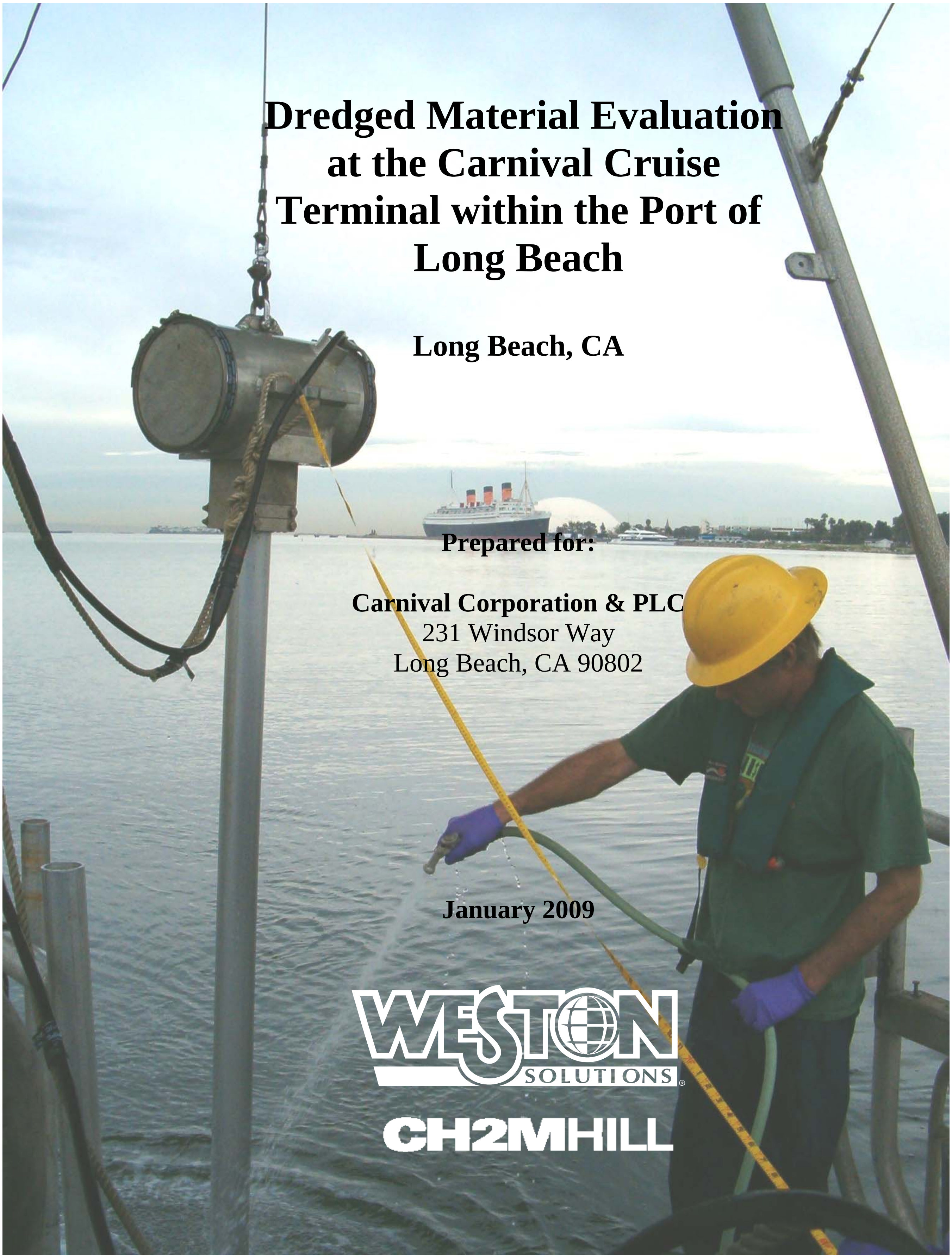

Dredged Material Evaluation at the Carnival Cruise Terminal within the Port of Long Beach

Long Beach, CA

Prepared for:

Carnival Corporation & PLC
231 Windsor Way
Long Beach, CA 90802

January 2009

WESTON SOLUTIONS

CH2MHILL

Dredged Material Evaluation at the Carnival Cruise Terminal within the Port of Long Beach

Long Beach, CA

Prepared for:

Carnival Corporation & PLC
231 Windsor Way
Long Beach, CA 90802

Prepared by:

Weston Solutions, Inc.
2433 Impala Drive
Carlsbad, California 92010

Under Contract To:

CH2M Hill
3 Hutton Centre Drive, Suite 200
Santa Ana, CA 92707

January 2009

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

BP	bioaccumulation potential
Carnival	Carnival Corporation & PLC
CCR	California Code of Regulations
CFR	Code of Federal Regulations
COC	chain of custody
DDT	dichlorodiphenyltrichloroethane
DGPS	Differential Global Positioning System
DMMT	Dredged Material Management Team
ER-L	effects range–low
ER-M	effects range–median
ID	identification
MLLW	mean lower low water
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
POLA	Port of Los Angeles
POLB	Port of Long Beach
QA	quality assurance
QC	quality control
SAP	sampling and analysis plan
SM	Standard Method
SP	solid phase
SPP	suspended particulate phase
STLC	soluble threshold limit concentration
TCLP	toxicity characteristic leaching procedure
TOC	total organic carbon
TTLC	Total threshold limit concentration
USEPA	United States Environmental Protection Agency
Weston	Weston Solutions, Inc.
WGS 84	World Geodetic System 1984

UNITS OF MEASURE

cm	centimeter
cy	cubic yard
°C	degrees Celsius
ft	feet or foot
L	liter
µg/g	microgram per gram
m	meter
ng/g	nanogram per gram
%	percent

1.0 INTRODUCTION

Carnival Corporation & PLC (Carnival) proposes to conduct maintenance dredging in the area surrounding the Carnival Cruise Terminal within the Port of Long Beach (POLB), Long Beach, California, as a result of recent sedimentation that has occurred (Figure 1). Maintenance dredging is required in this area to ensure adequate navigation depth for Carnival ships which utilize this cruise terminal on a regular basis. Specifically, dredging will be critical prior to the arrival of the newest and largest cruise ship, Carnival Splendor, scheduled for a maiden call from the Carnival Cruise Terminal on March 29, 2009. The Carnival Cruise Terminal is located on Pier H near the Queen Mary Terminal on the west side of Queensway Bay (Figure 1, Figure 2). The original footprint, delineated within the SAP, was estimated to extend south of the dolphins along Pier H; however, after sampling and preliminary testing the actual dredge footprint was redefined to include only the area along the Pier H dolphins.

Based on the proposed maintenance dredging plan, a potential of approximately 2,000 cubic yards (cy) of dredged material will need to be managed. For the purposes of the dredged material evaluation, one area (Area CT1) has been identified within the dredging footprint for sampling and analysis activities (Figure 2). This area will be dredged to -30 feet (ft) mean lower low water (MLLW) (-31 ft including a +1 ft overdredge allowance).

Carnival proposes to place the dredged material on Pier S at the temporary dewatering facility. Following dewatering, the material is proposed for beneficial use as construction fill for future construction projects. Prior to dredging and disposal activities, all material was evaluated to establish suitability for this disposal option. Potential dredged material was evaluated in accordance with the *Inland Testing Manual* (ITM) (USACE and USEPA, 1998).

1.1 Sampling and Testing Objectives

The objective of this investigation is to characterize material proposed for maintenance dredging in the area surrounding the Carnival Cruise Terminal for its environmental suitability for beneficial use or ocean disposal. A phased approach was proposed to evaluate the material for potential beach nourishment, placement at the POLB West Basin Storage Facility, ocean disposal, or upland placement on Pier S, as described in the Sampling and Analysis Plan (SAP; Weston Solutions, Inc. [Weston] and CH2M Hill, 2008).

The dredge footprint to be sampled is located at the Carnival Cruise Terminal on Pier H near the Queen Mary Terminal. One project area has been identified within this dredge footprint for the purposes of sampling and analysis activities (Figure 2). This area represents the -30 ft MLLW dredge footprint (-31 ft including a +1 ft overdredge allowance). The volume of dredged material, based on the project depth and on the projected bathymetry with an additional 2 ft overdredge allowance (1 ft paid overdredge + 1 ft allowance), is approximately 2,000 cy (Table 1).

