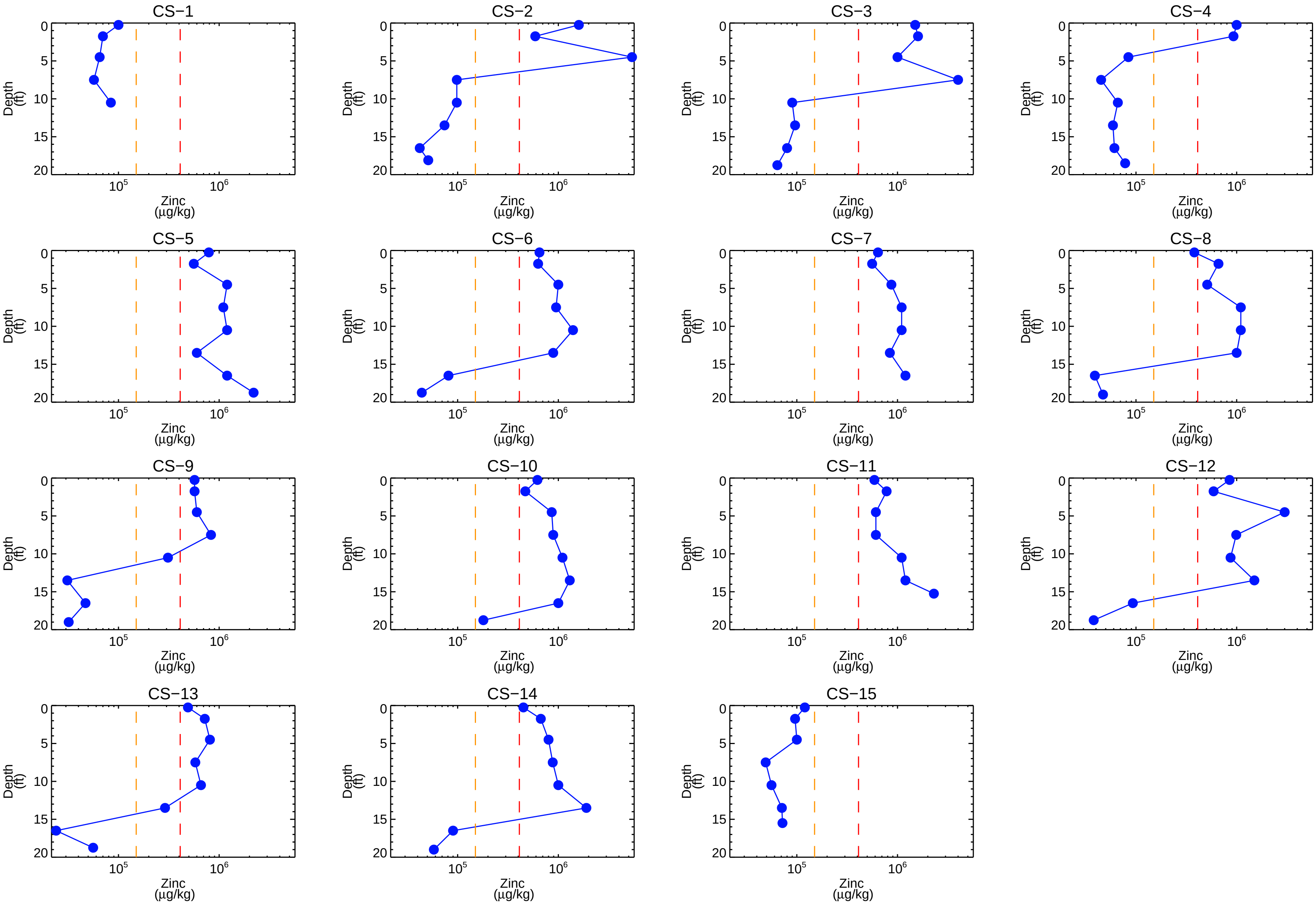


Figure B−2e

Zinc Concentrations in Sediment Cores from Consolidated Slip

Data collected in 2002. Values plotted at mid−depths.
Vertical lines show ERLs (orange), ERMs (red), and TMDL indirect effects sediment targets (purple) where applicable.
Duplicates from original sample results were averaged. Data source: AMEC

ANCHOR QEA

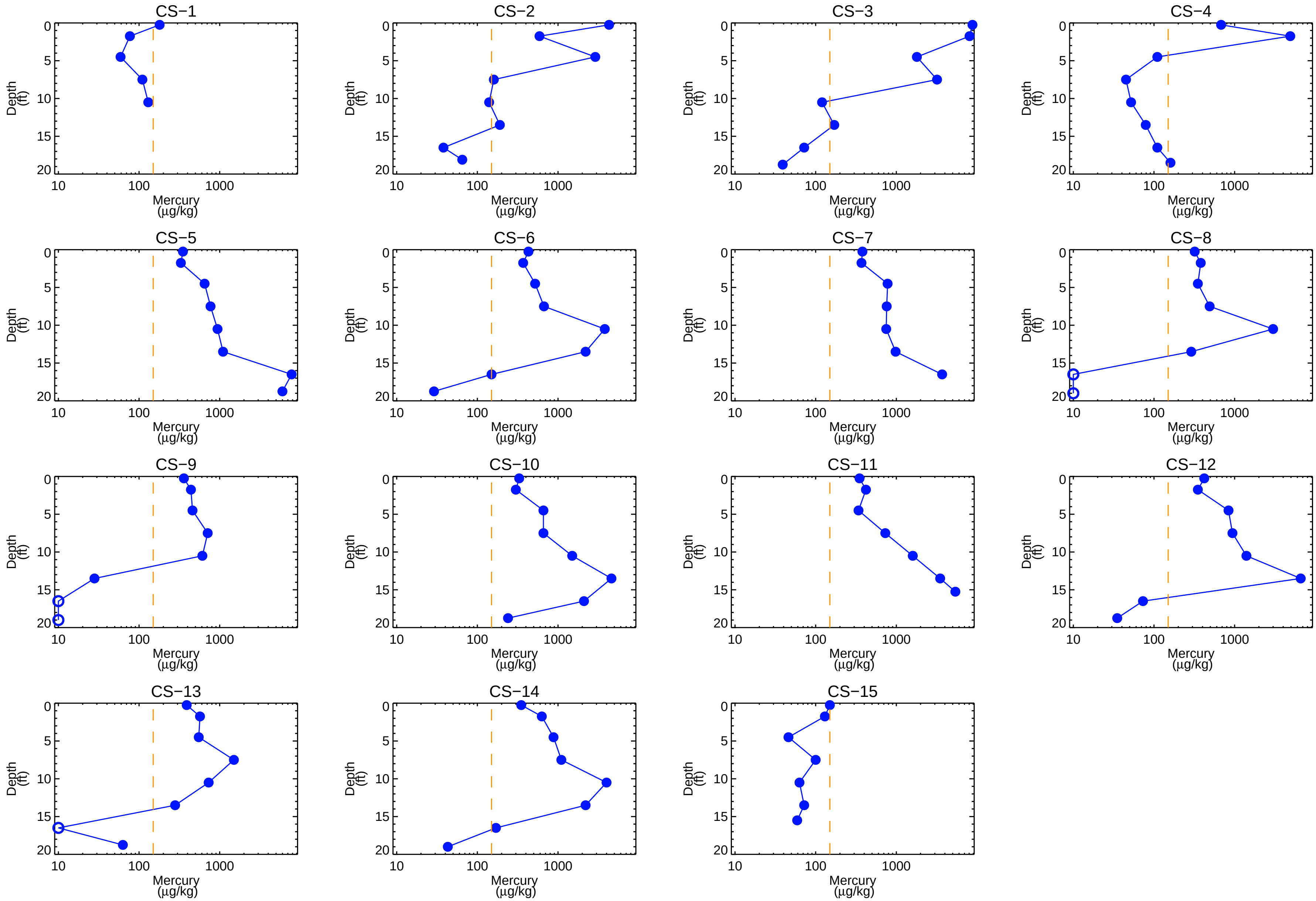


Figure B−2f

Mercury Concentrations in Sediment Cores from Consolidated Slip

Data collected in 2002. Values plotted at mid−depths.
Vertical lines show ERLs (orange), ERMs (red), and TMDL indirect effects sediment targets (purple) where applicable.
Non−detects set to half of reporting limit (method detection limit not available) and shown as open symbols.
Duplicates from original sample results were averaged. Data source: AMEC

