Review and Evaluation of Tentative Clean-Up and Abatement Order (No. R9-2011-001) for the Shipyard Sediment Site, San Diego Bay, San Diego, California

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Prepared on Behalf of:

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List of Acronyms

AET	-	apparent effects threshold
BAP	-	benzo(a)pyrene
BMP	-	best management practice
COC	-	chemical of concern
DO	-	dissolved oxygen
DTR	-	Draft Technical Report
DW	-	dry weight
ERM	-	effects range median
HPAHs	-	high molecular weight polynuclear aromatic hydrocarbons
LAETs	-	lowest apparent effects threshold
LDEQ	-	Louisiana Department of Environmental Quality
LOE	-	line-of-evidence
MESL	-	MacDonald Environmental Sciences Ltd.
ND	-	no data
NOAA	-	National Oceanic and Atmospheric Administration
PCBs	-	polychlorinated biphenyls
Pmax	-	maximum probability model.
QAPP	-	Quality Assurance Project Plan
RAO	-	remedial action objective
S	-	survival
SAP	-	Sampling and Analysis Plan
SCSA	-	sediment confirmation sampling area
SFF	-	Sustainable Fisheries Foundation
SMU	-	sediment management unit
SQGQ	-	sediment quality guideline quotient
SQG	-	sediment quality guideline
SQT	-	sediment quality triad
SS-MEQ	-	site-specific median effects quotient
SWAC	-	Surface-Area Weighted Average Concentration
TBT	-	tributyltin
TCAO	-	Tentative Clean-Up and Abatement Order
TMDL	-	total maximum daily load
TRV	-	tissue residue value
UCL	-	upper confidence limit
USDOJ	-	United States Department of Justice
USEPA	-	United States Environmental Protection Agency
USFWS	-	United States Fish and Wildlife Service
WQC	-	water quality criteria

Expert Report of Donald D. MacDonald Regarding the Tentative Clean-Up and Abatement Order (No. R9-2011-0001) for the Shipyard Sediment Site, San Diego Bay, San Diego, CA

A. Qualifications

1. I, Donald Douglas MacDonald, am the principal of MacDonald Environmental Sciences Ltd. (MESL) and Canadian Director of the Sustainable Fisheries Foundation (SFF). The Canadian offices of both organizations are located in Nanaimo, British Columbia, Canada.

2. I am a Registered Professional Biologist, a member of the British Columbia College of Applied Biology, and a Certified Fisheries Practitioner.

3. I am an expert in the field of ecological risk assessment, natural resource damage assessment, and ecosystem-based management. I specialize in designing and conducting investigations to evaluate the effects of contaminated sediment on ecological receptors, including benthic invertebrates, fish, and aquatic-dependent wildlife. I also specialize in the design and implementation of environmental quality monitoring programs.

4. I received my Bachelor of Science in Zoology in 1981 from the University of British Columbia, which is located in Vancouver, British Columbia.

5. Between 1982 and 1989, I was employed by a federal government agency (Environment Canada) as a Technical Planning Coordinator and as a Physical Scientist.

6. MESL was incorporated in 1989 and I have worked as an independent consultant over the past 21 years. Over that period, I have provided specialized consulting services to a wide range of clients in Canada, the United States, and elsewhere, including federal, state, provincial, and tribal government agencies, academic institutions, non-governmental organizations, and industry.

7. Over my professional career, I have authored over 300 primary journal articles, book chapters, and technical reports on a wide range of topics related to environmental assessment and management. In addition, I have edited several books that were published by various scientific organizations.

8. I have designed, conducted, and/or provided technical oversight on numerous ecological risk assessments and/or natural resources damage assessments at sediment-contaminated sites in North America. The tasks that were completed at several of these sites are briefly described to illustrate relevant experience in contaminated site assessment and remediation. My experience in the design and implementation of environmental monitoring programs is also briefly described.

    a. The Calcasieu Estuary site is located in the vicinity of Lake Charles, LA. At this site, I have conducted a baseline ecological risk assessment (2000-2002), developed preliminary remediation goals (i.e., clean-up goals) and evaluated post-remedial risks (2003), conducted a natural resource damage assessment (2005), evaluated the effects of the Citgo oil spill (2006), estimated ecological service losses in Bayou d'Inde (2009 - 2010), and provided advice on post-remediation monitoring (2010). To support these projects, I designed and implemented two sediment and biota sampling programs to provide the data and information needed to evaluate risks and/or injury to benthic invertebrates, fish, birds and mammals associated with exposure to metals, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofuran, and other contaminants. Clients included United States Environmental Protection Agency (USEPA), National Oceanic and Atmospheric Administration (NOAA), United States Fish and Wildlife Service (USFWS), and Louisiana Department of Environmental Quality (LDEQ).

b. The Tri-State Mining District is located in the Spring and Neosho river basins of Kansas, Missouri, and Oklahoma. At this site, I prepared the sampling and analysis plan to support evaluation of the effects on benthic invertebrates associated with exposure to contaminated sediments. The resultant data were used to develop concentration-response models and toxicity thresholds for selected chemicals of potential concern and contaminant mixtures. I used these data, including the toxicity thresholds, to evaluate risks to benthic invertebrates utilizing habitats throughout the study area. I have also developed sediment injury thresholds to support a natural resource damage assessment of the site (2006-2011). Clients included USEPA and USFWS.