Table 1. Proposed Depths and Volume of Material to be Removed from the Carnival Cruise Terminal Area at the POLB

Area	Project Depth (ft MLLW)	Volume to be Dredged to project depth (cy)	Volume to be Dredged to project depth plus 1 ft overdredge (cy)
CT1	**-30**	**700**	**2,000**

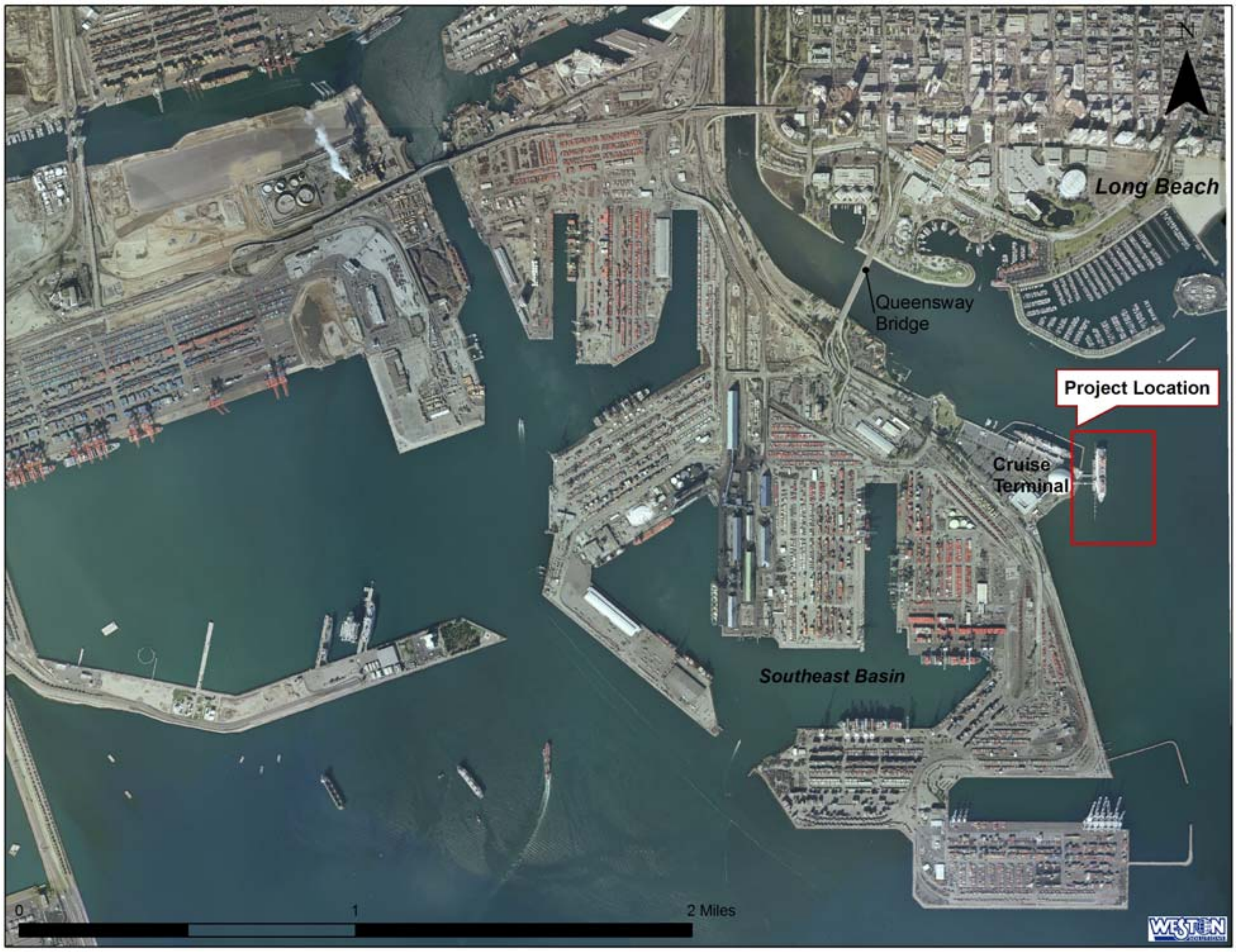

Figure 1. Overview of Sampling Area along the Carnival Cruise Terminal

Figure 2. Cruise Terminal Project Area with Sampling Locations

1.2 Phased Approach for Physical, Chemical and Biological Analyses

A phased approach was used to evaluate project material for its suitability for beach nourishment, placement at the POLB West Basin Storage Facility for future construction or beneficial uses, ocean disposal, or upland placement (Figure 3). In Phase I, sediment was analyzed for physical and chemical parameters as described in Section 2.4 of the SAP (WESTON and CH2M Hill, 2008). The next phases of analyses are discussed in Section 4.0.