ANCHOR QEA

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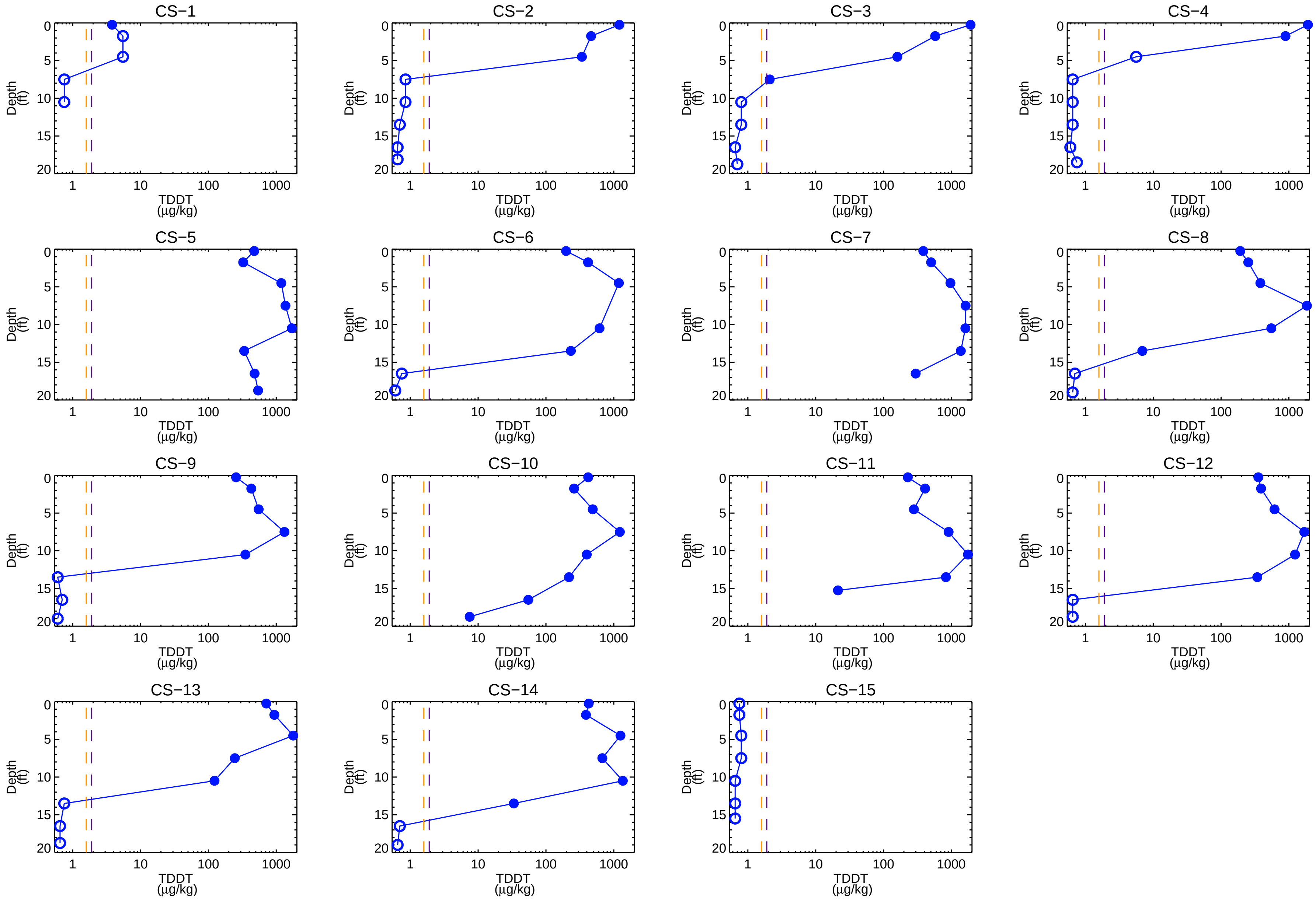

Figure B−2g

TDDT Concentrations in Sediment Cores from Consolidated Slip

Data collected in 2002. Values plotted at mid−depths.
Vertical lines show ERLs (orange), ERMs (red), and TMDL indirect effects sediment targets (purple) where applicable.
Non−detects set to half of reporting limit (method detection limit not available) and shown as open symbols.
Duplicates from original sample results were averaged. Data source: AMEC

ANCHOR QEA

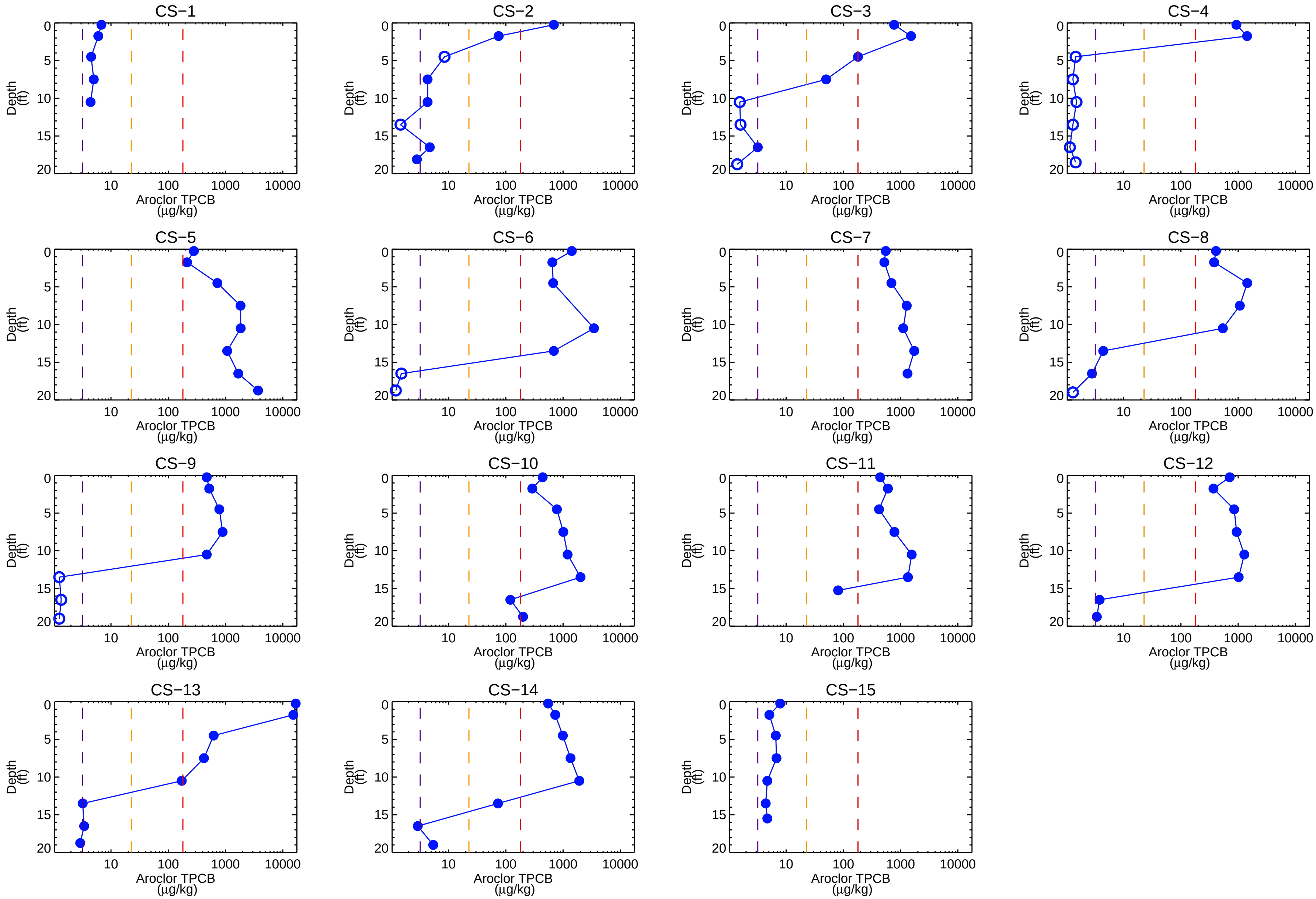

Figure B−2h

TPCB Concentrations in Sediment Cores from Consolidated Slip

Data collected in 2002. Values plotted at mid−depths.
Vertical lines show ERLs (orange), ERMs (red), and TMDL indirect effects sediment targets (purple) where applicable.
Non−detects set to half of reporting limit (method detection limit not available) and shown as open symbols.
Duplicates from original sample results were averaged. Data source: AMEC

ANCHOR QEA

BG − L:\PROJECTS\Ports_LA−LB\Harbor_Toxics_TMDL\Bioaccumulation_Model\IDL_Decks\POLA_LB_Bioacc__plot_dep_profile_Consol_slip.pro Wed Mar 19 16:17:58 2014