c. The Upper Columbia River is located between the Canada-U.S. border and Grand Coulee Dam in Washington State. At this site, I developed numerical sediment quality standards to support sediment management initiatives in the study area (2002). I have also provided USEPA with oversight support on the remedial investigation that was being conducted by the Discharger (2005-2010). This work included development of a problem formulation document, establishing expectations for data collection, reviewing and evaluating of sampling and analysis plans, providing oversight of laboratory toxicity testing programs, and reviewing environmental data and information. I have also supported the Natural Resources Trustees by contributing to the Natural Resource Damage Assessment Plan, reviewing settlement offers, and interpreting matching sediment chemistry and toxicity data from the site (2010-2011). Clients included USEPA, USFWS, Washington Department of Ecology, and the Confederated Tribes of the Colville Reservation.

d. The Indiana Harbor site is located in the vicinity of Gary, Indiana. Activities at the Indiana Harbor site have included reviewing and evaluating historical data and information, conducting a natural resource damage assessment, developing remedial action objectives, deriving preliminary remedial goals (i.e., clean-up goals), reviewing remedial alternatives, and predicting post-remedial risks to ecological receptors (1998-2007). Clients included United States Department of Justice and USFWS.

e. The Quathiaski Cove is located on Quadra Island, British Columbia. At this site, I have designed and implemented environmental sampling programs, evaluated the nature and extent of contamination, assessed risks to ecological receptors, developed numerical clean-up goals, reviewed and evaluated remedial alternatives, provided oversight during remediation, evaluated confirmation monitoring data, oversaw site restoration, prepared applications for certificates of compliance (2005-2011). The client was Weston Foods Canada.

f. I have also conducted investigations to assess risks and/or natural resource injury at the Passaic River-Newark Bay Complex (NJ), Hudson River site (NY), Bloomington PCB site (IN), Piles Creek site (NJ), Cornell-Dubilier site, NJ, Vermont Asbestos site (VT), Anniston PCB site (AL), Sauget site (IL), Crofton site (BC), Portland Harbor site (OR), and others. Furthermore, I have designed and/or implemented environmental monitoring programs (i.e., for water, sediment, and/or biota) for the Fraser River and Estuary (BC), Columbia River (BC), Flathead River (BC), Similkameen River (BC), Thompson River (BC), Kootenay River (BC), Strait of Juan de Fuca (BC), Slave River (NWT), Liard River (NWT), Peel River (NWT), Presque Isle Bay (PA), Delaware River (PA, DE), and Tampa Bay (FL).

9. An accurate copy of my Curriculum Vitae is included as Appendix 1 of this expert report.

10. In 2009, I authored “Development of a Sediment Remediation Footprint to Address Risks to Benthic Invertebrates and Fish in the Vicinity of the Shipyards Sediment Site in San Diego Bay, California.” This report provided an alternative approach to identifying a remediation footprint that would address impacts on benthic invertebrates and benthic fish utilizing aquatic habitats in the vicinity of the Shipyard Sediment Site. The remediation footprint presented in that document was intended to

complement the remediation footprint that was being developed for addressing risks to human health and aquatic-dependent wildlife.

11. This expert report contains my expert opinions, which I hold to a reasonable degree of scientific certainty. My opinions are based on application of professional judgment, training, experience, knowledge of facts or data related to my fields of expertise, as well as consultation with a qualified expert on Total Maximum Daily Loads (Barry W. Sulkin, M.S.), as applied to the review of the Tentative Clean-Up and Abatement Order and Draft Technical Report that were issued by the San Diego Water Board in 2010. These facts and data are typically and reasonably relied upon by experts in my field.

B. Summary of Expert Opinion

In my expert opinion, the remedial actions required under the Tentative Clean-Up and Abatement Order (No. R9-2011-0001; hereafter referred to as the "TCAO") and Draft Technical Report for Tentative Clean-Up and Abatement Order (No. R9-2011-0001; hereafter referred to as the "DTR") for the Shipyard Sediment Site, San Diego Bay, San Diego, California will likely result in improvements in sediment quality conditions at the site. However, there are a number of issues that must be addressed to ensure that the clean-up results in pollutant concentrations that do not unreasonably affect San Diego Bay beneficial uses. These issues include:

1. The Proposed Remedial Footprint does not include all of the polygons that meet the requirements for clean-up according to the methodology described in the DTR. Therefore, the Proposed Remedial Footprint should be expanded to include all of the polygons that meet the selection criteria.

2. Limitations on the establishment and implementation of the Alternative Clean-Up Levels make it difficult to determine if San Diego Bay beneficial uses will be unreasonably affected by the post-remedial contamination levels. To assure that beneficial uses are protected, Remediation Monitoring and Post-Remedial Monitoring must be improved to ensure that the Alternative Clean-Up Levels are achieved at the Shipyard Sediment Site following remediation.

