APPENDIX A

Dredging Requirements and Contaminated Sediment Management

"The following technical report reflects the findings and data available at the time the report was prepared and may not represent the current conclusions and steps forward in the main text of the HAMP, which has been updated after the completion of these reports. These more detailed technical reports provided in the appendices represent the foundation for the overall approach to the HAMP, but are not "living" documents that reflect updated steps forward, costing, quantities, etc. presented in the main text of the HAMP. The main text of the HAMP represents more current information and recommendations based on updated information, new studies, changes in conditions, new funding sources, and/or new regulations."

HARBOR AREA MANAGEMENT PLAN

DREDGING REQUIREMENTS & CONTAMINATED SEDIMENT MANAGEMENT

Technical Report

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ACRONYMS AND ABBREVIATIONS

BMP	Best Management Practice
CAD	confined aquatic disposal
CDF	confined disposal facility
City	City of Newport Beach
DDT	dichlorodiphenyltrichloroethane
EC_{50}	median effect concentration
ER-L	effect range-low
ER-M	effect range-median
FDA	U.S. Food and Drug Administration
FEMA	Federal Emergency Management Agency
ITM	Inland Testing Manual
LPC	limiting permissible concentration
MEC	MEC Analytical Systems, Inc.
MLLW	Mean Lower Low Water
MNR	monitored natural recovery
MPRSA	Marine Protection, Research, and Sanctuaries Act Title I
NAS	National Academy of Sciences
NSI	National Sediment Inventory
OTM	Ocean Testing Manual
O&M	operation and maintenance
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyls
pH	hydrogen ion concentration
RGP	Regional General Permit
SCCWRP	Southern California Coastal Water Research Project
SP	solid phase
SPP	suspended particulate phase
STFATE	short term fate
TBT	tributyltin
TIE	toxicity identification evaluation
TMDL	Total Maximum Daily Load
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
Weston	Weston Solutions Inc.

UNITS OF MEASURE

cm	centimeter
cy	cubic yards
^{o}C	centigrade
ft	feet or foot
°F	Fahrenheit
km	kilometer
M	million
mi	miles
mg/kg	milligram per kilogram
µg/kg	microgram per kilogram
%	percent

1.0 DREDGING REQUIREMENTS AND SEDIMENT MANAGEMENT

1.1 Introduction

In recent years, sedimentation in Lower Newport Bay has resulted in the narrowing and shoaling of the Federal Channels and adjacent non-federal channels that act as the main passageway for marina and harbor traffic. Therefore, there is a need for a plan to maintain the channels and berthing areas necessary for navigation of Lower Newport Bay in an economically and environmentally sound manner. Sediment catch basins constructed in Upper Newport Bay were somewhat effective in helping to reduce sedimentation; however, the Lower Bay has remained subject to heavy amounts of silt and sedimentation via tidal activity and storm events. The United States Army Corps of Engineers (USACE) and City of Newport Beach (City) plan to re-establish sufficient water depths along the Federal Channels and to improve navigation for the large quantity of sea-going vessels entering and leaving Newport Bay. Since 1929, there has been a long history of dredging within Newport Bay. This has served a dual purpose by addressing critical dredging needs such as improving navigation for sea-going vessels, and also by considering beneficial use alternatives.

1.2 Benefits of Dredging

By dredging the Lower Bay, the USACE and City hope to re-establish adequate water depths along the Federal Channels and to improve navigation for the high volume of sea-going vessels entering and leaving Newport Bay. The dredging of contaminated sediments may have a long-term positive effect on the environment due to the ongoing source of contaminants released to the environment if left in place.

1.2.1 Support of City of Newport Beach Harbor and Bay Element Goals

There has been a long history of dredging within Newport Bay, beginning in 1929. Dredging has served an important role in shaping this small boat harbor, while also enhancing beneficial uses of the bay through direct and indirect causes. For example, dredging directly improves safe access for vessels, while also indirectly reducing contamination within the bay through the removal of pollutants within sediments, potentially benefiting recreational activities, as well as the bay's flora and fauna. Furthermore, dredging activities are responsible for the maintenance and restoration of tidally-dependent ecosystems, and dredged materials have been used for beach replenishment. Thus, dredging and the use of dredged materials provide benefits to the environment, the local community, and society.

The City of Newport Beach has defined 13 goals in the Harbor and Bay Element that pertain to harbor issues (2001). These goals are intended to guide the regulation of development and use of its harbor, waterfronts, and bays. In accordance, direct and indirect effects of proposed dredging activities and management of contaminated sediment are analyzed in the context of enhancement of the City's Harbor and Bay Element goals, which are enumerated in the table below (Table 1).

Table 1. Contribution of Dredging and Management of Contaminated Sediment to the Harbor and Bay Element Goals

Harbor and Bay Element Goals	Dredging Effects[1]	Sediment Management Effects[1]
HB-1 Preservation of the diverse uses of the Harbor and waterfront that contribute to the charm and character of Newport Bay, and that provide needed support for recreational boaters, visitors, and residents.	○	○
HB-2 Retention of water-dependent and water-related uses and recreational activities as primary uses of properties fronting on the Harbor.	○	○
HB-3 Enhanced and updated waterfront commercial areas.		
HB-4 Preservation of existing commercial uses in the Harbor to maintain and enhance the charm and character of the Harbor and to provide support services for visitors, recreational boaters, and other water-dependent uses.	○	
HB-5 A variety of vessel berthing and storage opportunities.	○	
HB-6 Provision and maintenance of public access for recreational purposes to the City's coastal resources.		
HB-7 Protection and management of Upper Newport Bay commensurate with the standards applicable to our nation's most valuable natural resources.	○	●
HB-8 Enhancement and protection of water quality of all natural water bodies, including coastal waters, creeks, bays, harbors, and wetlands.	○	○
HB-9 A variety of beach/bulkhead profiles that characterize its recreational, residential, and commercial waterfronts.		
HB-10 Coordination between the City, county, state, and federal agencies having regulatory authority in the Harbor and Bay.		
HB-11 Adequate harbor access for coastal-dependent harbor maintenance equipment and facilities.	●	
HB-12 Balance between harbor revenues and expenses.		
HB-13 Maintain and enhance deep water channels and ensure they remain navigable by boats.	●	

[1] Open circles (○) indicate indirect effects.
Closed circles (●) indicate direct effects.

Through the maintenance and improvement of channels and proper depths of marinas, dredging and the use of dredge materials have the potential to contribute to the preservation of the diverse uses of the Harbor and the waterfront by enhancing support for local boaters (HB-1), retention of water-dependent and water-related uses (HB-2), preservation of the existing commercial uses in the harbor (HB-4), increase in the variety of vessel berthing opportunities (HB-5), maintenance and enhancement of harbor access for harbor maintenance equipment(HB-11), and maintenance and enhancement of deep water channels to ensure navigability by boats (HB-13). Dredging of sediment traps is an essential component of the management of Upper Newport Bay (HB-7),

since high levels of sedimentation threaten to reduce intertidal mudflat and estuarine habitats due to reduced tidal flows as upland habitats become more prevalent. Therefore, certain types dredging can be seen as beneficial to the bay's native biota. However, given the prevalence of eel grass beds within the harbor, dredging activities can result in the disturbance of this protected habitat through direct removal. Lastly, although dredging can temporarily adversely impact water quality due to the resuspension of sediments during operations, the dredging of contaminated sediments may have a long-term positive effect on water quality due to the removal of contaminants that could otherwise be continually released into the water column if left in place (HB-8). Therefore, environmental, economic, and social benefits can be derived from the productive use of dredging and dredged material within Newport Bay and adjacent beaches, and in so doing contribute to the City's Harbor and Bay Element goals.

Effective management of contaminated sediments within the bay will also have several environmental, social, and economic impacts. Some of these impacts contribute to the City's Harbor and Bay Element goals. Management of contaminated sediment has the potential to directly contribute to the protection and management of Upper Newport Bay (HB-7). Upper Newport Bay is a State Ecological Reserve and one of the last large undeveloped wetlands in southern California. It is home to a variety of threatened species. Removal and treatment of contaminated sediments can enhance the floral and faunal communities of the bay, benefiting not only those organisms that inhabit the sediments, but also fishes and invertebrates that feed on the benthic infauna, crustaceans, worms, and mollusks. In addition, sediment management activities can indirectly contribute to the preservation of the diverse uses of the harbor (HB-1), the retention of water-dependent dependent uses of the bay (HB-2), and the enhancement and protection of water quality (HB-8). Lower Newport Bay is a major recreational destination for tourists and locals. By reducing sediment contamination, the overall environmental conditions of the bay are improved, such as water quality, which has the potential to increase the level of recreational uses within the bay, such as swimming, fishing, and sailing. Furthermore, treatment and/or removal of contaminated sediments from the bay have the potential to improve long-term water quality, although such activities would likely have short-term adverse effects on localized water quality. Lastly, sediment treatment may also provide a source of sufficiently clean sand that can be used in beach replenishment and habitat enhancement activities. Therefore, environmental, economic, and social benefits can be derived from the effective treatment of contaminated sediments in conjunction with the productive use of materials within Newport Bay and adjacent beaches, thereby, contributing to the City's Harbor and Bay Element goals.