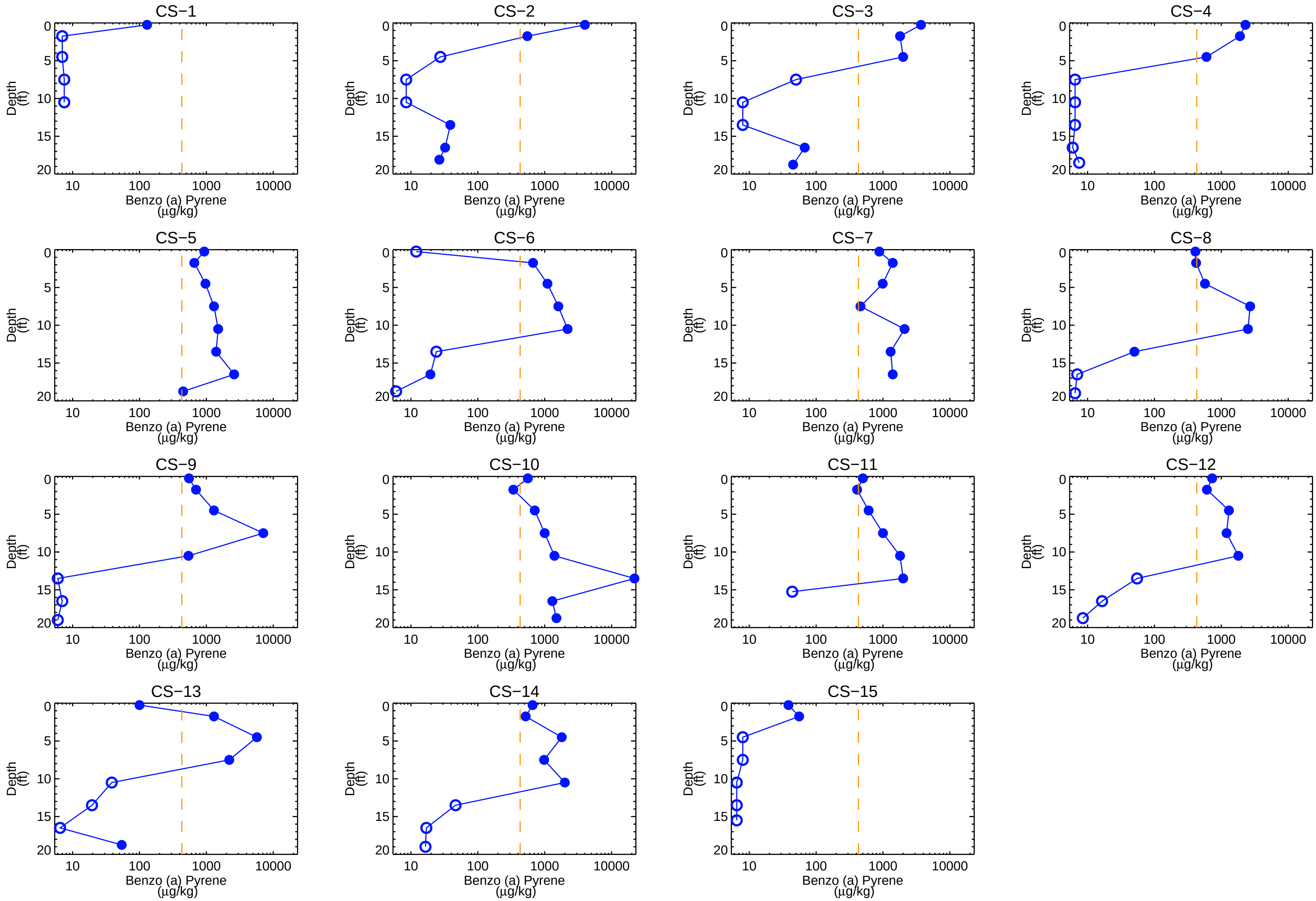

Figure B−2i

Benzo[a]pyrene Concentrations in Sediment Cores from Consolidated Slip

Data collected in 2002. Values plotted at mid−depths.
Vertical lines show ERLs (orange), ERMs (red), and TMDL indirect effects sediment targets (purple) where applicable.
Non−detects set to half of reporting limit (method detection limit not available) and shown as open symbols.
Duplicates from original sample results were averaged. Data source: AMEC

ANCHOR QEA

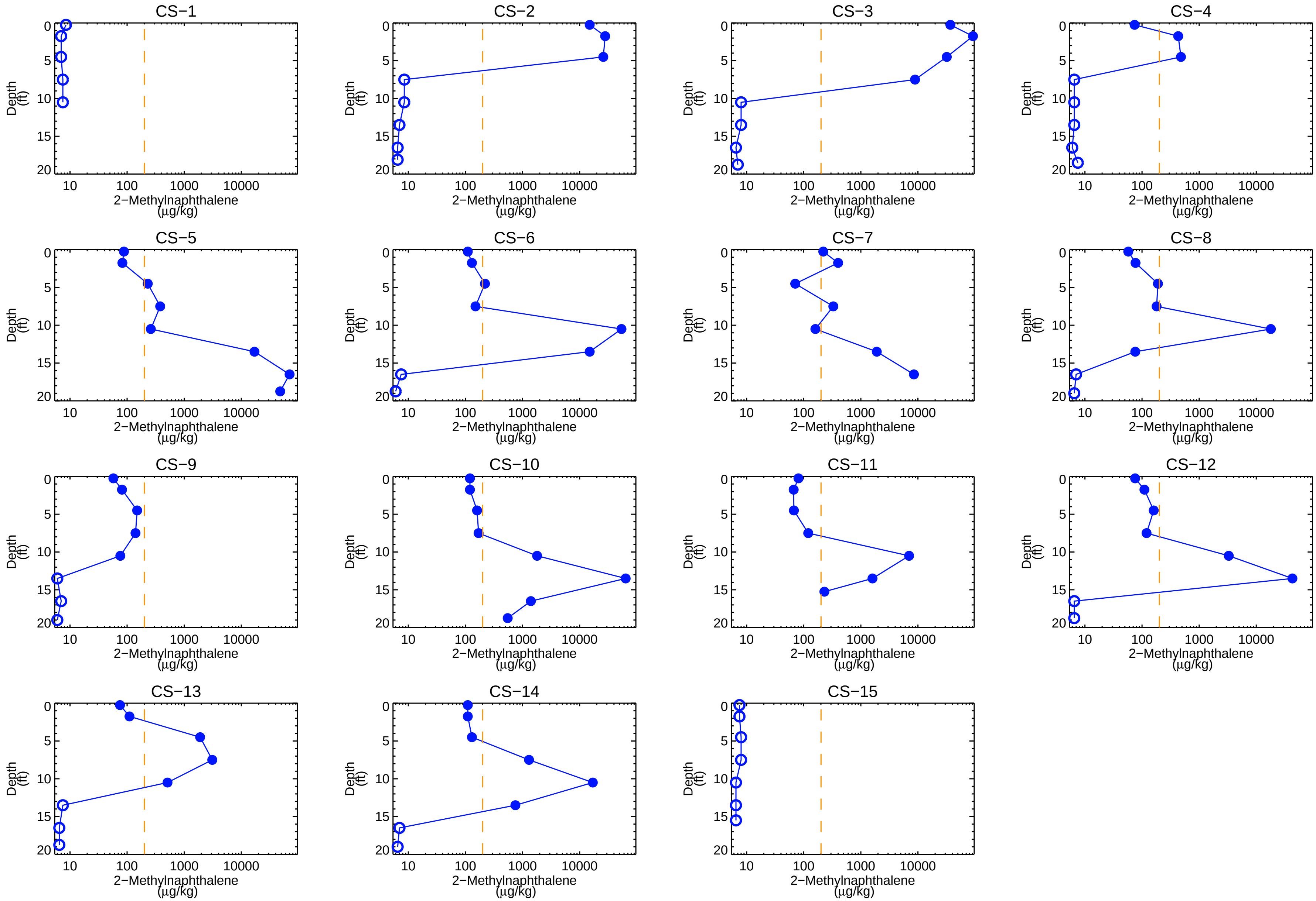

Figure B−2j

2−Methylnaphthalene Concentrations in Sediment Cores from Consolidated Slip

Data collected in 2002. Values plotted at mid−depths.
Vertical lines show ERLs (orange), ERMs (red), and TMDL indirect effects sediment targets (purple) where applicable.
Non−detects set to half of reporting limit (method detection limit not available) and shown as open symbols.
Duplicates from original sample results were averaged. Data source: AMEC

ANCHOR QEA

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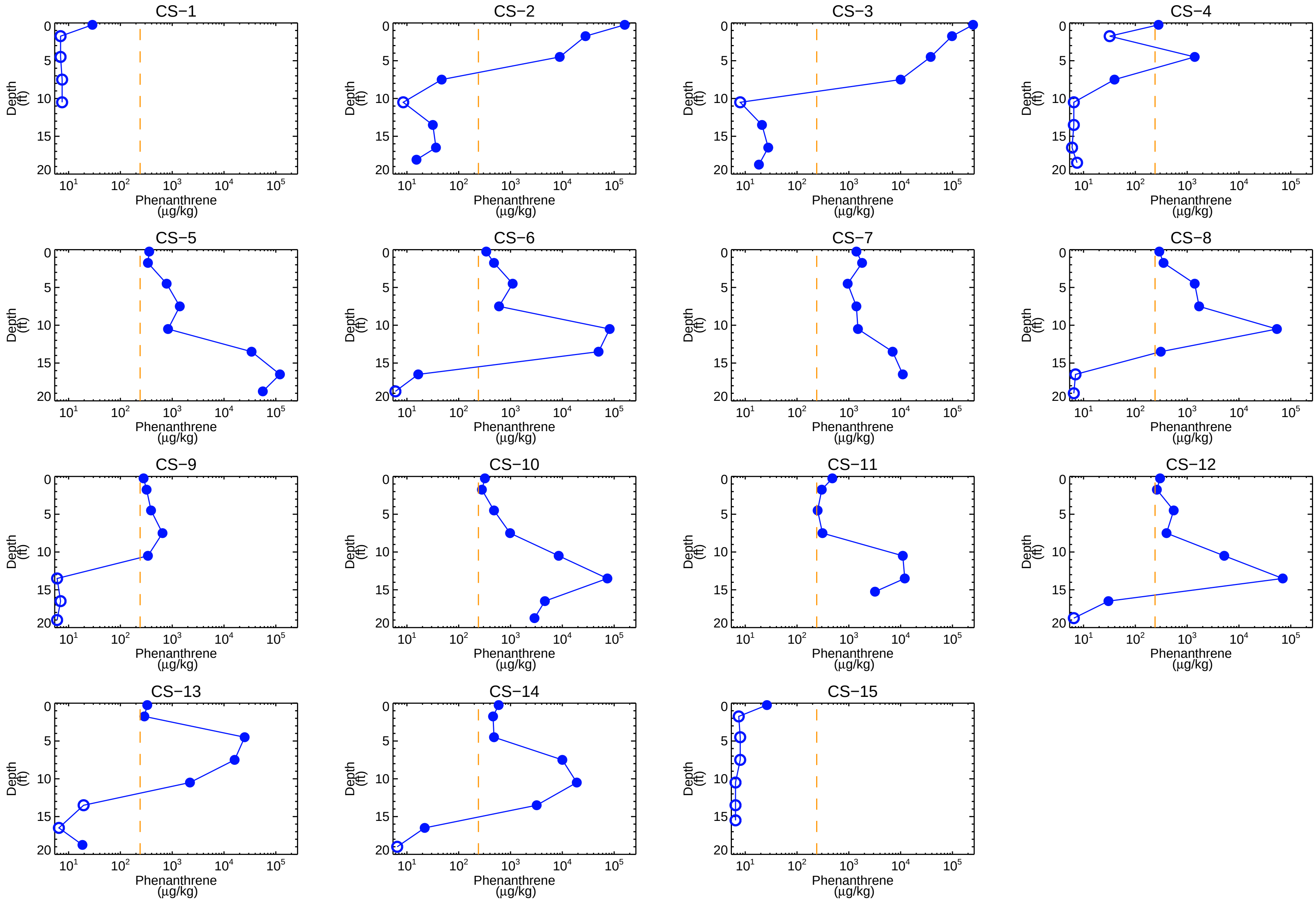