3. The requirements for Remediation Monitoring, as specified in Section B.1.l of the TCAO and in Section 34.1 of the DTR, do not mandate development and implementation of a Remediation Monitoring plan that will provide the data and information needed to assess compliance with water quality standards, to evaluate the effectiveness of remedial measures, or to identify the need for further dredging to achieve clean-up goals at the Shipyard Sediment Site. Therefore, the Remediation Monitoring requirements must be revised to address each of these issues.

4. The requirements for Post Remedial Monitoring, as specified in Section D of the TCAO and in Section 34.2 of the DTR, do not mandate development and implementation of a Post Remedial Monitoring plan that will provide the data and information needed to determine if the pollutant concentrations remaining in the sediments will not unreasonably affect San Diego Bay beneficial uses. In other words, the current Post Remedial Monitoring requirements do not require collection of the data and information needed to evaluate the effectiveness of remedial measures and to identify the need for further remediation to achieve clean-up goals at the Shipyard Sediment Site. Therefore, the Post Remedial Monitoring results cannot be used to objectively evaluate the effectiveness of the remedial measures or to assess the need for further remediation to achieve the clean-up goals at the Shipyard Sediment Site.

5. The Trigger Exceedance Investigation and Characterization process, described in Section D.4 of the TCAO and DTR, will not provide a basis for compelling the persons responsible for discharging contaminants of concern to conduct further remediation to achieve clean-up goals at the Shipyard Sediment Site.

C. Expert Opinion #1: Proposed Remedial Footprint

The Proposed Remedial Footprint does not include all of the polygons that meet the requirements for clean-up according to the methodology described in the DTR. Therefore, the Proposed Remedial Footprint should be expanded to include all of the polygons that meet the selection criteria.

C.1 Description of Methodology Used

The Proposed Remedial Footprint—the portion of the site that is targeted for remediation—is described in Section 33 and shown in Attachment 2, 3, and 4 of the TCAO. Section 33 of the DTR describes the process that was used to identify the polygons that were included in the Proposed Remedial Footprint. Briefly, this process involved the following steps:

- A number of polygons, termed Thiessen Polygons, were created using information on the locations of the stations where sediments were sampled by the Dischargers. *See* Exponent (2003) for details on the creation of Thiessen Polygons. Each Thiessen Polygon is intended to define the area of influence around its sampling point, so that any location inside the polygon is closer to its sampling point than it is to any of the other sampling points;

- After dividing the site into polygons, the Proposed Remedial Footprint was established by evaluating the available data for each station. According to the TCAO, the Proposed Remedial Footprint was established by identifying all of the polygons that had sediment pollutant levels likely to adversely affect the health of the benthic community and by ranking each polygon based on the level of contamination by the five primary chemicals of concern (COCs);

- Polygons with contaminant concentrations sufficient to adversely affect the health of the benthic community were identified in two ways. For those stations for which sediment quality triad data were available—sediment chemistry, sediment toxicity, and benthic invertebrate community structure—any polygon that was identified as "Likely" impaired was included in the Proposed Remedial Footprint, while "Possibly" impaired polygons were further evaluated to determine their priority for inclusion. *See* Table 18-14 of the DTR for more information on the weight-of-evidence framework that was used in the aquatic life impairment assessment. For non-Triad stations, sediment chemistry data alone were used to identify polygons for inclusion in the Proposed Remedial Footprint. More specifically, all non-triad stations exceeding the 60% lowest apparent effect threshold (LAET) values for the five primary COCs[1] or a site-specific median effects quotient (SS-MEQ) value of 0.9 were designated for remediation. The SS-MEQ was calculated by averaging the quotients derived for the five primary COCs. This was determined by dividing the measured concentration of the COC by the median concentrations of that COC in six triad samples, three of which were designated as likely impaired and three of which were designated as possibly impaired;

- The concentrations of the five primary COCs were also used to calculate a Composite Surface-Area Weighted Average Concentration (SWAC) Ranking Value for each polygon. In this approach, Composite SWAC Ranking Values were calculated for each polygon by dividing the concentration of each COC by the pre-remedial SWAC for that COC and summing the quotients that were calculated for the five primary COCs. This index of contamination was used to identify the most contaminated polygons that should be removed on a "worst first" basis. Such polygons were included in the Proposed Remedial Footprint on a priority basis. The polygons included in the Proposed Remedial Footprint had Composite SWAC Ranking Values ranging from 5.5[2] to 46.6.

- Finally, a number of polygons were excluded from the Proposed Remedial Footprint based on other considerations, including the results of triad evaluation or technical infeasibility. Station NA22 was excluded from the Proposed Remedial Footprint because a total maximum daily load (TMDL) is being developed for the mouth of Chollas Creek.

Using this procedure, 23 polygons were included in the Proposed Remedial Footprint. These polygons have composite SWAC Ranking Values greater than or equal to 5.5 and/or SS-MEQ greater than or equal to 0.9.