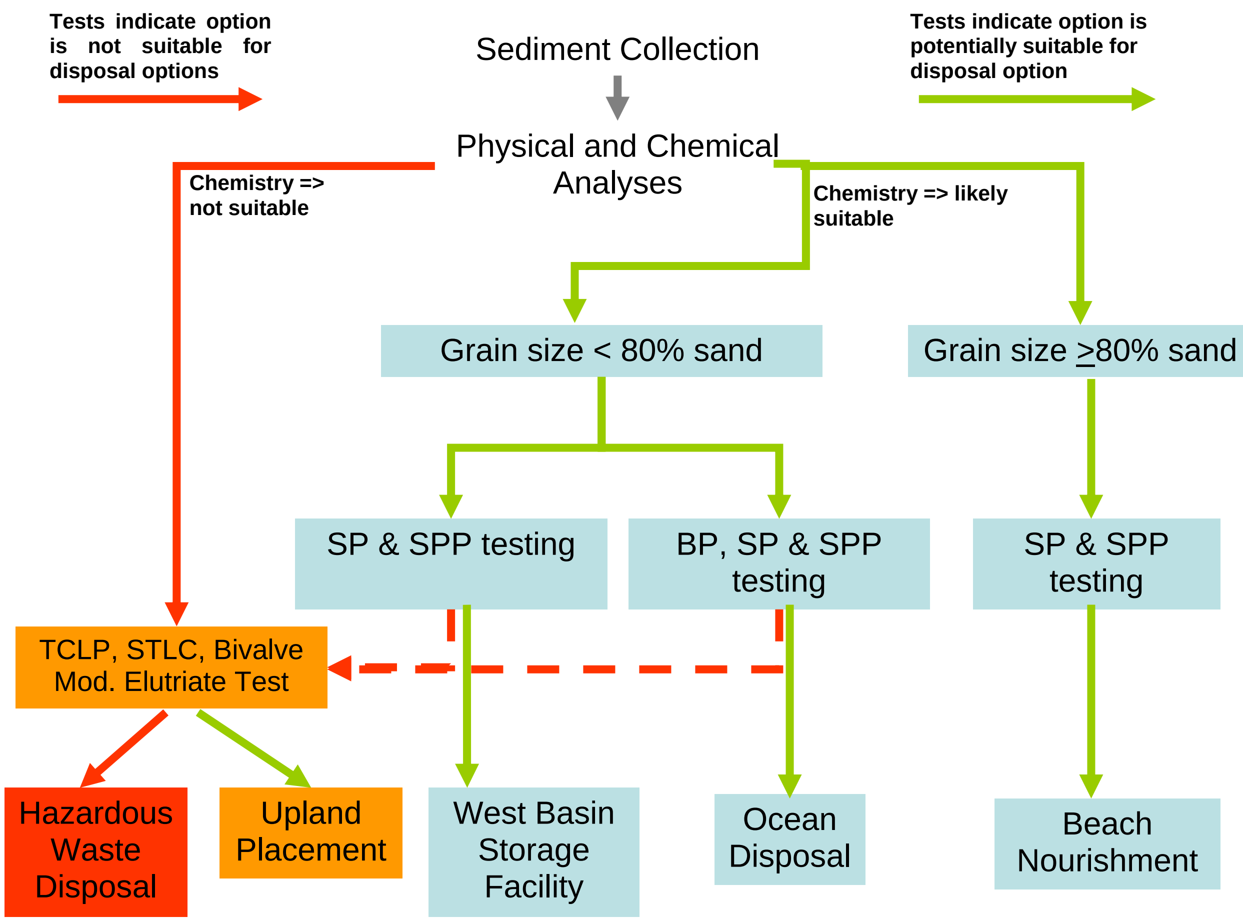

Figure 3. Phased Approach Used to Evaluate Sediment for Various Disposal Options

2.0 MATERIALS AND METHODS

2.1 Field Collection Program for Sediment Core Samples

Initially, the sampling design designated three locations for the collection of sediment core samples within the proposed maintenance dredging footprint along Pier H (Figure 2). Specifically, the original footprint was estimated to extend south of the dolphins along Pier H; however, after sampling and preliminary testing the actual dredge footprint was redefined to include only the area along the Pier H dolphins.

2.1.1 Sample Collection and Handling

Pre-plotted station positions were located using a Differential Global Positioning System (DGPS), accurate to less than 10 ft (3 m). All final station locations were recorded in the field using positions from the DGPS.