Figure B−2k

Phenanthrene Concentrations in Sediment Cores from Consolidated Slip

Data collected in 2002. Values plotted at mid−depths.
Vertical lines show ERLs (orange), ERMs (red), and TMDL indirect effects sediment targets (purple) where applicable.
Non−detects set to half of reporting limit (method detection limit not available) and shown as open symbols.
Duplicates from original sample results were averaged. Data source: AMEC

ANCHOR QEA

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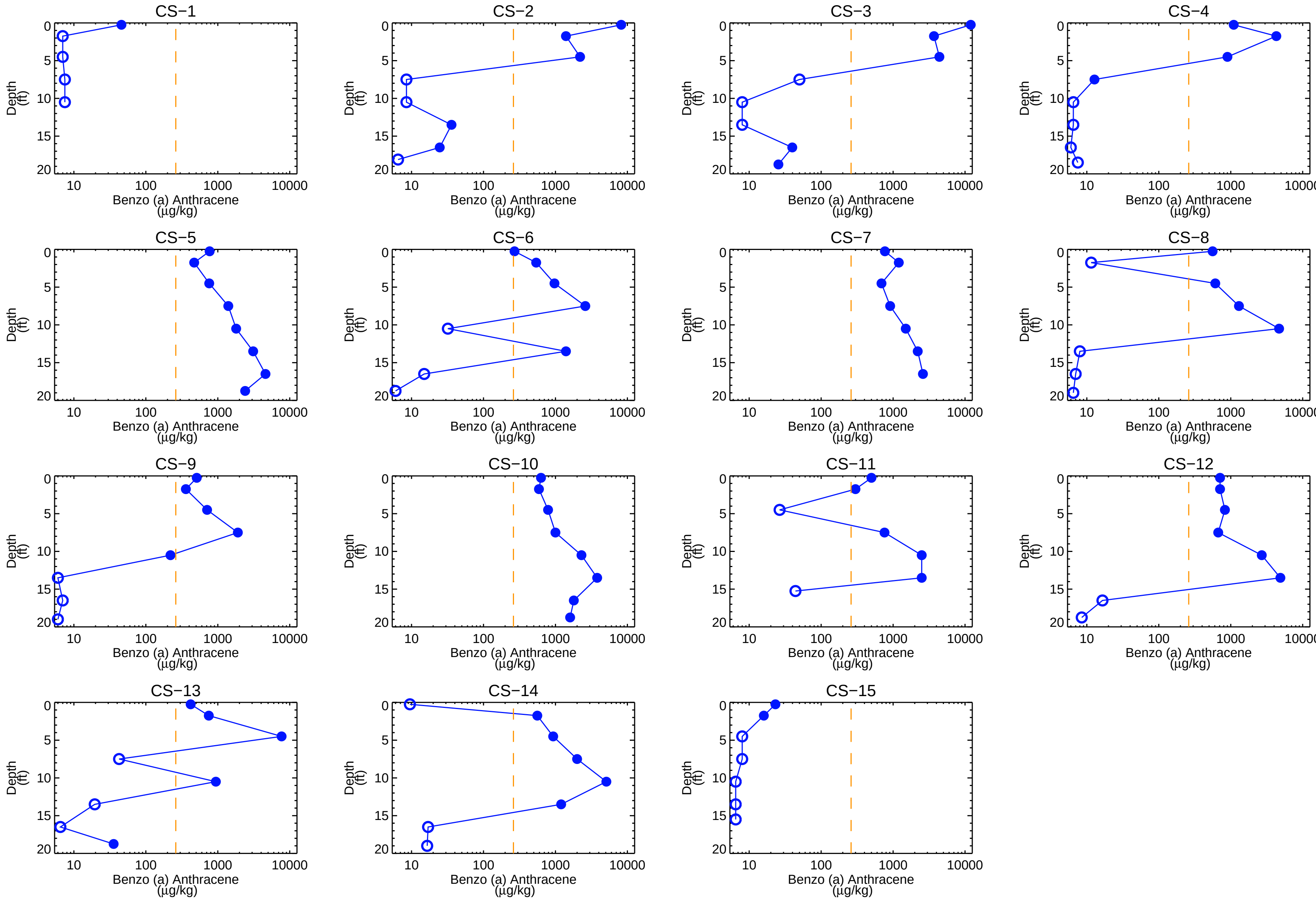


Figure B−2l

Benzo[a]anthracene Concentrations in Sediment Cores from Consolidated Slip

ANCHOR QEA

Data collected in 2002. Values plotted at mid−depths.
Vertical lines show ERLs (orange), ERMs (red), and TMDL indirect effects sediment targets (purple) where applicable.
Non−detects set to half of reporting limit (method detection limit not available) and shown as open symbols.
Duplicates from original sample results were averaged. Data source: AMEC

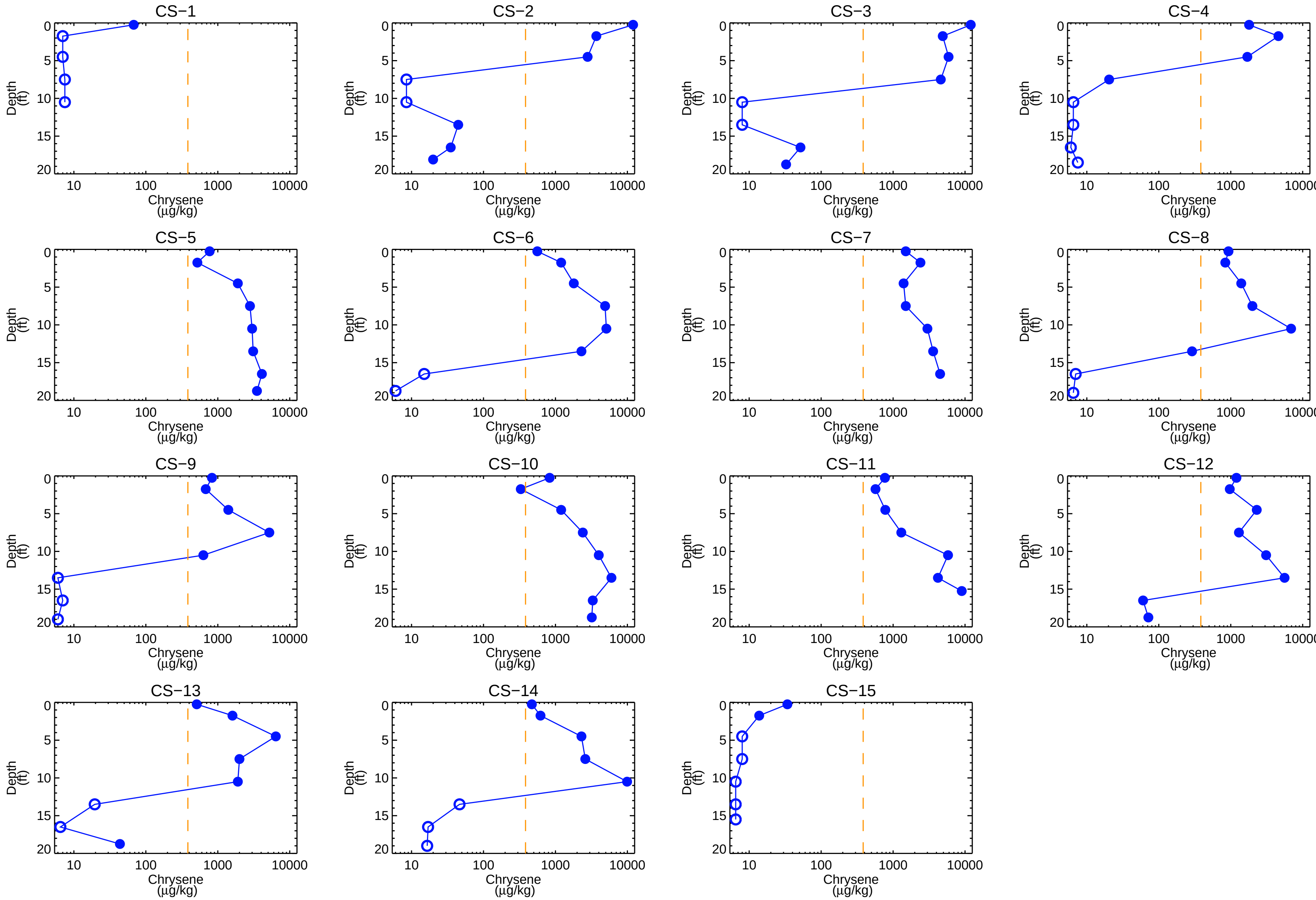


Figure B−2m

Chrysene Concentrations in Sediment Cores from Consolidated Slip

Data collected in 2002. Values plotted at mid−depths.
Vertical lines show ERLs (orange), ERMs (red), and TMDL indirect effects sediment targets (purple) where applicable.
Non−detects set to half of reporting limit (method detection limit not available) and shown as open symbols.
Duplicates from original sample results were averaged. Data source: AMEC