1.3 Overview of Dredging Requirements

1.3.1 Current Dredging Needs

The volume of material to be dredged in Lower Newport Harbor, based on harbor design depth (-20 ft mean lower low water [MLLW] inside federal channels and -10 ft MLLW outside of federal channels) and projected bathymetry, is approximately 425,000 cy inside federal channels and 300,000 cy outside federal channels, with an estimated 175,000 cy for over dredge volume. Total estimated volume of material required for management is 905,000 cy (Table 2).

Table 2. Current Dredging Needs Inside and Outside Federal Channels

Volume of Dredged Material (cy)			
Inside Federal Channel	Outside Federal Channel	Over dredge	Grand Total
425,000	300,000	175,000	900,000

1.3.2 Future Dredging Needs

Based on models developed by the USACE in the late 1990's and historic depositional records, approximately 1 to 1.5 M cy of sediment will be transported to Lower Newport Bay in a 15 year cycle. However, these models do not account for hydrological changes that will be implemented with the most recent designs for the Upper Newport Bay Restoration Project. In addition, these models do not access the impact of current dredging operations in Upper Newport Bay, which remove only the coarse grain size fraction. This model doesn't account for volumes by grain size fractions; therefore, sedimentation patterns cannot be predicted and are confounded by the current dredging operations in Upper Newport Bay. A model that incorporates grain size fraction information is needed. Additional data would need to be established to determine sedimentation rates and future dredging needs.

The City has a Regional General Permit (RGP), which is a 5 year renewable permit that allows property owners to apply to the City for permission to dredge within their dock area. This permit allows for up to 20,000 cy of sediment to be dredged each year. In the past 30 years, about 357,000 cy of sediment was dredged under the RGP. About 170,000 cy was disposed of at LA-3, and about 187,000 cy was used for beach replenishment.

Based on recent bathymetry, the removal of approximately 725,000 cy (without over dredge) is required to reduce harbor depths to design depths (Figure 1). Based on historic dredging efforts over the last 30 years, approximately 360,000 cy were dredged under the RGP and 289,000 cy were dredged by the USACE in the federal channels. Assuming sedimentation rates stay the same or diminish, an additional 650,000 cy will need to be dredged over the next 30 years to maintain harbor depths.

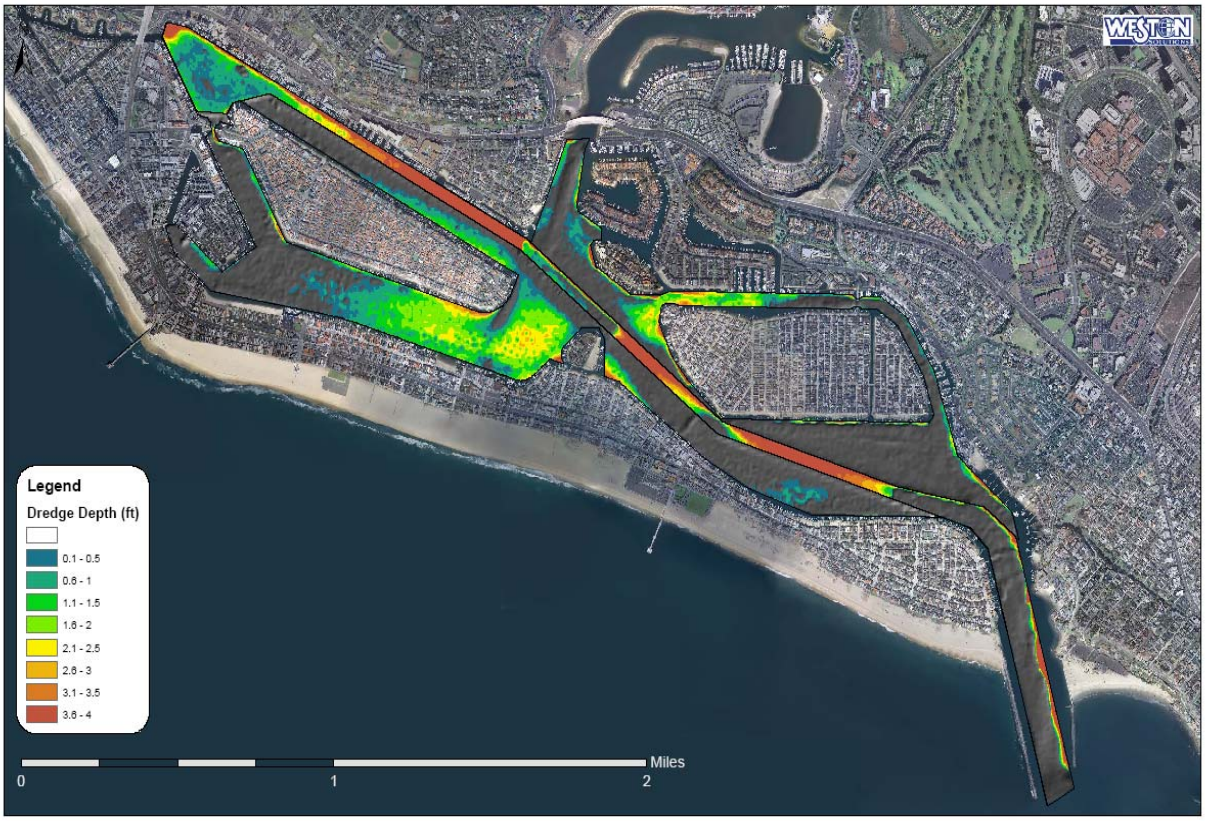

Figure 1. Dredging Needs in Lower Newport Bay

The ability of USACE to dredge the federal channels has been limited by federal funding. Current efforts are underway to seek funding for a "final federal dredge program" that will bring all federal channels to design depths. To incentivize the USACE, the City would agree to release the USACE of all future dredging and maintenance of waterways responsibilities. The advantages and disadvantages of releasing the USACE of their federal responsibilities are provided in Table 3.

Table 3. Advantages and Disadvantages of Releasing USACE from its Federal Responsibilities

Advantages of removing USACE responsibilities in Lower Newport Bay	Disadvantages of removing USACE responsibilities in Lower Newport Bay
• Once dredged, it is believed that the proposed sediment management plans will be designed to intercept 20 years of sediment from watershed, therefore, reducing dredging needs in the future. • The Harbor would still qualify for Federal Emergency Management Agency (FEMA) funding for natural disasters such as major El Nino storms resulting in emergency declarations and possible. • Federal funding for maintenance of recreational harbors will continue to be difficult to obtain • Federal harbor lines could be eliminated.	• Future dredging will not be a Upper Bay project, when completed would protect Lower Bay from significant impacts. • Loss of federal maintenance would most likely include loss of maintenance funds for breakwater • The City will need to develop a plan to fund future dredging projects.

1.4 Options for the Management of Sediment

1.4.1 Sustainable Sediment Management Alternatives

Dredging requires processing and handling of sediments, which are typically removed from a system and placed in confined disposal facilities (CDF) or in nearshore ocean disposal sites. Often this is done without considering alternative beneficial uses of the sediment. For some dredging projects, disposal issues can be problematic resulting in postponements or even cancellation of dredging at harbors. However, sediments which do not exceed predetermined criteria may be a viable source for beneficial use projects where some type of soil or fill is needed.

Beneficial use includes a wide variety of options that utilize dredged material for a productive purpose. Beneficial uses of dredged material may make traditional placement of dredged material unnecessary or at least reduce the level of disposal. The broad categories of beneficial uses, based on the functional use of the dredged material or site, defined by the USACE (1987) are as follows:

- Beach nourishment;
- Shoreline stabilization;
- Landfill cover for solid waste management;
- Material transfer (fill, dikes, roads, etc.);

Below is a discussion of the beneficial uses of dredged material that are most relevant to sediment from Newport Bay.

1.4.1.1 Beach Nourishment

Beach nourishment refers to the strategic placement of large quantities of beach quality sand on an existing beach to provide a source of nourishment for littoral movement or restoration of a recreational beach (Figure 2). Generally, beach nourishment projects are carried out along a beach where a moderate and persistent erosional trend exists. Sediment with physical characteristics similar to the native beach material used is mechanically or hydraulically placed. Please refer to the Beach Replenishment Appendix for further discussion on beach nourishment within Newport Bay; including key issues, development of a beach replenishment program, and recommendations.

Source: Carteret Count Shore Protection Office 2005.

Figure 2. Beach Nourishment Using Dredged Material from Inlet Realignment Project, Emerald Isle, NC

1.4.1.2 Shoreline Stabilization

Beneficial use of dredged material for shoreline stabilization includes the creation of berms or embankments at an orientation to the shoreline that will either modify the local wave climate in order to improve shoreline stability, or alter the wave direction to modify the rate or direction of local sediment transport. Berms may be constructed of a wide variety of dredged material, including rock or coarse gravel, sands, and clays (Figure 3). Stabilization and enhancement of eroding shorelines with dredged materials may also help reduce the volume and frequency of future maintenance dredging. Shoreline stabilization has the potential to improve recreational opportunities for surfing, swimming, sailing, and other activities.