Cores were collected using an electric vibracore (Figure 4), which was deployed from the Early Bird II, a 42-ft research vessel. The vibracore was equipped with a 4-inch (~10 cm) outer diameter aluminum barrel and stainless steel catcher to retain sediment. New polyethylene liners were inserted into the tube prior to sampling at each station to eliminate the possibility of cross contamination between stations. Upon retrieval of the vibracore, the liner with sediment core was removed from the aluminum tube and placed in a core tray for processing. The liner was cut vertically along the length of the sediment core and examined by a qualified scientist and photographed. The geologic description of each core included the texture, odor, color, length, and any evident stratification of the sediment. Core logs are provided in Appendix A. All sediment cores were collected to the project depth plus 2 ft. Multiple cores per location were collected to ensure sufficient material (≈ 90 L) for all potential testing and archives.

Sediment for environmental testing was placed into clean plastic bags, labeled, logged onto a field chain of custody (COC) form, and placed into a cooler. Samples remained on ice in the dark until they were delivered to Weston's laboratory in Carlsbad, California, for processing.

Figure 4. Electric Vibracore Sampler

2.1.2 Sample Processing and Storage

The sediment samples were stored at 4°C until processed. Each core sample was homogenized to a uniform consistency. One composite sample was prepared from the three cores. The composite sample was generated by homogenizing sediment to a uniform consistency at the laboratory using a stainless steel mixing apparatus, and was then placed into certified clean glass jars with Teflon-lined lids for chemical and physical analysis. Sediment samples intended for potential bioassay are currently stored at Weston's Carlsbad laboratory at 4^{o}C until follow-on analysis is determined. A sub-sample from each core, as well as the composite, was archived frozen in the event that further delineation of chemical contamination is required.

2.2 Physical and Chemical Analysis

Physical and chemical measurements of sediment in this testing program were selected to provide data on regional contaminants of potential concern in the project samples. All analytical methods used to obtain contaminant concentrations followed United States Environmental Protection Agency (USEPA) or Standard Methods (SMs). The specific sediment analyses, analytical methods, and target detection limits are described in the SAP (Weston and CH2M Hill, 2008). Cores from each station were analyzed for grain size, per the recommendations of the Dredged Material Management Team (DMMT). The composited sample was analyzed for chemical constituents in accordance with the phased testing approach described in the SAP (Weston and CH2M Hill, 2008).

Results of chemical analyses of project material were compared to effects range-low (ER-L) and effects range-median (ER-M) values developed by Long et al. (1995)[1] and total threshold limit concentrations (TTLCs) in accordance with Title 40 Code of Federal Regulations (CFR) part 261 and Title 22 of the California Code of Regulations (CCR).

[1] The effects range values are helpful in assessing the potential significance of elevated sediment-associated contaminants of concern, in conjunction with biological analyses. These values were developed from a large data set where results of both benthic organism effects (e.g., toxicity tests, benthic assessments) and chemical concentrations were available for individual samples. To derive these guidelines, the chemical values for paired data demonstrating benthic impairment were sorted in according to ascending chemical concentration. The 10^{th} percentile of this rank order distribution was identified as the ER-L and the 50^{th} percentile as the ER-M. While these values are useful for identifying elevated sediment-associated contaminants, they should not be used to infer causality because of the inherent variability and uncertainty of the approach.

3.0 PRELIMINARY RESULTS

3.1 Field Results

The number of cores, core locations, core lengths, water depths, and sampling depths at each station are provided in Table 2.

Table 2. Actual Core Locations, Core Lengths, and Sample Depths for Sediment Core Samples Collected from Carnival Cruise Terminal, POLB

Date	Time	Station Identification (ID)	Attempt	Tide (ft)	Water Depth (ft)	MLLW (ft) Water Depth - Tide	Latitude (WGS 84)	Longitude (WSG 84)	Penetration (ft)	Core Length Submitted for Analysis	Composite ID	Composite Analyses**	Comments
11/4/2008	11:50	CT1	1	4.3	33.0	-28.7	33.751439	-118.186862	5.5	4.0	CT	Chemical &Physical	None
11/4/2008	12:00	CT1	2	4.4	33.0	-28.6	33.751439	-118.186862	5.5	4.0			None
11/4/2008	12:20	CT1	3	4.5	33.0	-28.5	33.751439	-118.186862	5.5	4.0			None
11/4/2008	10:30	CT2	1	4.0	31.8	-27.8	33.749339	-118.186911	5.5	4.5			None
11/4/2008	10:45	CT2	2	4.0	31.8	-27.8	33.749339	-118.186911	6.0	4.0			None
11/4/2008	10:55	CT2	3	4.1	31.8	-27.7	33.749339	-118.186911	5.0	3.5			None
11/4/2008	11:05	CT2	4	4.2	31.8	-27.6	33.749339	-118.186911	5.0	0			No recovery; bag liner folded inside tube
11/4/2008	11:18	CT2	5	4.2	31.8	-27.6	33.749339	-118.186911	6.0	4.0			None
11/4/2008	9:10	CT3	1	3.8	33.6	-29.8	33.748451	-118.186921	5.5	4.5			None
11/4/2008	9:40	CT3	2	3.9	33.6	-29.7	33.748451	-118.186921	5.5	4.0			None
11/4/2008	10:02	CT3	3	3.9	33.6	-29.7	33.748451	-118.186921	5.5	4.0			None