ANCHOR QEA

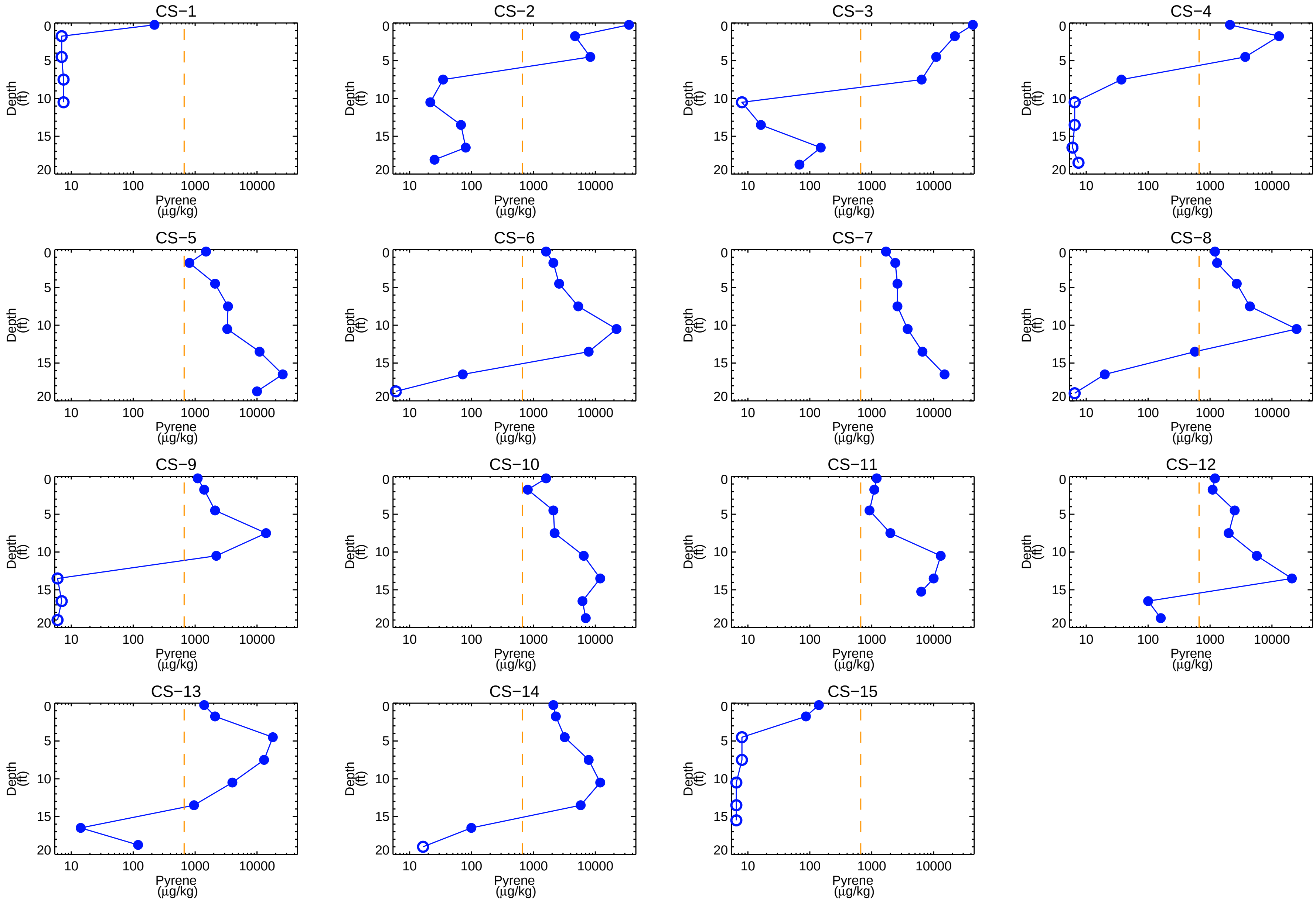


Figure B−2n

Pyrene Concentrations in Sediment Cores from Consolidated Slip

Data collected in 2002. Values plotted at mid−depths.
Vertical lines show ERLs (orange), ERMs (red), and TMDL indirect effects sediment targets (purple) where applicable.
Non−detects set to half of reporting limit (method detection limit not available) and shown as open symbols.
Duplicates from original sample results were averaged. Data source: AMEC

BG − L:\PROJECTS\Ports_LA−LB\Harbor_Toxics_TMDL\Bioaccumulation_Model\IDL_Decks\POLA_LB_Bioacc__plot_dep_profile_Consol_slip.pro Wed Mar 19 16:17:59 2014

APPENDIX C
FISH HARBOR SEDIMENT AND FISH DATA

1 INTRODUCTION

This appendix provides a summary of available sediment and fish chemistry data from Fish Harbor to support development of a Contaminated Sediment Management Plan. Characterizing current and historical contaminant levels in sediment and fish tissue data will aid in the evaluation of management alternatives for long-term compliance with the *Final Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Toxic Pollutants Total Maximum Daily Loads* (Harbor Toxics TMDL; RWQCB and USEPA 2011). Data are summarized and compared to total maximum daily load (TMDL) targets.

For Fish Harbor, contaminants of concern in the Harbor Toxics TMDL include the following:

- Sediment
  - Metals: copper, lead, and zinc
  - Pesticides and polychlorinated biphenyls (PCBs): chlordane, total dichlorodiphenyltrichloroethane (TDDT), and total PCB (TPCB)
  - Polycyclic aromatic hydrocarbons (PAHs): benzo[a]pyrene, phenanthrene, benzo[a]anthracene, chrysene, pyrene, and dibenz[a,h]anthracene
- Fish
  - Pesticides and PCBs: TDDT and TPCB

2 EXISTING DATA REVIEW

Data reviewed herein are primarily from the Ports of Long Beach and Los Angeles' (Ports') sediment and fish databases. Initially assembled in April 2013, the Ports' sediment physical and chemical databases and fish tissue chemistry database are extensive compilations of data collected by a variety of agencies as part of characterization and monitoring studies between 1980 and 2011 (Ports 2013; see Tables 1 and 2 of Ports 2013 for summaries by study and year). They include data from the Los Angeles/Long Beach Harbor, Eastern San Pedro Bay, Dominguez Channel, and nearshore areas along the Southern California Bight. The original data compilation focused on dichlorodiphenyltrichloroethane (DDTs), PCBs, and physical parameters (i.e., grain size). Only data meeting basic data quality requirements were included in the data compilation.

Since April 2013, data from additional sediment studies dating from 1998 to 2001 and 2006 to 2012, as well as data from additional fish studies dating from 1990 to 2012 (collected primarily from the Palos Verde Shelf), were acquired, and added to the sediment and fish data compilations. In addition, contaminants of concern summarized in the Ports' database were expanded to include metals and PAHs. These new data were included in the database following the same data handling and treatment procedures for consistency with the original compilations (Ports 2013). In addition to incorporating new data, sediment and fish compilations were modified with new duplicate and coordinate information. The fish data compilation included further standardization of fish and tissue names. Additional sediment characterization data collected in 2012 to support development of volume estimates for sediment management strategies were reviewed; these data are not in the Ports' database.

Where applicable, sediment chemistry data were compared against the Harbor Toxics TMDL direct effects targets for sediments (based on effects range low [ERL] criteria) and indirect effects targets for sediment and fish tissue (based on fish contaminant goal [FCG] criteria), and, for comparison, the listing criteria for sediment (based on effects range median [ERM] criteria) (Table C-1). A brief summary of subsurface sediment chemistry findings is also included for those studies in which subsurface sediment was collected.

Reports for each study, where available, were reviewed and are summarized in the following subsections.

2.1 Sediment

The Ports' sediment physical and chemical databases contain data from Fish Harbor from several studies (see sampling locations illustrated in Figure C-1):

- Bay Protection and Toxic Cleanup Program (BPTCP) from 1992 (SCCWRP 2012)
- Southern California Bight Regional Monitoring Program from 1998 (Bight '98; SCCWRP 2003) and 2003 (Bight '03; SCCWRP 2007)
- Port of Los Angeles (POLA) Al Larson Boat Shop[1] from 2005 (Weston 2007)
- POLA Water Resource Action Plan (WRAP)[2] from 2008 (Weston 2008)

[1] Only the top horizon of chemistry data (i.e., 0 to 1 foot or 0 to 2 feet) was included in the Ports' database.
[2] Grain size data not available for inclusion in the Ports' database.

- Data Gaps Sediment Characterization (Anchor QEA[3] 2012)

Table C-2 reports data counts of DDTs, PCBs, PAHs, and metals per study for Fish Harbor sediment. The following sections include summaries for each study, based on a review of study reports and evaluations of data.