Source: Miratech 2005

Figure 3. Dredging Material Hydraulically Placed in Geotubes for Shoreline Protection in Atlantic City, NJ

1.4.1.3 Landfill Cover

Dewatered dredged material may be used beneficially at landfills as daily or final cover, and as capping material for abandoned contaminated industrial sites known as "brownfields." Solid waste landfills require a minimum of 6 inches cover daily to prevent unsightly appearance, pest control, odor control, and prevent surface water infiltration. In addition, the closure of a landfill or brownfield requires a cap of clean material to isolate the solid waste from the surrounding environment. Dredged material typically possesses important cover material characteristics such as workability, moderate cohesion, and low permeability. Landfill cover is a viable beneficial use for consolidated clay, and silt/clay. Final cover and capping is applicable for virtually all sediment types, although amendments to the material may be required to achieve the required physical properties for the intended end use. In order for dredged material to be economically feasible for daily cover, the landfill should be located less than 50 mi (80 km) from the dredged material supply.

1.4.1.4 Material Transfer

The use of dewatered dredged material as construction fill for roads, construction projects dikes, levees, or CDF expansion is a practical beneficial use for sands/gravel, consolidated clay, and silt/ clay, although fine-grained dredged material may require amendment to provide the physical properties required for light load engineering uses. Material may be used as backfill to build or refurbish / reinforce existing bulkheads to accommodate possible sea level rise. These processes have been used in Holland to produce construction materials suitable for reinforcement of dykes and docks, sealant materials for CDF construction, noise barriers, and road embankments (Rijkswaterstaat, 2004). The applicability of dredged material to a particular construction project depends on the physical and engineering properties of the material and the specific requirements of the project. However, if the material has poor foundation qualities, a suitable additive such as cement may be added to increase shear strength and bearing capacity. The type, combination,

and amount of amendment material depends on the moisture content, the amount of fines (clays and silts), and organic content of the dredged material. Such amendments can also be used to stabilize contaminants, making this a potential use for contaminated dredged material.

Industrial and commercial development near waterways can be aided by the availability of fill material from nearby dredging activities. The direct placement of hydraulically placed fill requires specific engineering, environmental, and feasibility considerations, and is only viable if project sites are located within a few miles of dredging areas. Additionally, dewatered dredged material can also be used as construction fill to build port facilities, which may be a viable beneficial use alternative because dredged material is typically in surplus from routine maintenance dredging near proposed sites for port facilities.

1.4.2 Management of Materials Meeting Ocean Disposal Suitability Requirements

1.4.2.1 Ocean Disposal

Suitability of dredged material for ocean disposal is based on the Marine Protection, Research, and Sanctuaries Act Title I (MPRSA) Tier III analysis as described in the Ocean Testing Manual (OTM; United States Environmental Protection Agency [USEPA]/USACE, 1991) and the Inland Testing Manual (ITM; USEPA/USACE, 1998). Tier III analysis includes sediment chemistry, solid phase toxicity tests, suspended particulate phase toxicity tests, and bioaccumulation tests. If found suitable for ocean disposal; dredged material from Newport Bay will be placed in the USEPA designated LA-2 or LA-3 disposal sites. LA-2 is located within Los Angeles County, approximately six nautical miles from the entrance of Los Angeles Harbor (USACE, 2002). LA-3 is located within Orange County, approximately 4.5 nautical miles from the entrance of Newport Harbor (USEPA/USACE, 2005).

Dredged material is placed in open-water by means of a release from a hopper dredge or barge. The discharged material settles through the water column and deposits on the bottom of the placement site. The physical behavior of open-water placement, and thus its potential environmental impact, depends on the type of dredging and discharge operation used, physical characteristics of the material, and the hydrodynamics of the placement site. Several specialized practices have been developed to minimize environmental effects of open-water placement and include submerged discharge, lateral containment, thin-layer placement, capping and modifications of time, location, and volume (USEPA, 1992). Open-water placement has the potential for the management of large volumes of dredged material.

The cost associated with open-water placement is a function of the type of dredging equipment, the capacity of the dredge, the nature of the material, and the distance to the placement site.

1.4.2.2 Beach Nourishment

Please refer to section 1.4.1.1 for a detailed description of this management alternative.

1.4.3 Management of Materials Not Suitable for Ocean Disposal

The long history of commercial and recreational boating uses, as well as the urbanization of the watershed, has contributed to sediment toxicity and chemical contamination of Newport Bay. Contaminant chemicals and metals have accumulated within the bay's sediments, reaching levels

that exceed sediment quality standards in specific portions of the bay, such as the Rhine Channel (Bay and Brown, 2003). As a consequence, sediment management and treatment strategies are necessary to control and remediate sediment contamination in order to comply with state regulations and enhance the environmental conditions within the bay. In doing so, sediment management has the potential to contribute to the goals set forth in the Newport Beach Harbor and Bay Element (2001).

1.4.3.1 Confined Disposal Facility

A CDF is an engineered structure bound by confinement dikes for containment of dredged material. CDFs serve as a dewatering facility and can be used as a processing, rehandling and/or treatment area for beneficial use of dredged material. Dredged material may be placed temporarily or permanently in the CDF.

CDFs may be used for coarse and fine-grained material. The material is placed into the CDF either hydraulically or mechanically. Placing the material directly into the CDF from the dredging site through pipelines is the most economical method. The dredged material consists of a certain percentage of slurry when it is pumped into the facility. Depending on the placement method, slurry material initially deposited in the CDF may occupy from 1.2 times (mechanical placement) to 5 – 10 times (hydraulic placement) its original volume due to water content. Design of the CDF must account for this additional volume during the drying phase. Following placement, the finer sediments are allowed to consolidate, settle, and dewater. Water evaporates or percolates through the dike walls or into the ground. CDFs that use weirs to enable surface water to exit the facility must be designed with sufficient retention times to ensure adequate sediment settling will occur.

Dredged material placement within a CDF has several benefits. CDFs can prevent or substantially reduce the amount of dredged material re-entering the environment when properly designed, operated, and maintained. CDFs can provide either a temporary or permanent storage location for dredged material that will naturally vegetate if left undisturbed. Finally, CDFs can be used as processing and/or blending areas for beneficial use activities.

The size, design, and cost of a CDF are site-specific. Factors considered in the design of a CDF include: the location, physical nature of sediments to be placed (e.g., grain size, organic content, etc.), physical nature of project footprint, chemical nature of sediments (contaminated vs. clean), volume of sediments to be stored, placement method, and the length of time material will be stored at the facility. Depending on the design, operation and maintenance (O&M) costs of the CDF will vary.

1.4.3.2 Confined Aquatic Disposal

Confined aquatic disposal (CAD) is a process where dredged material is disposed at the bottom of a body of water, usually within a natural or constructed depression (i.e. created specifically for the disposal) or a relic borrow-pit created during previous construction activities. As with open-water placement, a CAD has the potential to store large volumes of dredged material. The difference between CAD and open-water placement is that the deposited material is confined to the designated area preventing lateral movement. Once the dredged material is placed within the CAD facility, the material could be left exposed to the surrounding water to be covered by natural sedimentation or capped with a layer of suitable clean material to prevent re-suspension.

The feasible use of a CAD facility depends on the capacity of the CAD and the availability of suitable locations in reasonable proximity to the dredging operations. Development of a CAD within Lower Newport Harbor could be used to increase bottom elevation and create an eelgrass habitat.

1.4.3.3 Shoreline Stabilization

Please refer to section 1.4.1.2 for a detailed description of this management alternative.

1.4.3.4 Landfill Cover

Please refer to section 1.4.1.3 for a detailed description of this management alternative.

1.4.3.5 Material Transfer

Please refer to section 1.4.1.4 for a detailed description of this management alternative.

1.4.3.6 In situ Treatment

Monitored Natural Recovery

Monitored natural recovery (MNR) is a remediation alternative that uses naturally occurring processes to contain, destroy, or reduce the bioavailability or toxicity of contaminants in sediment. This process is dependent on a relatively consistent rate of sediment deposition to cover the existing contaminated sediment in an aquatic environment, and deposited sediment should be resistant to resuspension. If using MNR to remediate contaminated sediment, it is necessary that contaminants are at relatively low concentrations throughout the area (i.e., significantly below hazardous waste concentrations), and are those that may be degraded to less toxic forms. In addition, significant anthropogenic disturbances are not permitted in areas where MNR is implemented. Therefore, it is necessary that the area does not need dredging to meet the City's needs. Given specific site characteristics, this remediation option is most appropriate if the expected risk of exposure to humans and aquatic organisms is relatively low and when the site is a sensitive habitat that may be permanently damaged by dredging or capping, such as eelgrass habitat.