C.2 Evaluation of the Methodology Used

The methods used to identify polygons for inclusion in the Proposed Remedial Footprint are described in the TCAO and in the DTR. Evaluation of these methods indicates that there are a number of limitations of

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[1] Copper of 552 mg/kg, mercury of 2.67 mg/kg, high molecular weight polynuclear aromatic hydrocarbons (HPAH) of 15.3 mg/kg, polychlorinated biphenyls, of 3.27 mg/kg, and tributyltin (TBT) of .11 mg/kg; *See* DTR Table 32-19

[2] While DTR Table 33-1 lists the lowest Composite SWAC Ranking Value as 5.5, Appendix Tables A33-1 and A33-2 list the lowest Composite SWAC Ranking Value as 5.4.

the underlying data and of the selection criteria that substantially influence the selection of polygons for inclusion in the Proposed Remedial Footprint including:

C.2.1 The sampling density is insufficient to accurately characterize the nature and extent of contamination at this type of site.

According to the TCAO and DTR, sediment samples were collected at only one location within each Thiessen Polygon. Yet, examination of the underlying sediment chemistry data indicates that there is substantial variability in contaminant concentrations across the site. More specifically, the concentrations of COCs typically varied by two orders of magnitude or more among sampling stations. *See* Table A33-3 of the DTR for more information on the variability of COC concentrations. Substantial variability was also evident for adjacent polygons. For example, the pre-remedy average surface sediment concentration of PAHs was 23.41 mg/kg DW at SW10.[3] In the adjacent polygons, PAH concentrations ranged from 7.0 to 15.0 mg/kg DW.

To address concerns regarding spatial variability in sediment chemistry, investigators frequently design sediment sampling programs to provide a high density of samples in the vicinity of point source discharges of contaminants. At Quathiaski Cove in British Columbia, for example, I collected sediment chemistry data at 82 stations to characterize a five-acre water lot at a shipyard site resulting in a sampling density of 17 stations per acre (MacDonald *et al.* 2008). By comparison, sediment chemistry data for 66 sampling locations were used to characterize about 148 acres at the Shipyard Sediment Site in San Diego Bay—a sampling density of 0.44 stations per acre. In some cases, such as NA21 and NA25, data from a single sediment sampling location was used to characterize over 11 acres of benthic habitat. Hence, sediment sampling conducted at the Shipyard Sediment Site was inadequate to accurately characterize the nature and extent of sediment contamination. The uncertainty in the nature and extent of contamination means that there is uncertainty in the protectiveness of the Proposed Remedial Footprint.

C.2.2 The Composite SWAC Ranking Value provides a consistent, but incomplete, basis for ranking polygons for inclusion in the Proposed Remedial Footprint.

As indicated above, the Composite SWAC Ranking Value was calculated using data on the pre-remedy average surface sediment concentrations of the five primary COCs for each polygon and on the SWACs of these COCs for the entire site. Accordingly, this index of contamination provides information on the magnitude of contamination at each location relative to the average concentration of the five primary COCs at the site. However, it is important to understand that this index does not provide a basis for evaluating the potential for adverse effects on human health or the environment. In addition, the index does not consider the concentrations of other contaminants that could be elevated in sediments from the site. Specifically, lead, zinc, low molecular weight (L) PAHs all exceed toxicity thresholds in surficial sediments at one or more sampling stations. *See* DTR Table A33-3.

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[3] *See* DTR Table A33-3, column "Fairey 13 total PAH - half detection limit"

C.2.3 The Composite SWAC Ranking Value was not applied consistently to identify polygons for inclusion in the Proposed Remedial Footprint.

According to the DTR, the lowest composite SWAC Ranking Value for stations included in the Proposed Remedial Footprint was 5.5. However, a total of 15 stations with Composite SWAC Ranking Values higher than 5.5 were not included in the Proposed Remedial Footprint. *See* Tables A33-1 and A33-2 of the DTR.

Table 33-6 of the DTR provides the rationale for excluding five of the fifteen polygons with Composite SWAC Ranking Values greater than 5.5 from the Proposed Remedial Footprint. However, the rationale provided in Table 33-6 is not always correct. For example, the rationale for excluding NA07 indicates that the concentrations of all COCs are below 60% LAET values. Yet, Table A33-3 indicates that high molecular weight (H) PAH levels in surficial sediments were 15.85 mg/kg DW at NA07, which exceeds the 60% LAET value of 15.3 mg/kg DW for HPAH. *See* Table 32-19. In addition, the rationale provided in Table 33-6 indicates that sediments from NA07 had low toxicity and low benthic impacts, but no benthic invertebrate community structure data were included for NA07 in the triad database that was provided by the San Diego Regional Board.

Furthermore, Table 33-6 fails to provide an explanation for excluding ten polygons with Composite SWAC Ranking Values greater than 5.5 from the Proposed Remedial Footprint. Therefore, the rationale provided in Table 33-6 of the DTR for excluding stations with Composite SWAC Ranking Values greater than 5.5 is arbitrary and does not justify the exclusions.