3.2 Results of Physical and Chemical Analyses

3.2.1 Grain Size Distribution

The grain size distributions of the three individual samples were similar among stations, demonstrating elevated concentrations of silt (Table 3). The sample from station CT1 consisted of 85.8% fine-grained materials (61.7% silt, and 24.1% clay), and 14.22% coarse-grained materials (0.02% gravel and 14.2% sand). The sample from station CT2 consisted of 77.0% fine-grained materials (61.5% silt, and 15.5% clay), and 23.0% coarse-grained materials (0.00% gravel and 23.0% sand). The sample from station CT3 consisted of 98.4% fine-grained materials (64.6% silt, and 33.8% clay), and 1.6% coarse-grained materials (0.00% gravel and 1.6% sand).

Table 3. Grain Size Distribution of Sediment Samples from Three Locations

Parameter	CT1	CT2	CT3
Grain Size Distribution			
% gravel	0.02	0.00	0.00
% sand	14.2	23.0	1.6
% silt	61.7	61.5	64.6
% clay	24.1	15.5	33.8

3.2.2 Sediment Chemistry Results

Results of physical and chemical analyses are shown in Table 4. TTLCs are not shown because no analytes exceeded their respective TTLC value.

In the CT composite sample, total organic carbon (TOC) was measured at 0.69%. Heavy metals were detected at low levels in the composite sample. Five metals (cadmium, chromium, mercury, silver, and zinc) were below their respective ER-L values. Four metals (arsenic, copper, lead, nickel) exceeded their respective ER-L value but were below the corresponding ER-M value. Eighteen individual polycyclic aromatic hydrocarbons (PAHs) were detected in the composite sample. All PAHs were below ER-L values, with the exception of dibenz[a,h]anthracene, which was slightly above it's ER-L value, but below the ER-M value. The concentration of total detectable PAHs were also well below their respective ER-L value. Four individual polychlorinated biphenyl (PCB) congeners were detected at low levels in the composite sample. Total detectable PCBs were below their respective ER-L value. The only chlorinated pesticides detected in the composite sample were dichlorodiphenyltrichloroethane (DDT) derivatives. Concentrations of 4,4'-DDD, 4,4'-DDE, and total detectable DDTs exceeded their respective ER-M values.

To confirm this finding (i.e., elevated DDTs) and to further assess individual station locations (if possible) for pesticides and PCBs within the revised dredge footprint, the individual core from station CT1 was submitted for additional chemistry analyses. Results of this analysis demonstrated similar concentrations of DDTs and PCBs in CT1, relative to the initially analyzed composite sample. In addition to DDT, chlordane and some of its constituents (alpha- and gamma-chlordane, and cis- and trans-nonachlor) were also detected in CT1 and total chlordane exceeded the ER-M value. A review of quality assurance (QA)/quality control (QC) results for chlorinated pesticides and the chromatograms confirmed the findings.

Analyses have also been performed to evaluate the concentration of other analytes including phthalates, phenols, and organotins. Results will be presented in the final report.