In situ capping

In situ capping is used to remediate contaminated sediment in place by covering or capping the contaminated sediment with clean material. A variety of materials may be used as caps including clean granular sediment, sand, or gravel. Caps can also be engineered to meet specific project requirements. Such engineering controls may include treatments to attenuate contaminant flux (e.g., organic carbon, impermeable liners to reduce mixing between the clean material and contaminated sediment, and bio-barriers to prevent penetration by deep burrowing organisms [i.e., ghost shrimp]). As a result of *in situ* capping, contaminated sediment is isolated from benthic organisms that bioturbate and release contaminants in sediment through resuspension or biological transfer through the food chain. The primary site characteristics that are important for successful implementation of capping include hydrodynamic conditions that are not likely to disturb the cap, adequate sediment strength to support a cap, sufficient water depth to support future uses once the cap is in place, and compatibility with existing or planned infrastructure and associated activities (i.e. piers, pilings) within the capping area. Significant anthropogenic disturbances are not permitted in areas where the cap is implemented. Therefore, it is necessary that the area does not need dredging to meet the City's needs. An *in situ* capping alternative may

be more appropriate than MNR when the long-term risk reduction associated with contaminant exposure is more important than potential alterations of habitat resulting from the capping process. Similarly, *in situ* capping may be more appropriate than dredging when there is risk of contaminant exposure during removal activities, or residual contamination at a site.

1.4.3.7 Upland Treatment

Certain treatment technologies may be applied to the dredged material to reduce contaminant exposures to acceptable levels. Treatments involve reducing, separating, immobilizing and/or detoxifying contaminants, and could be applicable either as stand alone units or combined as part of a treatment train.

Dewatered dredged material has been manufacture into various construction materials, using the treatment methods listed below. It has been proven as a valuable resource in the production of riprap or blocks for erosion protection (rock), concrete aggregates (gravel/sand), production of bituminous mixtures and mortar (sand), raw material for brick manufacturing (clay), and ceramics and tile (clay).

<u>Physical/Chemical Treatment Processes</u>
Soil Washing/Particle Sorting Technologies
A valuable overview of washing/sorting technologies is presented by Olin et al (1999), and step-wise evaluation procedures in Olin-Estes and Palermo (2000). During sediment washing, contaminated dredged material is slurried and subjected to physical collision, shearing, and abrasive actions and aeration, cavitation, and oxidation processes, and in some cases while reacting with chemical additives. Soil washing involves separating sediment particles based on differences in size, density, or surface chemistry. Since contaminants tend to associate with produced water, fine-grained and organic materials, removal of these fractions may render the remainder of the material suitable for a broader range of beneficial uses.

Washing technologies span a wide range of sophistication, including simple sluicing processes to a hydrocyclone concentrator. In general, screened material is slurried and fed into mechanical equipment such as hydrocyclones and settling tanks, designed to remove silts and clays from granular particles. After separation, silts and clays may be either dewatered mechanically or pumped into a CDF for settling, and the coarser sand fraction (which is generally less contaminated) can be stockpiled for confirmatory testing and subsequent beneficial use.

Solidification
Solidification has a long track record in the treatment of dredged materials (GLC, 2004). Sediment solidification reduces the availability of contaminants by the addition of Portland cement, coal fly ash, cement kiln dust, lime, asphalt and/or other stabilizing chemicals to create soil aggregates. As a result, these treatments bind the small dredged material particles into larger aggregates with improved physical and chemical properties that enable the treated sediment to be used as aggregate in some types of construction processes. In the process, these stabilization techniques may reduce the accessibility of associated contaminants, thus reducing their availability to the environment. The end product can be used in landfill closure and brownfield remediation projects.

Chemical extraction and stabilization
Chemical extraction increases the solubility of contaminants, thereby mobilizing them from the sediment phase into the aqueous phase, where they may be removed by further processes. Extraction options include the addition of surfactants, acids, bases or chelators, and may be enhanced by temperature elevations of 99 to 140 °F (37 to 60 °C). Removal efficiency depends on the porosity of the material and the treatment time. Extraction processes can be further optimized by incorporation with separation processes, which tend to reduce the total volume of material and increase the concentration of the most contaminated, finer or less dense material. In addition, the water used in the washing process may be treated to remove metals and organics, and recycled to the treatment plant for use. Soil washing technologies using a blend of biodegradable detergents, chelating and oxidizing agents, and high pressure water jets to remove both organic and inorganic contaminants have been developed by BioGenesis, Inc. and Weston Solutions Inc. (Weston). This combination of mechanical and chemical processes has been shown to reduce organic compounds by approximately 90 percent and the inorganic compounds by approximately 70 percent. The process produces an end material that is suitable for use as a base for manufactured topsoils.

Chemical binding processes reduce the solubility of contaminants, thereby reducing their availability to pore water leaching and bioavailability. While these processes have been used in effluent and drinking water treatment for decades, their application to the stabilization of contaminants in solid materials is recent.

Thermal Treatment Processes
Vitrification
Vitrification is the process of converting sediment into glass aggregate, a process that destroys organic contaminants at 99.99 percent efficiencies and immobilizes metals within a glass matrix using a high-temperature plasma torch. The plasma torch is an effective method for heating sediments to temperatures that are higher than can be achieved in rotary kilns (see thermal desorption below). Plasma temperatures can reach 5430 °F (3000 °C) at which the sediment is melted using fluxes to produce a glass product. The molten glass can be quenched to produce a glass aggregate or directly fed to glass manufacturing equipment to produce a salable product.

Thermal desorption
Thermal desorption requires the application of very high temperatures to break down organic compounds, and has been applied to both moderately and highly contaminated dredged material. In this process, dredged materials are tumbled in a rotary kiln while applying temperatures around 930 – 2550 °F (500-1400 °C). Depending on the temperature and duration of the digest, this technique has been shown to eliminate some metal and organic compounds, Thermal desorption at the lower temperature results in a waste stream of hazardous material as a side product that may still require disposal at a hazardous waste treatment facility. Temperatures around 2550 °F (1400 °C) have been shown to completely destroy all organic compounds, and vitrify metals into a melted matrix. However, at these high temperatures some metals can be volatilized, therefore requiring comprehensive air permits. Higher temperature treatment can lock metals into a solid, melted matrix. The higher temperature demonstration has been conducted in existing cement plants with an associated “Cement-Lock” technology. Cement-Lock technology, developed by the Gas Technology Institute, can utilize any type of dredged

material. The ability of existing cement plants to handle large volumes of dredged material may reduce overall costs. The end result is construction-grade cement.

Biological Treatment Processes

A variety of technologies exist that may be characterized as bioremediation technologies, or processes that use organisms to reduce contaminant concentrations in materials. However, only some of these technologies have been tested for their use in the decontamination of sediment. Potential for bioremediation of contaminated sediments is discussed in the following references: (Price and Lee, 1999; Fredrickson et al., 1999; Price et al., 1999; Myers and Williford, 2000).

Composting

Composting involves mixing dredged material with organic matter and wood chips to accelerate the degradation of some contaminants (particularly polychlorinated biphenyls [PCBs] and polycyclic aromatic hydrocarbons [PAHs]; GLC 2004). The organic matter 'biosolids' (e.g., sewage sludge or manure) provide nutrients and microbes and the wood chips provide moisture and a substrate for microbial action. There are numerous types of composting technologies including windrow, static pile, vessel, and vermi-composting; however, not all of these technologies have been fully tested for use with dewatered dredged material. A pilot study using composting technology is being conducted by the USACE-Detroit District in the Great Lakes basin at the Milwaukee and Green Bay CDFs in an attempt to create marketable topsoil. Composting dredged material also has been used to create topsoil at the Toledo Harbor CDF. The resulting topsoil has been used for landfill capping and landscaping throughout the city of Toledo.

Land Farming

Land farming involves encouraging microorganisms to degrade contaminants within an enclosed area, such as a lined bed with leachate and aeration procedures in place. In this process, water and nutrients are often added to facilitate a successful microbial community. This technology has been primarily applied to soil, though small-scale studies and one pilot study have demonstrated its applicability to large-scale projects.

Phytoremediation

Phytoremediation uses living plants to facilitate the breakdown or immobilization of certain contaminants in dredged material. This technology has been used extensively to decontaminate soils and groundwater. Full scale studies have also been performed to demonstrate the usefulness of phytoremediation to decontaminate sediment; however, fewer studies have been completed on sediment as compared to soil or groundwater, using this technology (Belt Collins, 2002).

Fungal Remediation

Fungal remediation (also called mycoremediation) has been evaluated as a bioremediation treatment for certain organic contaminants in dredged material. This treatment involves the use of select fungal strains as "keystone" species along with the diverse array of naturally occurring organisms commonly present in soils and sediments, and uses these combinations of species to initiate a cascade of biological processes (Jack Word, personal communication; Belt Collins, 2002). Unlike conventional bioremediation applications, this fungal-centric biological consortium is capable of degrading complex organic contaminants including a variety of aromatic compounds. This occurs when fungal enzymes weaken the typically resilient carbon

bonds of the aromatic rings, allowing naturally occurring microbes to further degrade sediment contaminants until the compounds are reduced to basic chemical elements (i.e. carbon dioxide and water). Preliminary investigations have demonstrated the potential to reduce complex organic contaminant concentrations (PAHs, PCBs, and dichlorodiphenyltrichloroethane [DDT]) by up to 97 percent in soils and sediments.