C.2.4 There is insufficient evidence to demonstrate that the SS-MEQ threshold (0.9) provides a reliable basis for identifying polygons that are "Likely" impacted and hence, should be included in the Proposed Remedial Footprint. Without clear and convincing evidence in the record demonstrating that 0.9 is an appropriate threshold, it is not possible to demonstrate that the polygons included in the Proposed Remedial Footprint are sufficient to protect existing and reasonably foreseeable beneficial uses of San Diego Bay.

According to the information provided in Section 33.1.3 of the DTR, non-Triad stations with SS-MEQ values greater than 0.9 were predicted to be "Likely" impacted and included in the Proposed Remedial Footprint. However, the technical basis for selecting 0.9 as the threshold for "Likely" impacted sediment samples is not described in Section 32.5.2 of the DTR. Rather, the text indicates that a threshold of 0.9 had 73% overall reliability.[4] While the results of the reliability evaluation are presented in Table 32-21, the underlying data are not provided. Therefore, it is not possible to determine if alternate thresholds for SS-MEQ would have higher or lower reliability. Therefore, it is uncertain if the selected SS-MEQ threshold provides the most reliable tool for identifying non-Triad stations that are "Likely" impacted.

In addition, Table 33-2 of the DTR indicates that supporting calculations for SS-MEQ values are presented in Appendix 33, yet no such calculations are provided in Tables A33-1 to A33-8. Failure to provide the calculations of SS-MEQ values for each polygon prevents reviewers from determining if stations with SS-MEQ values greater than 0.9 have been excluded from the Proposed Remedial Footprint.

C.2.5 There is insufficient evidence to demonstrate that the 60% LAET values provide a reliable basis for identifying polygons that are "Likely" impacted and, hence, should be included in the Proposed Remedial Footprint.

Importantly, the 60% LAET values presented in Table 32-19 are substantially higher than the sediment quality guidelines that were used in the Triad assessment presented in the DTR and those that have been routinely used to evaluate sediment quality conditions at marine and estuarine sites throughout the United States (Table 1).

[4] DTR Table 32-21 reports this value as 70%.

TABLE 1. COMPARISON OF 60% LAET VALUES TO EFFECTS RANGE MEDIAN (ERM) VALUES

Priority COC	60% LAET Value	ERM Value[1]
Copper	552 mg/kg DW	270 mg/kg DW
Mercury	2.67 mg/kg DW	0.71 mg/kg DW
HPAH	15.3 mg/kg DW	9.6 mg/kg DW
TPCB	3.27 mg/kg DW	0.18 mg/kg DW
TBT	1.1 mg/kg DW	0.06 mg/kg OC[2]

[1]From Long *et al.* (1995)
[2]From Meador *et al.* (2002): Reported as 6000 ng/g OC, which was converted to 0.06 mg/kg assuming an organic carbon content of 1%.

According to the information provided in Section 32.5.2 of the DTR, additional sampling was conducted in 2009 to provide the data needed to determine if the 60% LAET and SS-MEQ thresholds could reliably predict the likelihood of sediment quality impacts to the benthic community at the Shipyard Sediment Site. Sediment samples were collected at five stations located outside the Proposed Remedial Footprint and submitted for chemical analysis, toxicity testing, and benthic invertebrate community analysis. Based on comparisons of the measured concentrations of COCs to the 60% LAET and to the SS-MEQ threshold (0.9), it was predicted that none of the samples would be "Likely" impacted. All five samples were classified as "Unlikely" impacted or "Possibly" impacted based on examination of the sediment chemistry, sediment toxicity, and benthic community. Hence, it was concluded that the 60% LAET and the SS-MEQ threshold provided reliable predictors of likely benthic impairment at the Shipyard Sediment Site.

This conclusion is invalid for the following reasons:

- A scientifically-defensible evaluation of the reliability of the 60% LAET values and SS-MEQ threshold requires data on chemical composition, toxicity, and benthic community structure for substantially more than five sediment samples. Such evaluations of reliability or predictive ability are typically conducted with matching sediment chemistry and toxicity data on at least 50 sediment samples. For example, at the Tri-State Mining District and Calcasieu Estuary sites, 70 to 100 sediment samples were used to evaluate reliability of the toxicity thresholds (MacDonald et al. 2002; 2009; 2010).

- The samples that were collected to support the reliability assessment had maximum concentrations of the five primary COCs that were substantially lower than the 60% LAET values, as follows:

TABLE 2. COMPARISON OF 60% LAET VALUES TO THE MAXIMUM CONCENTRATIONS OF COCS MEASURED DURING THE SUPPLEMENTAL SAMPLING PROGRAM

Priority COC	60% LAET Value	Maximum Concentration
Copper	552 mg/kg DW	258 mg/kg DW
Mercury	2.67 mg/kg DW	1.18 mg/kg DW
HPAH	15.3 mg/kg DW	8.1 mg/kg DW
TPCB	3.27 mg/kg DW	0.83 mg/kg DW
TBT	1.11 mg/kg DW	0.15 mg/kg DW

Therefore, much lower values than the 60% LAET would also have provided a reliable basis for classifying these sediment samples as not "Likely" impacted. That is, the data that were collected did not provide a basis for determining if the 60% LAET values represented thresholds for adverse effects on benthic organisms or if adverse effects would be observed at lower levels:

- The samples that were collected to support the reliability assessment had SS-MEQ values that were substantially below the threshold that was used to identify "Likely" impacted samples; they ranged from 0.38 to 0.69 (calculated from data presented in Table 32-20 of the DTR) compared to the threshold of 0.9. Therefore, lower values than the selected SS-MEQ threshold would also have provided a reliable basis for classifying these sediment samples as not "Likely" impacted;

- The available data did not provide a basis for determining if the selected 60% LAETs or the SS-MEQ threshold provided reliable bases for classifying sediment samples as "Likely" impacted because the thresholds were never exceeded in these five sediment samples; and

- The procedures that were used to classify sediment samples as "Likely" impacted may not provide a sensitive basis for identifying sediment samples that are toxic to benthic invertebrates or associated with impairment of the benthic invertebrate community.

C.2.6 The procedures that were used to designate sediment samples from the Shipyard Sediment Site as "Likely" impacted are not protective.

These procedures are not protective for the following reasons.

- Sediment samples from the Shipyard Sediment Site were designated as moderately or highly toxic if: *(1)* the survival of amphipods exposed to a sediment sample was statistically significantly different from the control treatment **and** *(2)* control-adjusted survival was lower than the lower prediction limit for the reference sediment samples (72.9% survival; as presented in Table 18.7 of the DTR). Table 6 presents the data that were used in the DTR to establish the lower prediction limits for reference sediment samples.

- This approach to defining the normal range of amphipod responses is not consistent with the practices that are currently recommended by the Science Advisory Group on Sediment Quality Assessment. *See* Sustainable Fisheries Foundation (2007). Current guidance for determining reference conditions includes screening the toxicity test results and including samples in the reference envelope only if response rates are within the range specified for an acceptable negative control treatment: control-adjusted survival of 80 to 100% for amphipods. *See* American Society for Testing and Materials (2010). This screening step is applied to ensure that candidate reference samples with response rates that are influenced by the presence of unmeasured contaminants are not included in the reference pool. By applying this criterion, sediment samples with less than about 82% (see Table 7 for details on the recalculation of the reference envelope for the amphipod toxicity test) control-adjusted survival would be designated as toxic at the Shipyard Sediment Site. This is generally consistent with the guidance established by the California State Water Resources Control Board in its draft "Water quality control plan for enclosed bays and estuaries (CSWRCB 2008)." This limitation of the toxicity designation procedures also applies to the other toxicity test endpoints.

C.2.7 The rationale for excluding polygon NA22 from the Proposed Remedial Footprint is inappropriate. This area was included in the geographic scope of the Shipyard Sediment Site and, therefore, should be included on the list of the candidate Remedial Footprint stations.

According to Section 33.1.1 of the DTR, Station NA22 was "Likely" impaired based on moderate sediment chemistry, moderate toxicity, and moderate benthic community impairment. These results indicate that NA22 should be remediated because COCs in sediments are likely adversely affecting benthic invertebrates within this polygon. The conjecture about the potential effects of propeller testing on the benthic community is inconsistent with the methodology outlined in the DTR and should have no bearing on the results of the evaluation of this station. Importantly, the suggestion that the TMDL process will provide a more effective basis for making a decision on NA22 is invalid for the following reasons:

- The Mouth of Chollas, Switzer, Paleta Creeks TMDL ("Creek Mouth TMDL") will not address the existing contamination in polygon NA22. TMDLs are forward-looking policies intended to reduce the loading of contaminants to receiving water bodies, not to remove existing contamination. That is, the TMDL process will not provide a vehicle for remediating contaminated sediment within the NA22 polygon. A new and separate remediation process would need to be initiated after completion of the Creek Mouth TMDL to address existing contaminated sediment in NA22, if it is not remediated under the TCAO.

- The Creek Mouth TMDL does not address the same list of contaminants as the TCAO for the Sediment Shipyard Site. That is, the TMDL is focused on chlordane, PAHs, PCBs, and DDTs. Metals and TBT are not being addressed under the TMDL.

- The Creek Mouth TMDL will help to prevent the recontamination of the Shipyard Site, particularly polygon NA22.

- NA22 polygon is not included in post-remedial monitoring so it will not be possible to determine whether or not the TMDL achieves the same clean-up goals as those achieved under the TCAO for the Sediment Shipyard Site.

C.2.8 The rationale provided in Table 33-6 of the DTR for excluding certain polygons from the Remedial Footprint is not sufficient.

The rationale provided for excluding several polygons from the Proposed Remedial Footprint is flawed in several ways:

- The polygon SW03 was excluded from the Proposed Remedial Footprint, even though sediments within this polygon had elevated levels of cadmium. Cadmium levels in SW03 were not considered in the development of the Proposed Remedial Footprint because it was categorized as a secondary contaminant of concern at the Shipyard Sediment Site. This rationale is not reasonable because any substance that is identified as a risk driver—as cadmium was for SW03—should necessarily be considered in the development of clean-up goals.