2.1.1 Regional Programs

Five samples were collected within Fish Harbor as part of regional programs, including the BPTCP (SCCWRP 2012), Bight '98 (SCCWRP 2003), and Bight '03 (SCCWRP 2007). During each program, surface sediment was collected, consisting of the top 2 centimeters (cm). Station locations are presented in Figure C-1.

For the three locations sampled in Fish Harbor, BPTCP monitoring results from 1992 indicated elevated concentrations of metals, DDTs, and PCBs in surface sediment (Table C-3). Concentrations in all copper samples exceeded the ERL value, with two sample concentrations exceeding the ERM value. Two of the three samples exceeded ERL values for lead and zinc; one zinc measurement exceeded the ERM value. All TDDT measurements exceeded ERL and TMDL indirect effects sediment values. Two of the three samples exceeded the ERL and ERM values for TPCB; all exceeded the TMDL indirect effects sediment target. Data were not available for chlordane or PAHs.

For the one location sampled within Fish Harbor, Bight '98 monitoring results indicated that surface sediment was predominantly sand (61 percent) and had elevated concentrations of metals, DDTs, and PCBs (Table C-3). Copper was greater than the ERL value. TDDT concentrations exceeded ERL and TMDL indirect effects sediment values. TPCB levels were greater than the ERL and TMDL indirect effects sediment values. No data were available for chlordane or PAHs.

In addition to sediment chemistry, bioassay testing and benthic macrofauna analysis was performed during the Bight '98 monitoring (SCCWRP 2003). No toxicity was observed to amphipods (98 percent survival relative to the control). Benthic community results indicated

[3] Data shown in Table 5 of Anchor QEA 2012.

reference conditions at this site. Based on these results, this station was categorized as unimpacted (available on Southern California Coastal Research Project's Sediment Quality Objective database).

A special study to evaluate benthic response indices was conducted within the Bight '03 monitoring program. Limited sediment chemistry, toxicity, and benthic analyses were evaluated in a targeted location within Fish Harbor (SCCWRP 2007). Results indicated that surface sediment was predominantly fine-grained materials (89 percent silt and clay) and had elevated concentrations of metals, DDTs, and PAHs. Lead was greater than the ERL value, while copper and zinc were greater than the ERM value (Table C-3). TDDT was greater than the ERL and TMDL indirect effects sediment values. Benzo[a]pyrene, benzo[a]anthracene, and chrysene levels exceeded ERL values. No data were available for chlordane. Moderate toxicity was observed to amphipods (66 percent survival relative to the control). Benthic community results indicated moderate disturbance at this site.

2.1.2 Port of Los Angeles Special Studies

2.1.2.1 Sediment Characterization in the Vicinity of Al Larson Boat Shop

In 2005, Weston Solutions, Inc., conducted a sediment characterization study in the vicinity of Al Larson Boat Shop to delineate the horizontal and vertical distribution of contaminants (Weston 2007). Sediment cores were collected during two separate sampling events. Note that the Ports' database only contains chemistry results for the top horizon of chemistry data (0 to 1 foot or 0 to 2 feet), because this dataset is not used to describe current conditions due to sampling depths exceeding 0.5 foot; data evaluations were based on data within the Ports' database.

In January 2005, sediment cores were collected at 21 stations using a piston core to a target depth of 5 feet below the sediment surface (AL and FS locations in Figure C-1). Cores were segmented into 1-foot intervals and submitted for physical and chemical analyses following a phased approach. Grain size of surface sediment (0- to 1-foot interval) varied between stations. Generally, stations located offshore consisted of predominantly fine-grained materials (silt and clay), while nearshore stations consisted of more coarse-grained materials (sand and gravel). Subsurface sediment (intervals below 1 foot) was primarily coarse-grained materials (sand and gravel) (Weston 2007).

Results of chemical analysis indicated that additional data were needed to delineate the extent of contamination further. In September 2005, additional cores were collected at 10 stations using a vibracore to a target depth of 10 feet below the sediment surface (SV locations[4] in Figure C-1). Cores from seven stations were segmented into 2-foot intervals and submitted for physical and chemical analyses following a phased approach.[5] Grain size of surface sediment (0- to 2-foot interval) was primarily coarse-grained materials (sand and gravel), except for two stations (SV-11 and SV-12; Weston 2007). Subsurface sediment (intervals below 2 feet) was primarily coarse-grained materials (sand and gravel), except for two stations (SV-8 and SV-12 [4 to 6 feet]).

Elevated concentrations of metals, DDTs, PCBs, and PAHs were measured in samples collected in the 0- to 1-foot and 0- to 2-foot intervals (Table C-3). Almost all samples contained copper, lead, and zinc concentrations greater than ERL values, with more than half of the samples exceeding ERM values for copper and zinc. The majority of TDDT and TPCB measurements exceeded ERL, ERM, and TMDL indirect effects sediment values. About a third to half of the samples contained concentrations exceeding ERL values for benzo[a]pyrene, phenanthrene, benzo[a]anthracene, chrysene, and pyrene; one dibenzo[a,h]anthracene measurement exceeded the ERL value. No data were available for chlordane.

Chemistry results for subsurface sediment were described by Weston (2007). Briefly, several metals including arsenic, cadmium, copper, lead, mercury, and zinc were measured at concentrations greater than ERM values at at least one station. Copper exceeded the Total Threshold Limit Concentration (TTLC), or State of California hazardous waste level, in subsurface sediment at three stations (AL4-10[6] and AL4-13), while mercury exceeded the TTLC at two stations. TPCB Aroclors and TDDTs exceeded ERM values at multiple

[4] Note that stations with data from the top 0.5 foot were included in the Ports' sediment chemistry database and are shown in Figure C-1.

[5] Sediment from stations SV-4, SV-5, and SV-6 were not submitted for analysis.

[6] Copper concentrations in two sampling depth intervals exceeded the TTLC.

stations. Tributyltin was measured at elevated concentrations in subsurface sediment at multiple stations (up to 5,460 micrograms per kilogram [µg/kg]; AL4-14); however, no established sediment quality guidelines are available for this compound to provide comparison.

2.1.2.2 Sediment Characterization in Support of Water Resource Action Plan

In 2008, Weston conducted a sediment characterization study to support the sediment quality portion of the WRAP (Weston 2008). Sediment cores were collected at four stations within outer Fish Harbor using a vibracore (Figure C-1). Cores were segmented into a surface layer (0 to 0.5 foot), 0.5 to 2 feet, and subsequent 2-foot intervals. Sediment from the 0 to 0.5 and 4- to 6-foot intervals were analyzed for grain size and chemistry. Surface sediment (0 to 0.5 foot) was primarily fine-grained materials (silt and clay), except for one station (LAWRAP007; 89 percent sand) (Weston 2008). Subsurface sediment (4- to 6-foot interval) was primarily sand, except for one station (LAWRAP010; 58.2 percent fine-grained material) (Weston 2008).

Elevated concentrations of metals, DDTs, PCBs, and PAHs were measured in surface sediment (0 to 0.5 foot; Table C-3). Three out of four samples contained copper and zinc concentrations exceeding ERL values; lead exceeded the ERL value in two of the four samples. All TDDT and the majority of TPCB measurements exceeded ERL and TMDL indirect effects sediment values. Levels of benzo[a]pyrene, benzo[a]anthracene, chrysene, and pyrene exceeded ERL values in at least one sample. No data were available for chlordane.

Chemistry results in subsurface sediment (4- to 6-foot interval) for this study were summarized by Weston (2008). Briefly, subsurface sediment (4- to 6-foot interval) from two stations demonstrated metals concentrations that exceeded ERL values, with mercury greater than the ERM value at one station. TPCB exceeded the ERL value at one station while DDTs exceeded the ERL or ERM values at two of the four stations.

2.1.2.3 Data Gaps Sediment Characterization

In 2012, Anchor QEA, LLC, conducted a sediment characterization study to estimate the volume of material to be managed for compliance with the Harbor Toxics TMDL

(Anchor QEA 2012). Sediment characterization data were used to supplement the existing data summarized above and provide a more accurate estimation of the sediment volume to be managed for each alternative. Sediment cores were collected at 18 stations using a vibracore to a depth of 8 feet below the sediment surface (Figure C-1). Sediment cores were segmented into 2-foot intervals, and sediment from the 4- to 6-foot and 6- to 8-foot intervals were analyzed for metals.

In addition to core samples, surface sediment was collected at nine stations in outer Fish Harbor (Figure C-1). Surface sediment was collected using a ponar grab sampler, and the top 5 cm was analyzed for contaminants.

Surface sediment (top 5 cm) from all stations contained pesticide, PCB, and PAH concentrations that exceeded one or more TMDL targets (Table C-3). TDDT exceeded ERL, ERM, and TMDL indirect effects sediment values in all samples. TPCB in all samples exceeded the TMDL indirect effects sediment target and exceeded the ERL in about half of the samples. Levels of benzo[a]pyrene, benzo[a]anthracene, and chrysene exceeded ERL values in almost all samples.

In outer Fish Harbor, exceedances of metal ERL values in subsurface sediment (4- to 6-foot interval) were substantially lower than those in surface sediment from the same samples (Anchor QEA 2012). Five stations had one or more metals exceeding their respective ERL values. In inner Fish Harbor, four stations had metal concentrations exceeding ERL values in the 4- to 6-foot interval (Anchor QEA 2012).

2.2 Fish

The Ports' fish chemistry database contains data from Fish Harbor from one study conducted by Weston in 2011 (Weston 2012). The mid-point of the trawl line is illustrated in Figure C-2. No other recent fish tissue chemistry data have been found for the Fish Harbor area.