1.5 Overview of Contaminated Sediment Issues

Agricultural activities, commercial and recreational boating uses, and urbanization of the watershed, has resulted in widespread contamination in Upper and Lower Newport Bay. The primary contaminants of concern include DDTs, mercury, copper, and pyrethroids. A discussion of the possible sources of contaminants is presented in Section 1.5.1. A discussion of the distribution of contaminants is presented in Sections 1.5.2.1 and 1.5.2.2. A discussion of sediment toxicity data is presented in Sections 1.5.3.1 and 1.5.3.2 .

1.5.1 Contaminants of Concern

1.5.1.1 DDTs

Widespread DDT contamination in the bay is the result of historical agricultural activities in the surrounding areas. Organochlorine pesticides, such as DDT, were widely used as pesticides from the mid-1940s to the 1970's. It has been estimated that the use of DDT reached peak levels in the mid-1960's. Because of lenient sewage treatment and waste disposal laws and scientific ignorance about the detrimental effects of DDT, the Palos Verdes Shelf became one of the largest DDT-contaminated sites in the country. Today, an estimated 100 tons of DDT are scattered cover a 17 square mile superfund site up to 200 feet below the ocean surface. An end to continued domestic usage of DDT was decreed on June 14, 1972. Rivers that meander through historical agricultural farmland are impacted with DDT, and its breakdown products DDE and DDD. At least 40 years after their use was prohibited, their presence is still observed in sediment and biota. Levels of DDT have been declining since the late 1960s, yet it continues to enter rivers and streams from atmospheric deposition and the erosion of agricultural soils. Since these pesticides generally have moderate-to-low water solubility and moderate-to-high environmental persistence, they have the strong potential for accumulation in sediment and aquatic biota.

1.5.1.2 Mercury

Possible sources of mercury in the bay include historical antifouling boat paints, historical shipyard activities, the natural locally occurring geological material known as cinnabar, and mercury mining. Mercury mining occurred at Red Hill mine between 1880 and 1939, and the San Diego Creek may have transported sediment containing mercury into the bay. Potential pathways have been identified based on media, and include direct contact, flux / leaching to surface waters / runoff, resuspension and transport of sediment, leaching to groundwater, volatilizations, and fugitive dust from sediment / soil surface. The most common being metallic mercury, mercuric sulphide, mercuric chloride, and methylmercury. Natural processes can change the mercury from one form to another. For instance, chemical reactions in the atmosphere can transform elemental mercury into inorganic mercury. Some micro-organisms can produce organic mercury, particularly methylmercury, from other mercury forms. Methylmercury can

accumulate in living organisms and reach high levels in fish and marine mammals via a process called biomagnification (i.e. concentrations increase in the food chain) (Figure 4).

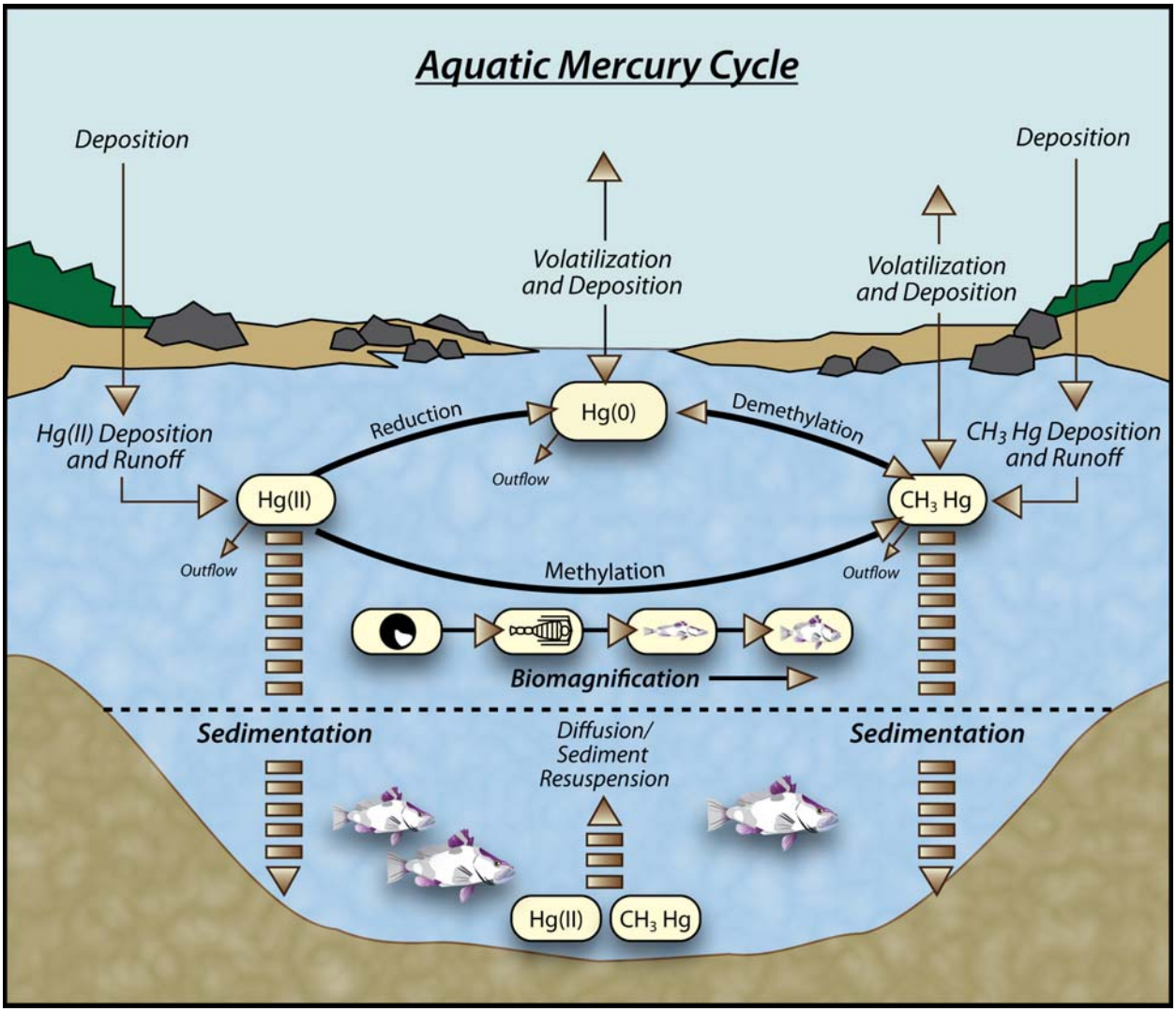

Figure 4. Aquatic Mercury Cycle

1.5.1.3 Copper

Sources of copper include antifouling paints, hull cleaning, cooling water, NPDES discharges, industrial processes, stormwater, mining and point source runoff. Copper, in a variety of formulated fungicides, herbicides and algaecides, is widely used in antifouling paints to control the growth of bacteria and fungus. Copper has a lithic biogeochemical cycle; therefore, it has a strong propensity for sediments and soils. Because it adsorb so strongly to sediments and soil, copper usually does not leach into groundwater, and does not contaminate drinking water supplies. Elemental copper does not break down in the environment and may be found in plants and animals, and at elevated concentrations in filter feeders such as mussels and oysters. Two forms of copper, Cu^{+1} (cuprous) and Cu^{+2} (cupric) can occur in aqueous environments, however, their relative stabilities depend on factors such as hardness, alkalinity, temperature, hydrogen ion concentration (pH), ionic strength and dissolved organic carbon.

1.5.1.4 Pyrethroids

A possible source of pyrethroids is historic agricultural uses and residential uses. Pyrethroids are used residentially in insecticides that previously had organophosphates as the active ingredients (California Department of Pesticide Regulation, 2004). Pyrethroids, which consist of 40% of all pesticide products, display high toxicity to a wide range of aquatic organisms including invertebrates, but also have a strong affinity towards sediment and soil particles. Therefore, pyrethroids may not be bioavailable to organisms. Most pyrethroids are broken down or degraded rapidly by sunlight or other compounds found in the atmosphere, therefore often lasting 1 or 2 days before being degraded. Since many of these compounds are extremely toxic to fish, they are usually not sprayed directly onto water, but they can enter lakes, ponds, rivers, and streams from rainfall or runoff from agricultural fields and eventually find their way to coastal areas. Pyrethroids are not easily taken up by the roots of plants and vegetation because their affinity to soil. Because these compounds adsorb so strongly to soil pyrethroids usually do not leach into groundwater, do not contaminate drinking water supplies, and volatilize from soil surfaces slowly. Microorganisms in water and soil degrade these compounds. However, some of the more recently developed pyrethroids can persist in sediment and soil for several months or years before they are degraded.