Table 4. Results of Physical and Chemical Analyses

Parameter	Units	ERL value	ERM value	CT_Comp	CT1
General Chemistry					
Ammonia-N	mg/dry kg			8.75	
Dissolved Sulfides	mg/dry kg			<0.2	
Percent Solids	Percent			61.8	
Total Organic Carbon	Percent			0.69	
Total Sulfides	mg/dry kg			130.4	
Specific Gravity				2.63	
Trace Metals					
Arsenic (As)	µg/dry g	8.2	70	10.66	
Cadmium (Cd)	µg/dry g	1.2	9.6	0.777	
Chromium (Cr)	µg/dry g	81	370	51.68	
Copper (Cu)	µg/dry g	34	270	47.77	
Lead (Pb)	µg/dry g	46.7	218	59.52	
Mercury (Hg)	µg/dry g	0.15	0.71	0.12	
Nickel (Ni)	µg/dry g	20.9	51.6	33.72	
Selenium (Se)	µg/dry g			0.278	
Silver (Ag)	µg/dry g	1	3.7	0.353	
Zinc (Zn)	µg/dry g	150	410	132.9	
PCBs					
Aroclor 1016	ng/dry g			<10	
Aroclor 1221	ng/dry g			<10	
Aroclor 1232	ng/dry g			<10	
Aroclor 1242	ng/dry g			<10	
Aroclor 1248	ng/dry g			<10	
Aroclor 1254	ng/dry g			<10	
Aroclor 1260	ng/dry g			<10	
PCB003	ng/dry g			<1	
PCB008	ng/dry g			<1	
PCB018	ng/dry g			<1	
PCB028	ng/dry g			<1	
PCB031	ng/dry g			<1	
PCB033	ng/dry g			<1	
PCB037	ng/dry g			<1	
PCB044	ng/dry g			<1	
PCB049	ng/dry g			<1	
PCB052	ng/dry g			7.7	
PCB056/060	ng/dry g			<1	
PCB066	ng/dry g			6.6	
PCB070	ng/dry g			2.1	
PCB074	ng/dry g			1.9	
PCB077	ng/dry g			<1	
PCB081	ng/dry g			<1	
PCB087	ng/dry g			<1	
PCB095	ng/dry g			<1	
PCB097	ng/dry g			<1	
PCB099	ng/dry g			<1	
PCB101	ng/dry g			<1	
PCB105	ng/dry g			<1	
PCB110	ng/dry g			<1	
PCB114	ng/dry g			<1	
PCB118	ng/dry g			<1	
PCB119	ng/dry g			<1	
PCB123	ng/dry g			<1	
PCB126	ng/dry g			<1	
PCB128	ng/dry g			<1	

Parameter	Units	ERL value	ERM value	CT_Comp	CT1
PCB138	ng/dry g			<1	
PCB141	ng/dry g			<1	
PCB149	ng/dry g			<1	
PCB151	ng/dry g			<1	
PCB153	ng/dry g			<1	
PCB156	ng/dry g			<1	
PCB157	ng/dry g			<1	
PCB158	ng/dry g			<1	
PCB167	ng/dry g			<1	
PCB168+132	ng/dry g			<1	
PCB169	ng/dry g			<1	
PCB170	ng/dry g			<1	
PCB174	ng/dry g			<1	
PCB177	ng/dry g			<1	
PCB180	ng/dry g			<1	
PCB183	ng/dry g			<1	
PCB187	ng/dry g			<1	
PCB189	ng/dry g			<1	
PCB194	ng/dry g			<1	
PCB195	ng/dry g			<1	
PCB200	ng/dry g			<1	
PCB201	ng/dry g			<1	
PCB203	ng/dry g			<1	
PCB206	ng/dry g			<1	
PCB209	ng/dry g			<1	
Total PCBs	ng/dry g	22.7	180	18.3	
Pesticides					
2,4'-DDD	ng/dry g			<1	3.2
2,4'-DDE	ng/dry g			<1	4.6
2,4'-DDT	ng/dry g			<1	<1
4,4'-DDD	ng/dry g	2	20	25.5	15.3
4,4'-DDE	ng/dry g	2.2	27	37.3	27.8
4,4'-DDT	ng/dry g	1	7	<1	<1
Total DDTs	ng/dry g	1.58	46.1	62.8	50.9
Aldrin	ng/dry g			<1	<1
BHC-alpha	ng/dry g			<1	<1
BHC-beta	ng/dry g			<1	<1
BHC-delta	ng/dry g			<1	<1
BHC-gamma	ng/dry g			<1	<1
Chlordane-alpha	ng/dry g			<1	6.7
Chlordane-gamma	ng/dry g			<1	7.9
Total Detectable Chlordane	ng/dry g	0.5	6	0	14.6
DCPA (Dacthal)	ng/dry g			<5	<5
Dicofol	ng/dry g			<1	3
Dieldrin	ng/dry g			<1	<1
Endosulfan Sulfate	ng/dry g			<1	<1
Endosulfan-I	ng/dry g			<1	<1
Endosulfan-II	ng/dry g			<1	<1
Endrin	ng/dry g			<1	<1
Endrin Aldehyde	ng/dry g			<1	<1
Endrin Ketone	ng/dry g			<1	<1
Heptachlor	ng/dry g			<1	<1
Heptachlor Epoxide	ng/dry g			<1	<1
Methoxychlor	ng/dry g			<1	<1
Mirex	ng/dry g			<1	<1
Oxychlordane	ng/dry g			<1	<1
Perthane	ng/dry g			<5	<5