A summary of the results is provided in Table C-4. This table shows the average TPCB and TDDT concentrations for each of the three fish species collected from Fish Harbor as part of the Weston (2012) study: California halibut (*Paralichthys californicus*), white croaker

(*Genyonemus lineatus*), and queenfish (*Seriphus politus*). The percent of samples exceeding TMDL fish tissue targets is also provided.

Average TDDT concentrations varied by species and ranged from 21 µg/kg for California halibut (n=1), which is equivalent to the fish target, to 450 µg/kg for white croaker (n=7), which is more than 20 times the fish target for TDDT. Exceedances of the fish TDDT target ranged from 0 percent for California halibut to 100 percent for white croaker, with 71 percent of TDDT concentrations exceeding the target concentration for queenfish (n=7).

Average TPCB congener concentrations varied by species and ranged from 5.6 µg/kg for California halibut (n=1), or just above the fish target to 651 µg/kg for white croaker (n=7), which is more than 180 times the fish target for TPCB. Exceedances of the fish TPCB target were 71 percent of queenfish (n=7) and 100 percent for both California halibut and white croaker.

3 SUMMARY

Recent investigations within Fish Harbor determined a preliminary spatial (horizontal and vertical) extent of contaminated sediments. These investigations included regional programs (SCCWRP 2003, 2007, 2012), and sediment characterization studies in the vicinity of Al Larson Boat Shop (Weston 2005), in support of the WRAP (Weston 2008), and in support of data gaps analysis (Anchor QEA 2012). These studies identified several contaminants of concern within surface and subsurface sediments, including metals, DDTs, PAHs, and PCBs; concentrations exceeded TMDL targets at many stations. Based on these investigations, almost 1 million cubic yards of sediment as deep as 10 feet below the mudline are at concentrations above the Harbor Toxics TMDL numeric targets. Additional studies are needed to better define the extent of the contaminated sediment and confirm there are no ongoing sources of contamination in the area.

Limited fish data have been collected within Fish Harbor (i.e., one study in 2011). Of the 15 fish collected, almost all contained elevated PCB and DDT concentrations relative to respective TMDL fish targets.

Special studies are ongoing to address specific data gaps as part of site-specific bioaccumulation model. Specific objectives include understanding the fish tissue linkage to sediment contaminant concentrations, fish usage patterns, sediment transport and contaminant fate processes, and potential for recontamination.

4 REFERENCES

Anchor QEA, L.P., 2012. Technical Memorandum to Kathryn Curtis, Port of Los Angeles. Regarding: Sampling and Analysis of Sediments within Fish Harbor at the Port of Los Angeles. September 19, 2012.

Ports (Ports of Long Beach and Los Angeles), 2013. Compilation of Sediment, Fish Tissue, and Mussel Tissue Datasets for the TMDL Support Program. April 2013.

RWQCB and USEPA (Los Angeles Regional Water Quality Control Board and U.S. Environmental Protection Agency), 2011. *Final Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Toxic Pollutants Total Maximum Daily Loads*. May 2011.

SCCWRP, 2003. Southern California Bight 1998 Regional Monitoring Program. Technical Report.

SCCWRP, 2007. Southern California Bight 2003 Regional Monitoring Program. Technical Report.

SCCWRP, 2012. California Sediment Quality Objectives Database. Available from: http://www.sccwrp.org/Data/SearchAndMapData/DataCatalog/CaliforniaSedimentQualityObjectivesDatabase.aspx.

Weston Solutions, Inc., 2007. Chemical and Geotechnical Characterization of Sediments in the Vicinity of Al Larson Boat Shop, Port of Los Angeles. Prepared for the Port of Los Angeles, Environmental Management. April 2007.

Weston, 2008. Draft Report Sediment Characterization in Support of the Water Resources Action Plan, Ports of Los Angeles. September 2008.

Weston, 2012. POLA POLB SQO Part II data from 2011. Excel files. Provided to Anchor QEA on behalf of the Ports of Long Beach and Los Angeles.

TABLES

Table C-1
TMDL Targets for Sediment and Fish

Parameter	Units	Sediment			Fish
		Direct Effects Criteria (ERL) [1]	Indirect Effects Target [2]	Effects Range Median (ERM) [3]	Indirect Effects Criteria (FCG) [2]
Metals					
Cadmium	mg/kg	1.2	---	---	---
Chromium	mg/kg	81	---	370	---
Copper	mg/kg	34	---	270	---
Lead	mg/kg	46.7	---	---	---
Mercury	mg/kg	0.15	---	---	---
Zinc	mg/kg	150	---	410	---
Pesticides and PCBs					
Chlordane	µg/kg	0.5	1.3	6	5.6
Dieldrin	µg/kg	0.02	---	8	0.46
Toxaphene	µg/kg	0.1	0.1	---	6.1
Total PCBs	µg/kg	22.7	3.2	180	3.6
Total DDTs	µg/kg	1.58	1.9	---	21
PAHs					
Benzo[a]anthracene	µg/kg	261	---	---	---
Benzo[a]pyrene	µg/kg	430	---	---	---
Chrysene	µg/kg	384	---	---	---
Pyrene	µg/kg	665	---	---	---
2-Methylnaphthalene	µg/kg	201	---	---	---
Dibenzo[a,h]anthracene	µg/kg	260	---	---	---
Phenanthrene	µg/kg	240	---	---	---
High Molecular Weight PAHs	µg/kg	1700	---	---	---
Low Molecular Weight PAHs	µg/kg	552	---	---	---
Total PAHs	µg/kg	4022	---	---	5.47

Notes:

1 Direct effects criteria are from Table 3-7 of Harbor Toxics TMDL (RWQCB and USEPA 2011).

2 Indirect effects criteria are from Table 3-8 of Harbor Toxics TMDL (RWQCB and USEPA 2011).

3 ERM criteria are from Table 2-4 of Harbor Toxics TMDL (RWQCB and USEPA 2011) for marine and estuarine sediments.

µg/kg = micrograms per kilogram

mg/kg = milligrams per kilogram

DDT = dichlorodiphenyltrichloroethane

ERL = effects range low

FCG = fish contaminant goal

PAH = polycyclic aromatic hydrocarbon

PCB = polychlorinated biphenyl

TMDL = total maximum daily load

Table C-2
Summary of Sediment Data Collected within Fish Harbor

Source	Sample Year	Type	Depth	Number of Samples	Number of Samples Per Analyte				
					DDT	PCB		PAH [2]	Metals [2]
						Aroclor	Congener		
BPTCP	1992	Grab	0-2 cm	3	3	---	3	---	3
SCC_B98	1998	Grab	0-2 cm	1	1	---	1	1	1
SCC_B03	2003	Grab	0-2 cm	1	1	---	1	1	1
POLAALBS-2005	2005	Core	0-1 ft, 0-2 ft	25	25	25	4	25	25
POLAWRAP	2008	Core [3]	0-0.5 ft, 0.5-2 ft, and subsequent 2-ft intervals	4	4	4	4	4	4
Anchor QEA	2012	Grab	0-5 cm	9	9	---	9	9 [4]	9
		Core	0-2 ft and subsequent 2-ft intervals up to 8 ft	36	---	---	---	---	36

Notes:

1 Counts are based on data contained in the Ports' sediment chemistry database.

2 For simplicity, counts reflect those for one PAH or one metal.

3 Sediment from the 0-0.5 ft and 4-6 ft intervals were analyzed for chemistry. The Ports' database includes chemistry for 0-0.5 ft; numbers here reflect counts in the Ports' database.

4 Only eight measurements were available for some individual PAHs.

Anchor QEA = Anchor QEA, LLC

BPTCP = Bay Protection and Toxic Cleanup Program

cm = centimeters

DDT = dichlorodiphenyltrichloroethane

ft = feet

PAH = polycyclic aromatic hydrocarbon

PCB = polychlorinated biphenyl

POLAALBS-2005 = Port of Los Angeles special study in vicinity of Al Larson Boat Shop