1.5.2 Review of Existing Sediment Chemistry Data

In preparation of sediment management activities in support of maintaining navigable waterways, docks, and bulkheads in Newport Bay, an understanding of the potential for sediment contamination is necessary. Information on contaminated sediment within the bay will be used to help determine quantity of material that may not be suitable for ocean disposal, determine the distribution of contaminants, and help develop sediment management alternatives. Therefore, a review of existing sediment chemistry data was performed for Newport Bay. Existing sediment conditions in Upper Newport Bay has a direct effect on the sediment quality in Lower Newport Bay due to sedimentation via tidal activity and storm events. Therefore, a review of contaminated sediment in Upper Newport Bay was also necessary. Elevated levels of contaminants of concern in Upper and Lower Newport Bay are discussed in the following sections.

1.5.2.1 Distribution of Contaminants in Upper Newport Bay

<u>DDTs</u>
In November 2000, MEC Analytical Systems, Inc. (MEC) collected sediment cores from 5 sites in Upper Newport Bay (including offshore of Newport Dunes, Dover Shores, and the Upper Newport Bay boat launch facility) for Tier III analysis (MEC, 2001). Chemical analyses on the composite sample indicated elevated levels DDT congeners. The concentration of 4,4'-DDE (59 µg/kg) exceeded the corresponding effects range-median (ER-M; 27 µg/kg). A refined analysis of each station of Area 3 was performed to see if there were differences in sediment contamination among the different stations. Elevated concentrations of DDE were evenly distributed among the stations with concentrations ranging from 28 to 58 µg/kg. All concentrations of DDE exceeded the corresponding ER-M.

In March 2002, MEC collected sediment cores from Upper Newport Bay for Tier III analysis (MEC, 2003a). Samples were collected from 5 stations within Area A (Unit II Basin), 2 stations within Area N (New Island East Side Channel), and 1 station within Area HD (Hot Dog Island

Channel). Due to stratification in Area A sediment, samples were split into tops and bottoms. The top sample represented the top 2.29 to 2.44 ft of sediment. Chemical analyses of composite samples from Areas A Top, N, and HD indicated elevated levels of DDT congeners. The concentration of 4,4'-DDE in Area A Top (35.2 µg/kg) and Area N (46.6 µg/kg) exceeded the corresponding ER-M. Likewise, the concentration of 4,4'-DDT in Area HD (10.8 µg/kg) exceeded the corresponding ER-M (7 µg/kg).

In May 2005, Weston collected sediment from Newport Bay for Tier III analysis (Weston, 2005). Samples were collected from the channel and marina immediately north of Galaxie View Park (Area 3a) and the area around Bayside Village Marina (Area 3b). Chemical analyses of the composite samples indicated elevated levels of DDT congeners. The concentration of 4,4'-DDE at Area 3a (42 µg/kg) and Area 3b (30 µg/kg) exceeded the corresponding ER-M. Total detectable DDTs in area 3a (48.4 µg/kg) also exceeded the corresponding ER-M (46.1 µg/kg). In bioaccumulation testing with *Macoma nasuta* and *Nephtys caecoides*, DDT congeners were detected is tissue chemistry. Total DDT concentration in each treatment was well below Food and Drug Administration guidance of 5.0 mg/kg wet weight. Total DDT was also below the concentration shown to cause effects in marine biota.

In 2006, stormwater from San Diego Creek and Santa Ana-Delhi watersheds was sampled to link contamination in Upper Newport Bay to stormwater runoff and identify possible sources of contamination (Peng et al., 2007). Stormwater particulate concentrations of DDTs were an order of magnitude greater at agricultural land use sites when compared to other land uses. Concentrations of DDTs from stormwater particulates were greater than or equal to concentrations in sediment collected from Upper Newport Bay, indicating that stormwater is contributing to DDT contamination in the bay.

<u>Mercury</u>
In May 2005, Weston collected sediment from 3 stations near Bayside Village Marina for Tier III analysis (Weston, 2005). Chemical analyses of the composite of all three stations did not indicate elevated levels of mercury; however, the concentration (0.82 mg/kg) at one station (3-2) exceeded the corresponding ER-M.

1.5.2.2 Distribution of Contaminants in Lower Newport Bay

<u>Copper</u>
In September 2000 and May 2001, Southern California Coastal Water Research Project (SCCWRP) conducted an assessment of sediment toxicity in Newport Bay (Bay et al., 2004). Samples were collected using a Van Veen grab, and the top 2 cm of multiple grabs were composited together for chemical analyses. Concentrations of copper in Rhine Channel sediment (634 and 607 mg/kg) exceeded the corresponding ER-M (270 mg/kg).

In 2002, SCCWRP conducted an assessment of contamination in Rhine Channel (Bay and Brown, 2003). Samples were collected from 15 stations using a Van Veen grab, and the top 2 cm of multiple grabs were composited together for chemical analyses. Copper concentrations exceeded ER-M at 14 stations with concentrations ranging 225 to 957 mg/kg. Highest concentrations were detected in the upper channel between 29th Street drain and the cannery area, and also the central part of the channel between Balboa Boatyard and South Coast Shipyard. However, the lowest concentrations were detected near the entrance to Rhine Channel.

In November 2004, Anchor Environmental conducted a sediment remediation feasibility study on the Rhine Channel (Anchor, 2006). Samples were collected with a piston corer at 16 stations (15 of the same locations sampled in the 2002 SCCWRP survey). Cores were split at distinct geologic layers and analyzed to characterize the vertical extent of contamination. Chemical analyses of the Rhine Channel sediment indicated elevated levels of copper. Surficial sediment exceeded corresponding effects range-low (ER-L) or ER-M at every station ranging from 88.9 to 635 mg/kg. Elevated concentrations were also consistently measured in subsurface sediment.

DDTs

In November 2000, MEC collected sediment cores from 6 sites near Linda Isle including the shoreline west of the main Upper Newport Bay Channel south of the Pacific Coast Highway bridge for Tier III analysis (MEC, 2001). Chemical analyses of the composite sample indicated elevated levels of the chemical analogues of DDT. The concentration of 4,4'-DDE (39 µg/kg) exceeded the corresponding ER-M (27 µg/kg). A refined analysis of each station was performed to see if there were differences in sediment contamination within the area. Concentrations of 4,4'-DDE were undetectable at stations 2-1, 2-3, and 2-4. However, concentrations at stations 2-2, 2-5, and 2-6 ranged from 8 to 22 µg/kg, which exceeded corresponding ER-L of 4,4'-DDE, but were below ER-M. Bioaccumulation testing with clams and polychaetes resulted in elevated concentrations of DDTs in tissue; however, concentrations were lower than the concentration established by National Academy of Sciences (NAS) or National Sediment Inventory (NSI) as standards for maximum prey concentrations that are protective of wildlife. This indicates that the elevated concentrations of DDTs, while measurable are not sufficiently high enough to have adverse effects on wildlife. After full Tier III analysis, dredged material from the Linda Isle area was determined acceptable for ocean disposal at LA-3.

In May 2001, SCCWRP conducted an assessment of sediment contamination in Newport Bay (Bay et al., 2004). Samples were collected using a Van Veen grab, and the top 2 cm of multiple grabs were composited together for chemical analyses. Elevated levels of DDT congeners were detected in the Turning Basin station (NB4). Concentrations of 4,4'-DDD (25.6 µg/kg) and 4,4'-DDE (30.4 µg/kg) exceeded corresponding ER-M values. Total detectable DDTs (56.0 µg/kg) also exceeded corresponding ER-M.

In September and October 2002, MEC collected sediment cores from the Federal Channels in Lower Newport Bay for Tier III analysis (MEC, 2003b). Samples were collected from Balboa Reach (Area 1), Lido Isle Reach (Area 2), Harbor Island Reach (Area 3), and Newport Channel (Area 4). Chemical analyses of composite samples from all areas except Balboa Reach indicated elevated levels of DDT congeners. The concentration of 4,4'-DDE at Area 2 (51 µg/kg), Area 3 (31.8 µg/kg), and Area 4 (89.5 µg/kg) exceeded the corresponding ER-M. In Area 4, concentrations of 2,4'-DDE (30 µg/kg), 2,4'-DDT (9.2 µg/kg) and 4,4'-DDD (21.3 µg/kg), also exceeded the corresponding ER-M values. Total detectable DDTs in Area 2 (67.3 µg/kg) and Area 3 (161.9 µg/kg) exceeded the corresponding ER-M (46.1 µg/kg). Sediment chemistry was also performed on the individual cores to look at the differences in sediment contamination within the area. Individual core location analyses detected the highest concentrations of DDT congeners near the confluence of the different channels (Area 4), while the lowest concentrations were found along Balboa Channel (Area 3) and at the locations near the harbor entrance (southeastern portion of Area 1). Failure of the refrigeration unit may have compromised sample

integrity; therefore areas were re-sampled in November 2002. Individual cores were analyzed for pesticides. There was a fair amount of variability between the two sampling events, suggesting that total DDT is somewhat patchy in its spatial distribution within Newport Harbor. A second sampling and analysis effort was conducted in May 2003 to assess the vertical distribution of DDT contamination (MEC, 2003b). Nineteen of the original 28 stations and two new stations in the vicinity of Harbor Island Reach were sampled. Results indicated fairly widespread contamination of DDT congeners. ER-M values were exceeded at nearly every depth in each location with the exception of station 5 and 30. Highest concentrations were found at three feet or more below the surface (Figure 5). This indicates that it may be possible to dredge and ocean dispose the cleaner material within the top few feet of the surface, provided they pass the OTM suitability determination.