- Technical infeasibility was identified as a rationale for excluding NA07, NA08, NA23, and NA27 from the Remedial Footprint. However, the evaluations of the technical feasibility of dredging within all or a portion of these polygons, as presented in Section 33.1.4 of the DTR, only include conclusory statements about technical infeasibility. These conclusions are not supported by evidence in the record, such as engineering assessments, that would render these conclusions scientifically valid.

- No rationale was provided for excluding NA01, NA04, NA06, NA16, NA16, NA21, SW25, or SW 29 from the Remedial Footprint.

C.2.9 The DTR failed to explicitly consider the potential effects on fish with small home ranges associated with exposure to contaminated sediments during the development of the Proposed Remedial Footprint.

This represents a major limitation of the Proposed Remedial Footprint because fish with small home ranges are known to utilize benthic habitats at the site and the concentrations of PCBs in sediments are sufficient to adversely affect the reproduction of fish at various locations. As a result, adverse effects on the health of benthic fish could occur at the site following remediation if the polygons with elevated levels of PCBs in sediments are not included in the Proposed Remedial Footprint. The polygons with concentrations of PCBs in sediments sufficient to adversely affect fish reproduction include NA01, NA04, NA07, NA16, SW06, SW18, and SW29 (see Table 1 of this document for more information on the hazard quotients that were calculated for these polygons). According to the DTR, the work that was done at the site on fish with large home ranges was inconclusive[5] and, hence, was not used in the development of the Proposed Remedial Footprint.

C.3 Conclusions Regarding the Proposed Remedial Footprint

The TCAO and the DTR describe the process that was used to develop the Proposed Remedial Footprint for the Sediment Shipyard Site. This process was designed to enable the Dischargers to meet Alternative Clean-Up Levels for the Shipyard Sediment Site and generally involved:

- Identifying and including in the Proposed Remedial Footprint all of the polygons where contaminated sediments were likely to adversely affect the health of the benthic community; and,

- Ranking the remaining polygons based on the concentrations of the five priority contaminants and selecting the most highly contaminated of these polygons—on a "worst first" basis—for inclusion in the Proposed Remedial Footprint, such that the predicted post-remedial SWACs for all five primary COCs would meet the Alternative Clean-Up Goals for aquatic-dependent wildlife and human health.

Based on the results of the evaluation of the methods that were presented in the TCAO and the DTR, I draw the following conclusions on the Proposed Remedial Footprint:

C.3.1. Developing the Proposed Remedial Footprint using Thiessen Polygons constructed to identify the area represented by each sediment sampling location is a scientifically valid method that has been used in other sediment remediation projects. However, the polygons developed at the Shipyard Sediment Site using this method are unusually large (i.e., up to 12 acres), which generates uncertainty in remedial decisions made for large areas based on limited sampling.

C.3.2 Evaluating risks to human health and aquatic-dependent wildlife using SWACs of contaminants in sediment is a scientifically valid approach that has been used in other sediment remediation projects. However, SWACs do not provide a basis for accurately assessing the impacts on benthic invertebrates or benthic fish. Other tools are needed to evaluate risks to these ecological receptors.

5 DTR Appendix 15, section A15.2.3

C.3.3 Evaluating risks to benthic invertebrates using a sediment quality triad (SQT) approach is a scientifically valid approach that has been used in other sediment remediation projects. However, effective application of this approach requires appropriate interpretation of sediment chemistry, sediment toxicity, and benthic invertebrate community structure data. The procedures described in the DTR for interpreting such data are not always consistent with the best current guidance.

C.3.4 Virtually all of the SQT stations evaluated had concentrations of contaminants that indicated that benthic invertebrates receive moderate to high exposure to contaminants at the Shipyard Sediment Site. This finding is in agreement with other interpretations of the sediment chemistry data, including my prior analysis in 2009 (MacDonald 2009).

C.3.5 The sediment toxicity data collected at the Shipyard Sediment Site have not been interpreted using methods that are consistent with the current guidance by the Science Advisory Group on Sediment Quality Assessment. *See* MacDonald *et al.* (2009 for more information). While reference conditions were defined for each toxicity test endpoint, the calculations of the 95% prediction limits were unduly influenced by inclusion of data for reference sediment samples that had unacceptably low amphipod survival, bivalve normal development, and/or sea urchin fertilization. For the bivalve toxicity test endpoint, insufficient data were compiled to support calculation of a valid reference envelope. This problem could be effectively addressed by adopting the procedures for determining level of toxicity established by the California State Water Resources Control Board (CSWRCB 2008). Table 6 and 7 provide comparisons of the reference envelope developed for use in the DTR to a reference envelope that was developed using procedures that are more scientifically defensible.