POLAWRAP = Port of Los Angeles Water Resource Action Plan

Ports = Ports of Long Beach and Los Angeles

SCC_B98 = Bight Regional Monitoring Program 1998

SCC_B03 = Bight Regional Monitoring Program 2003

Table C-3
Summary of Fish Harbor Sediment Chemistry Results

	Harbor Toxics TMDL Values [1]			1992 BPTCP Grab: 0-2 cm			1998 SCC_98 Grab: 0-2 cm			2003 SCC_B03 Grab: 0-2 cm			2005 POLAALBS Core: 0-1 ft, 0-2 ft			2008 POLAWRAP [4] Core: 0-0.5 ft			2012 Anchor QEA Grab: 0-0.5 cm			2012 Anchor QEA Core: 4-6 ft, 6-8 ft		
					% exceeding			% exceeding			% exceeding			% exceeding			% exceeding			% exceeding			% exceeding	
Parameter	units	ERL	ERM	Samples	ERL	ERM	Samples	ERL	ERM	Samples	ERL	ERM	Samples	ERL	ERM	Samples	ERL	ERM	Samples	ERL	ERM	Samples	ERL	ERM
Metals																								
Copper	mg/kg	34	270	3	100	67	1	100	0	1	100	100	25	100	72	4	75	0	9	100	11	36	25	0
Lead	mg/kg	46.7	---	3	67	---	1	0	---	1	100	---	25	92	---	4	50	---	9	78	---	36	17	---
Zinc	mg/kg	150	410	3	67	33	1	0	0	1	100	100	25	92	56	4	75	0	9	100	11	36	19	0
Pesticides and PCBs																								
Chlordane	µg/kg	0.5	6	0	---	---	0	---	---	0	---	---	0	---	---	0	---	---	9	0 [5]	0	0	---	---
Total PCBs - Aroclor	µg/kg	22.7	180	0	---	---	0	---	---	0	---	---	25	84	64	4	75	0	0	---	---	0	---	---
Total PCBs - congener	µg/kg	22.7	180	3	67	67	1	100	0	1	0	0	4	50	25	4	75	0	9	56	0	0	---	---
Total DDTs	µg/kg	1.58	---	3	100	---	1	100	---	1	100	---	25	96	---	4	100	---	9	100	---	0	---	---
PAHs																								
Benzo[a]anthracene	µg/kg	261	---	0	---	---	1	0	---	1	100	---	25	40	---	4	25	---	8	13	---	0	---	---
Benzo[a]pyrene	µg/kg	430	---	0	---	---	1	0	---	1	100	---	25	36	---	4	50	---	9	11	---	0	---	---
Chrysene	µg/kg	384	---	0	---	---	1	0	---	1	100	---	25	44	---	4	50	---	8	13	---	0	---	---
Pyrene	µg/kg	665	---	0	---	---	1	0	---	1	0	---	25	52	---	4	25	---	9	0	---	0	---	---
Dibenzo[a,h]anthracene	µg/kg	260	---	0	---	---	1	0	---	1	0	---	25	4	---	4	0	---	8	0	---	0	---	---
Phenanthrene	µg/kg	240	---	0	---	---	1	0	---	1	0	---	25	32	---	4	0	---	9	0	---	0	---	---

Notes:

1 Harbor Toxics TMDL direct effects targets for sediments (based on ERL), indirect effects targets for sediment and fish tissue (based on fish contamination goal), and, for comparison, the listing criteria for sediment (based on ERM) are listed in Table C-1.

2 The following parameters have numeric targets in the Harbor Toxics TMDL, but are not listed constituents for Fish Harbor in the Harbor Toxics TMDL and therefore were not evaluated: cadmium, chromium, mercury, dieldrin, toxaphene, 2-methylnaphthalene, high molecular weight PAHs, low molecular weight PAHs, and total PAHs.

3 Exceedances are based on data contained in the Ports of Long Beach and Los Angeles (Ports') sediment chemistry database and Anchor QEA 2012.

4 Sediment from the 0-0.5 ft and 4-6 ft intervals were analyzed for chemistry. The Ports' database includes chemistry for 0-0.5 ft; numbers here reflect counts in the Ports' database.

5 Chlordane from 2012 was calculated as the sum of chlordane-alpha, chlordane-gamma, and trans-Nonachlor. All concentrations were below the method detection limit of 1 µg/kg, which is greater than the ERL.

µg/kg = micrograms per kilogram
Anchor QEA = Anchor QEA, LLC
BPTCP = Bay Protection and Toxic Cleanup Program
cm = centimeters
ERL = effects range low
ERM = effects range median
ft = feet
mg/kg = milligrams per kilogram
PAH = polycyclic aromatic hydrocarbon
PCB = polychlorinated biphenyl
POLAALBS-2005 = Port of Los Angeles special study in vicinity of Al Larson Boat Shop
POLAWRAP = Port of Los Angeles Water Resource Action Plan
SCC_B03 = Bight Regional Monitoring Program 2003
SCC_B98 = Bight Regional Monitoring Program 1998
TMDL = total maximum daily load

Table C-4
Summary of Fish Harbor Fish Tissue Chemistry Results

		California Halibut	Queenfish	White Croaker
Total DDTs (ND = 0)	Number of Samples	1	7	7
	Mean (µg/kg)	21.0	65.6	450
	Standard Deviation	N/A	51.6	482
	% Exceeding Fish Target (21 µg/kg)	0%	71%	100%
Total PCB Congeners (ND = 0)	Number of Samples	1	7	7
	Mean (µg/kg)	5.6	85.2	651
	Standard Deviation	N/A	162	365
	% Exceeding Fish Target (3.6 µg/kg)	100%	71%	100%

Notes:

Fish were collected in 2011.

Units are in wet weight.

Skin-off fillets were analyzed for chemical constituents.

Non-detects were assumed to be zero in the summing of DDT derivatives or PCB congeners.

µg/kg = microgram per kilogram

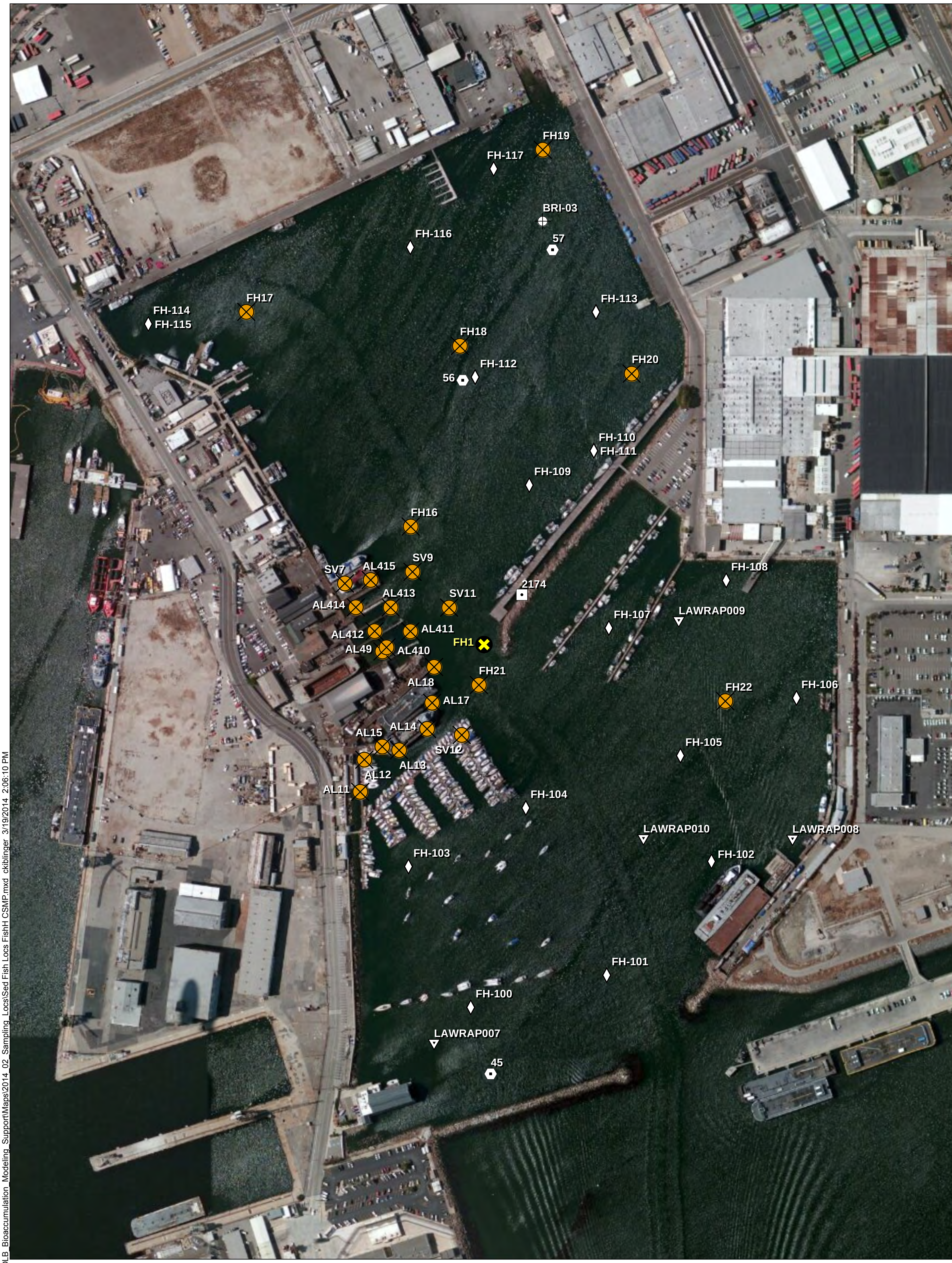
DDT = dichlorodiphenyltrichloroethane

N/A = not applicable

ND = non-detect

PCB = polychlorinated biphenyl

FIGURE



Q:\Jobs\120711-01.01_Port_of_Los_Angeles\POLA_POLB_Bioaccumulation_Modeling_Support\Maps\2014_02_Sampling_Locs\Sed Fish Locs FishH CSMP.mxd ckiblinger 3/19/2014 2:06:10 PM

LEGEND

Surface Sediment (top 0.5 ft or less)
- BPTCP 1992
- Bight '98
- Bight '03
- POLA WRAP 2008
- Anchor QEA 2012

Subsurface Sediment (> 0.5 ft)
- POLA ALBS 2005

Fish Sampling Location - 2011

NOTES:
1. Locations are shown for samples analyzed for chemistry.
2. Surface sediment data were defined as data collected within the top 0.5 ft or less. Subsurface sediment data were defined as data collected below the top 0.5 ft, including samples with intervals starting at the surface and extending beyond 0.5 ft.

Feet
0 150 300

ANCHOR QEA

Figure C-1
Fish Harbor Sediment and Fish Sampling Locations
Los Angeles Harbor