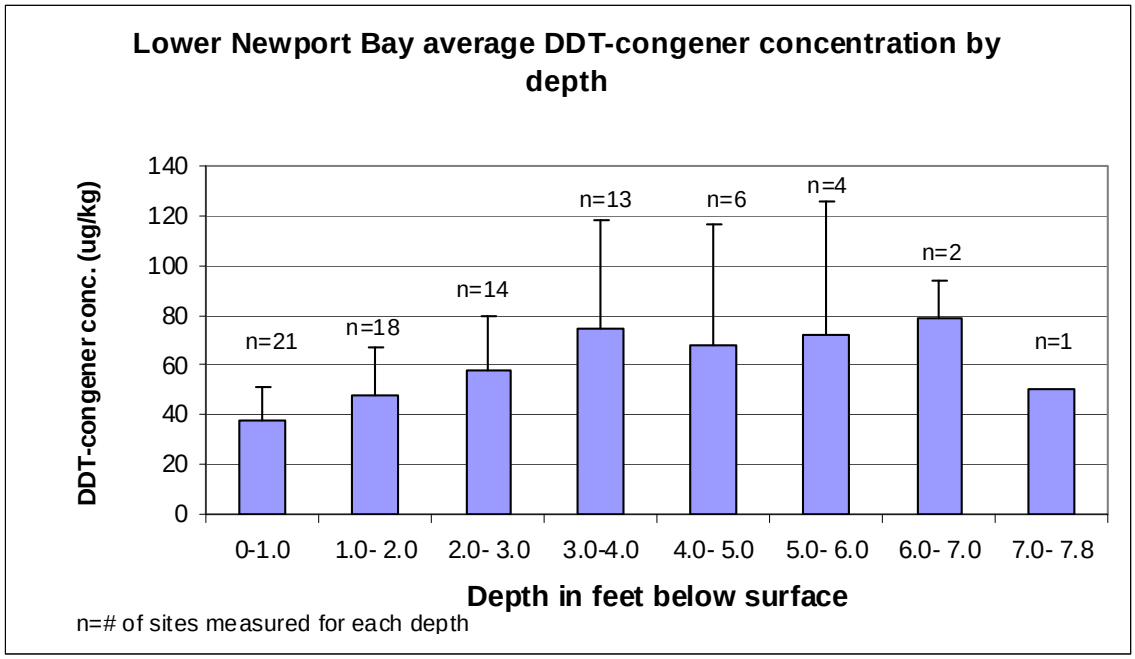

Figure 5. Average DDT-congener concentrations (µg/kg) in Lower Newport Bay along one foot depth increment (MEC 2003b).

In 2002, SCCWRP conducted an assessment of contamination in Rhine Channel (Bay and Brown, 2003). Samples were collected from 15 stations using a Van Veen grab, and the top 2 cm of multiple grabs were composited together for chemical analysis. Elevated levels total DDTs were detected at concentrations ranging 30 to 98 µg/kg, some which exceeded corresponding ER-M. Highest concentrations were detected near the entrance to Rhine Channel.

In November 2004, Anchor Environmental conducted a sediment remediation feasibility study on the Rhine Channel (Anchor, 2006). Samples were collected with a piston corer at 16 stations (15 of the same locations sampled in the 2002 SCCWRP survey). Cores were split at distinct geologic layers and analyzed to characterize the vertical extent of contamination. Chemical analyses of the station RS04-01 indicated elevated levels of 4,4'-DDE in subsurface sediments, which exceeded corresponding ER-M.

In May 2005, Weston collected sediment from Lower Newport Bay for Tier III analysis (Weston, 2005). Samples were collected from two areas. Area 1 included the area near Lido Island and the north shore of Balboa Peninsula. Area 2 included the area south of the Pacific Coast Highway Bridge, north of Harbor Island Reach, and the shorelines of Linda Isle and Harbor Island. Chemical analyses of the composite samples indicated elevated levels of DDT congeners. The concentrations of 4,4'-DDE at Area 1 (28 µg/kg) and Area 2 (30 µg/kg) exceeded the corresponding ER-M. The concentrations of DDT congeners were also elevated in tissue chemistry of *M. nasuta* and *N. caecoides* after bioaccumulation testing. However, total DDT concentrations were well below U.S. Food and Drug Administration (FDA) guidance of 5.0 mg/kg wet weight. Total DDT concentrations were also below the concentration shown to cause effects in marine biota.

Mercury

In August 1998, MEC performed a Tier II investigation on Lower Newport Bay Harbor (MEC 1998). Sediment from the Main Channel and three areas surrounding the Main Channel were sampled for chemical and physical analyses to support ocean disposal of the dredged material at the LA-3 USEPA designated ocean disposal site. Chemical analyses of project sediments indicated relatively low concentrations of all analytes measured with the exception of mercury. The concentration of mercury (1.16 mg/kg) at station A3-10 (south of Harbor Island surrounding Main Channel) exceeded the corresponding ER-M (0.71 mg/kg).

In September and October 2002, MEC collected sediment cores from the Federal Channels in Lower Newport Bay for Tier III (MEC, 2003b). Samples were collected from 5 sites within Lido Isle Reach (Area 2). Chemical analyses of the composite sample indicated elevated levels of mercury (0.72 mg/kg), which exceeded the corresponding ER-M.

In September 2000 and May 2001, SCCWRP conducted an assessment of sediment contamination in Newport Bay (Bay et al., 2004). Samples were collected using a Van Veen grab, and the top 2 cm of multiple grabs were composited together for chemical analyses. Concentrations of mercury in Rhine Channel sediment (5.3 and 5.8 mg/kg) and Turning Basin sediment (1 and 0.73 mg/kg) exceeded the corresponding ER-M. As described in *Newport Bay Toxics TMDLs*, mercury concentrations in Rhine Channel have historically exceeded the ER-M. Sediment TMDL target for mercury has been developed for Rhine Channel (0.13 mg/kg).

In 2002, SCCWRP conducted an assessment of contamination in Rhine Channel (Bay and Brown, 2003). Samples were collected from 15 stations using a Van Veen grab, and the top 2 cm of multiple grabs were composited together for chemical analyses. Elevated levels of mercury were detected at every station. Concentrations ranged from 2.4 to 14.3 mg/kg and exceeded corresponding ER-M. Highest concentrations were detected in the upper channel between 29th Street drain and the cannery area. Lowest concentrations were detected near the entrance to Rhine Channel.

In November 2004, Anchor Environmental conducted a sediment remediation feasibility study on the Rhine Channel (Anchor, 2006). Samples were collected with a piston corer at 16 stations (15 of the same locations sampled in the 2002 SCCWRP survey). Cores were split at distinct geologic layers and analyzed to characterize the vertical extent of contamination. Chemical analysis of the Rhine Channel sediment indicated elevated levels of mercury. Surficial sediment

exceeded corresponding ER-M at every station ranging from 1.12 to 3.68 mg/kg. Elevated concentrations were also consistently measured down to the interface between native and recent sediments.

In May 2005, Weston collected sediment from 10 sites around Lido Island including the north shore of Balboa Peninsula for Tier III analysis (Weston, 2005). Chemical analyses of the composite sample indicated elevated levels of mercury. The concentration of mercury (0.82 mg/kg) exceeded the corresponding ER-M.

Other Contaminants
Besides copper, DDTs, and mercury, several other contaminants of concern were detected in Rhine Channel sediment. In 2002, total PCBs and zinc were detected at concentrations greater than ER-M (Bay and Brown, 2003). Highest concentrations of total PCBs were detected in the upper channel between 29th Street drain and the cannery area. In 2004, lead, zinc, total PAHs, and total PCBs were all detected at concentrations greater than corresponding ER-M values (Anchor, 2006). Elevated concentrations of arsenic, cadmium, nickel, and tributyltin (TBT) were also detected in surface and subsurface samples throughout the channel.

1.5.3 Review of Existing Sediment Toxicity Data

Extensive toxicity testing has been performed in Newport Bay over the last several years. Many of these tests resulted in measurable or significant toxicity to test organisms. Toxicity testing conducted within the last 3 years has identified specific areas that were not suitable for ocean disposal. Based on these evaluations, approximately 561,280 cy of this material is not suitable for ocean disposal and is recommended for beneficial use or treatment. A summary of toxicity in Newport Bay sediment is discussed in the following sections.