Parameter	Units	ERL value	ERM value	CT_Comp	CT1
Toxaphene	ng/dry g			<10	<10
cis-Nonachlor	ng/dry g			<1	2.3
trans-Nonachlor	ng/dry g			<1	4
Phenols					
2,4,6-Trichlorophenol	ng/dry g			<50	
2,4-Dichlorophenol	ng/dry g			<50	
2,4-Dimethylphenol	ng/dry g			<100	
2,4-Dinitrophenol	ng/dry g			<100	
2-Chlorophenol	ng/dry g			<50	
2-Methyl-4,6-dinitrophenol	ng/dry g			<100	
2-Nitrophenol	ng/dry g			<100	
4-Chloro-3-methylphenol	ng/dry g			<100	
4-Nitrophenol	ng/dry g			<100	
Pentachlorophenol	ng/dry g			<50	
Phenol	ng/dry g			<100	
Phthalates					
Butylbenzyl Phthalate	ng/dry g			50	
Di-n-butyl Phthalate	ng/dry g			<75	
Di-n-octyl Phthalate	ng/dry g			<10	
Diethyl Phthalate	ng/dry g			<100	
Dimethyl Phthalate	ng/dry g			<50	
bis(2-Ethylhexyl) Phthalate	ng/dry g			546	
Organotins					
Dibutyltin	ng/dry g			<1	
Monobutyltin	ng/dry g			<1	
Tetrabutyltin	ng/dry g			<1	
Tributyltin	ng/dry g			<1	
Polynuclear Aromatic Hydrocarbons					
1-Methylnaphthalene	ng/dry g			<1	
1-Methylphenanthrene	ng/dry g			<1	
2,3,5-Trimethylnaphthalene	ng/dry g			<1	
2,6-Dimethylnaphthalene	ng/dry g			6.2	
2-Methylnaphthalene	ng/dry g			1.6	
Acenaphthene	ng/dry g			<1	
Acenaphthylene	ng/dry g			4.2	
Anthracene	ng/dry g			14.4	
Benz[a]anthracene	ng/dry g			36.2	
Benzo[a]pyrene	ng/dry g			84.6	
Benzo[b]fluoranthene	ng/dry g			64.4	
Benzo[e]pyrene	ng/dry g			62	
Benzo[g,h,i]perylene	ng/dry g			103.3	
Benzo[k]fluoranthene	ng/dry g			47.7	
Biphenyl	ng/dry g			<1	
Chrysene	ng/dry g			55.5	
Dibenz[a,h]anthracene	ng/dry g			73.6	
Dibenzothiophene	ng/dry g			<1	
Fluoranthene	ng/dry g			45.1	
Fluorene	ng/dry g			<1	
Indeno[1,2,3-c,d]pyrene	ng/dry g			122.5	
Naphthalene	ng/dry g			1.8	
Perylene	ng/dry g			39.5	
Phenanthrene	ng/dry g			17	
Pyrene	ng/dry g			54.2	
Total PAHs	ng/dry g	4022	44792	833.8	

3.2.3 TCLP Chemistry Results

Analysis is in progress. Results will be applicable to Port of Long Beach and the eventual beneficial use as construction fill.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the elevated concentrations of fine-grained material (i.e. >60% silt) from samples collected as part of this study, the material to be dredged is not suitable for beach replenishment. Material recommended for beach replenishment is greater than 80% sand.

Concentrations of total DDTs (and derivatives) and total chlordane exceeded ER-M values in the composite or individual core sample, respectively. As a consequence, this material may not be suitable for ocean disposal at the EPA designated disposal site (LA2).

The management option recommended for consideration is placement of potential dredged material from the Carnival Cruise Terminal at the Pier S temporary dewatering facility. Following dewatering, the material is proposed for beneficial use as construction fill for future construction projects.

5.0 REFERENCES

Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management, 19:81-97.

USEPA (United States Environmental Protection Agency). 2006. CFR Title 40: Protection of Environment. Available online at: http://www.epa.gov/epahome/cfr40.htm.

WESTON and CH2M Hill. 2008. Sampling and Analysis Plan, Dredged Material Evaluation at the Carnival Cruise Terminal within the Port of Long Beach. Long Beach, CA. October.