1.5.3.1 Sediment Toxicity in Upper Newport Bay

In November 2000, MEC collected sediment cores from 5 sites in Upper Newport Bay (including offshore of Newport Dunes, Dover Shores, and the Upper Newport Bay boat launch facility) for Tier III analysis (MEC, 2001). Measurable toxicity was observed in solid phase (SP) testing of the composite sample with *Eohaustorius estuarius* and *Mysidopsis bahia*. Biological significant toxicity was only observed with the amphipod. Measurable effects were also observed with suspended particulate phase (SPP) testing with *Mytilus galloprovincialis* (median effect concentration [EC_{50}] = 75%). As a composite sample, project material from Upper Newport Bay was determined unacceptable for ocean disposal at LA-3. It is possible contamination and associated toxicity is not distributed evenly throughout the area; therefore, additional testing was conducted on each station. A second sampling episode was conducted in March 2001 to collect additional material for toxicity analysis. Stations 3-1, 3-3, and 3-4 resulted in measurable toxicity on mussel larvae exposed to sediment elutriates; however, a short term fate (STFATE) model was run and samples met limiting permissible concentration (LPC) requirements for ocean disposal. SP testing with *E. estuarius* at station 3-1 resulted in significant toxicity relative to the reference sediment. Therefore, this sample was not acceptable for ocean disposal at LA-3.

In March 2002, MEC collected sediment cores from Upper Newport Bay for Tier III analysis (MEC, 2003a). Sediment elutriate testing with *Strongylocentrotus. purpuratus* (EC_{50} = 15.5 to 66.7%) resulted in measurable toxicity to Areas A Top and Bottom (Unit II Basin), B Bottom

(Unit I/III Basin), D Upper Channel (access channel from Unit I/III Basin to Unit II Basin), D Lower Channel (access channel from Unit II Basin to Pacific Coast Highway bridge), HD (Hot Dog Island Channel), N (New Island East Side Channel), and SA (Santa Ana-Delhi Channel). Sediment elutriate testing with *Menidia beryllina* (LC_{50} = 57.4 to 86.0%) resulted in measurable toxicity to Areas A Top, B Top, HD, and N. Therefore, a STFATE model was performed and all samples met LPC requirements for ocean disposal.

In September 2000 and May 2001, SCCWRP conducted an assessment of sediment toxicity in Newport Bay (Bay et al., 2004). One goal of this study was to determine if toxicity is persistent year-round. Samples were collected using a Van Veen grab for the September survey and diver cores for the May survey. The top 2 cm were composited together for SP testing using *E. estuarius*. Five samples were collected from Upper Newport Bay. Results indicated the same spatial pattern of toxicity between both sampling events, with 60% of samples toxic. Toxicity was present year round and not influenced by seasonal factors. Samples collected from the entrance of Dune Lagoon (NB6), from Unit II Basin (NB8), and from the mouth of San Diego Creek (NB10) demonstrated measurable toxicity. The mouth of San Diego Creek station demonstrated significant and persistent toxicity. Therefore, toxicity identification evaluations (TIE) were conducted with sediment from this station to identify the contaminants of concern. TIE results indicated that multiple toxicants of concern were present. Toxicity was most likely not due to metals or naturally occurring factors (i.e. grain size, ammonia). Nonpolar organic constituents were the dominant toxicant; however, a review of chemistry indicated that DDTs, PCBs, and PAHs were not likely responsible for toxicity. Toxicity at this site is most likely due to runoff of an unmeasured contaminant such as an organic pesticide (i.e., pyrethroids).

In May 2005, Weston collected sediment from 6 stations immediately above the Pacific Coast Highway bridge for Tier III analysis (Weston, 2005). Two composite samples were created. Area 3a consists of sediment from 3 stations in the channel and marina immediately north of Galaxie View Park. Area 3b consists of sediment from 3 stations near Bayside Village Marina. Sediment elutriate testing with sediment from Areas 3a and 3b resulted in measurable toxicity to *Mytilus sp*. (EC_{50} = 67 and 91%, respectively). A STFATE model was performed and all samples met LPC requirements for ocean disposal.

1.5.3.2 Sediment Toxicity in Lower Newport Bay

In September/October and November 2002, MEC collected sediment cores from the Federal Channels in Lower Newport Bay for Tier III analysis (MEC, 2003b). Samples were collected from 5 sites within each area (Balboa Reach, Lido Isle Reach, Harbor Island Reach, and Newport Channel). SPP testing of Area 4 (Newport Channel) resulted in measurable toxicity (EC_{50} = 79.8%) to mussel larvae. A STFATE model was run and the sample met LPC requirements for ocean disposal. SP testing of all samples resulted in measurable toxicity to the amphipod *E. estuarius*. Survival was significantly lower and 20% less than survival of animals exposed to the reference. Therefore, samples did not meet LPC requirements for ocean disposal. A second sampling and analysis effort was conducted in July 2003 (MEC, 2003b). It was thought that further sampling and analysis might lead to the delineation of cleaner sub-areas for which ocean disposal would be acceptable. SP testing of Area 8 (Upper Yacht Anchorage off of the southeastern end of Lido Isle) and Area 14 (south of Harbor Island at the intersection of Main Channel and Balboa Channel) resulted in significant toxicity to *E. estuarius*. Therefore, these samples were also determined to not be suitable for ocean disposal.

In September 2000 and May 2001, SCCWRP conducted an assessment of sediment toxicity in Newport Bay (Bay et al., 2004). One goal of this study was to determine if toxicity is persistent year-round. Samples were collected using a Van Veen grab, and the top 2 cm of multiple grabs were composited together for SP testing using *E. estuarius*. Five samples were collected from Lower Newport Bay. Results indicated the same spatial pattern of toxicity between both sampling events, with 80% of samples toxic. Toxicity was present year round and not influence by seasonal factors. Samples collected at north side of Bay Island (NB2), Rhine Channel (NB3), Turning Basin (NB4), and Lido Isle Reach (NB5) demonstrated measurable toxicity. Rhine Channel station demonstrated significant and persistent toxicity. Therefore, TIEs were conducted with sediment from Rhine Channel to identify the contaminants of concern. TIE results indicated that multiple toxicants of concern were present and metals may have contributed to toxicity. Copper and mercury were detected at this site at concentrations greater than the corresponding ER-M. Toxicity was not due to naturally occurring factors (i.e. grain size, ammonia). The TIE did not characterize the contaminant most likely responsible for toxicity.

In 2002, SCCWRP conducted an assessment of contamination in Rhine Channel (Bay and Brown, 2003). Samples were collected from 15 stations using a Van Veen grab, and the top 2 cm of multiple grabs were composited together for SP testing with *E. estuarius*. Eleven sites were toxic (significantly different and less then 80% of control survival) to amphipods. The most toxic sites were at the entrance of the Rhine Channel and near Lido Shipyard. However, most sites in the upper portion of Rhine Channel were not toxic to *E. estuarius*.

1.5.3.3 Confounding Factors

Specific areas of Newport Bay found unsuitable for ocean disposal were the result of significant toxicity to *E. estuarius*. Current investigations suggest that some toxicity observed to *E. estuarius* may be the result of confounding factors (i.e. grain size) and not the result of contamination (NewFields, 2007, currently under review). The indigenous habitat of *E. estuarius* typically is sandy sediment. While these organisms are tolerant of a wide variety of grain sizes, extremely fine sediments may not be suitable. Studies have shown that survival of many organisms may be affected by grain size distribution (DeWitt et al., 1989). In addition, previous studies conducted by Weston (formerly MEC Analytical) have demonstrated that survival of *E. estuarius* is affected by grain size extremes (i.e., >75% sand or >75% clay). Specifically, increased mortality associated with increased proportions of sand or clays in sediment. To determine whether toxicity measured in Newport Bay was confounded by grain size, additional testing with multiple amphipod species is recommended in conjunction with pore water testing.

1.6 Recommendations

1.6.1 Phase 1 – Near-Term Solution for Management of Dredged Materials and Maintenance of Navigational Depths

1. Sediment Management Plan – 1 year / $350,000
    a. Management of Materials meeting Ocean Disposal Suitability Requirements
    b. Management of Materials for Beneficial Use
        i. Review of alternatives with logistical, technical, and economic feasibility evaluation
        ii. Geotechnical evaluation for construction or bulkhead restoration suitability
    c. Management of Materials Unsuitable for Either Ocean Disposal or Beneficial Use
        i. Identification of sediment rehandling facility
        ii. Identification and evaluation of CAD facilities/alternatives
2. MPRSA Tier III evaluation - 6 months / $400,000
3. Master Dredging Plan and Schedule – 6 months / $90,000
    a. Design and Dredging Requirements
    b. Schedule including consideration of environmental windows
    c. Identification and Mitigation of Potential Impacts: Habitat, Water Quality, Harbor Activities, Navigation and Public Access, Noise, Aesthetics, Air Quality
    d. Equipment and Best Management Practices (BMPs)

1.6.2 Phase 2 – Long-Term Solution Management of Dredged Materials and Maintenance of Navigational Depths

1. Sediment Transport Study – 9 months / $100,000
    a. Data Collection, Analysis and Modeling
    b. Forecasted Sediment Budget for Lower Newport Bay and Estimate of Future Dredging Needs
2. Sustainability Plan for Maintenance of Harbor Channels – 6 months / $175,000
    a. Identification and Discussion of significant load sources (contaminants and sediments)
    b. Identification and Discussion of relevant BMPs for reduction of source loadings
    c. Identification and Discussion of Potential Future Development Impacts
    d. Long-term Management Plan for Future Dredging Needs

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