C.3.6 For polygons for which sediment chemistry data only were available, the DTR switched assessment methods from the SQGQ1 to SS-MEQ to assess impacts on the benthic invertebrate community, even though SQGQ1 method is preferable (i.e., the SQGQ1 method is effects-based and could be consistently applied at the site). While calculation of SS-MEQ values provides a consistent index of contamination in sediment samples from the Shipyard Sediment Site, SS-MEQ does not provide an effects-based tool for predicting adverse effects on the benthic community. In the context of this review, an effects-based tool is an indicator of contamination that is based on relationships between sediment chemistry and sediment toxicity. Such effects-based tools (e.g., SQGQ1) provide a basis for understanding the probability and/or magnitude of toxicity to benthic invertebrates (or other receptors) at specific levels of contaminations. The SQGQ1, the frequency of exceedance of SQGs, and the upper prediction limit for reference samples provide much more relevant tools for predicting adverse effects on the benthic community. *See* Finding 18 of the DTR; MacDonald (2009). Assuming toxicity to benthic invertebrates is classified using the criteria established by the California State Water Resources Control Board (CSWRCB 2008), 21 of the 29 (i.e., 72%) sediment samples, with moderate or high line-of-evidence (LOE) rankings for sediment chemistry were moderately or highly toxic to benthic invertebrates. *See* Table18-6 of the DTR. Further, all of the sediment samples with low LOE rankings for sediment chemistry were not toxic or had low toxicity to benthic invertebrates, resulting in an overall reliability of 73%. *See* Table18-6 of the DTR. With this level of reliability of the selected sediment chemistry metrics for the Triad samples, there is no rational reason to develop a different tool for evaluating the non-Triad sediment samples, particularly when SS-MEQ is not based on effects on benthic invertebrates (i.e., the SS-MEQ is not more reliable than the SQGQ1 method in terms of correctly classifying sediment samples as toxic or not toxic).

C.3.7 The Composite SWAC Ranking Value that was developed to identify the most contaminated polygons that would be included first in the Proposed Remedial Footprint was not applied consistently in the TCAO or the DTR. The Proposed Remedial Footprint includes 23 polygons with SWAC ranking values greater than or equal to 5.5, but left out 15 polygons with Composite SWAC Ranking Values greater than 5.5.

C.3.8 The Proposed Remedial Footprint excludes polygons, like NA07, with concentrations of contaminants in sediment that likely pose higher risks to human health and aquatic-dependent wildlife than some of the polygons included in the Proposed Remedial Footprint.

C.3.9 The Proposed Remedial Footprint excludes polygons with concentrations of contaminants in sediment that likely pose high risks to benthic fish.

C.3.10 The Proposed Remedial Footprint excludes polygons or portions of polygons, like NA20, NA21, and NA22, which are being considered in the Mouth of Chollas Creek TMDL assessment process. The DTR explains that these polygons or portions of these polygons were removed from the Proposed Remedial Footprint because they "fall within an area that is being evaluated as part of the TMDLs for Toxic Pollutants in Sediment at the Mouth of Chollas Creek TMDL and is not considered part of the Shipyard Sediment Site for the purposes of the TCAO." This decision was based on the assertion that "the additional samples from the TMDL will allow a better assessment of the causes of potential impairment in the mouth of the Chollas Creek area." While additional data could support a more in-depth assessment of this area, the conclusion that the TMDL process will address sediment contamination in these polygons is incorrect because the TMDL process will not provide a vehicle for remediating contaminated sediment.

C.3.11 The DTR explains why the Proposed Remedial Footprint excludes seven polygons—NA07, NA08, NA23, NA27, SW03, SW06, and SW19—that would otherwise be included in the Proposed Remedial Footprint. *See* Table 33-6 of the DTR. However, the explanation for excluding these polygons is not scientifically valid and is, in some cases, based on erroneous conclusions regarding contaminant concentrations or potential for impacts to the benthic community. For example, the DTR excluded NA07 and NA23 from the Proposed Remedial Footprint based on conclusions that dredging these polygons "had technical feasibility problems." Specifically, the DTR concluded that dredging both polygons would "undermine the slope." In order to be scientifically valid, these conclusions of technical infeasibility must be supported by detailed engineering studies of the existing slope and the impacts that various dredging techniques would have on the slope. The DTR provides no information about the existing sediment slope and includes no engineering studies to support its conclusion that dredging these polygons is technically infeasible. For this reason, the technical infeasibility conclusion for these polygons is not scientifically defensible.

In summary, the process for developing the Proposed Remedial Footprint is conceptually sound and is consistent with the approach used at other sites in the United States to guide remedial activities. However, there are a number of inconsistencies in the application of the procedures that need to be corrected to ensure that the Proposed Remedial Footprint will meet the goals articulated in the TCAO and DTR. In addition, the results of an independent evaluation of the available data and information that I performed in 2009 indicate that additional polygons should be included in the sediment remedial footprint for the Shipyard Sediment Site (MacDonald 2009). Table 5 presents the results of an evaluation for seven polygons that should be added to the Remedial Footprint to address inconsistencies in the procedures applied in the DTR and to address risks to fish utilizing habitats within the study area.

The results of this analysis indicate that the following polygons pose unacceptable risks to fish and would likely or possibly adversely affect the benthic community: NA01, NA04, NA07, NA16, SW06, SW18, and SW29. In addition, polygon NA22 should be included in the Remedial Footprint because it meets the criteria established in the DTR and it is not valid to exclude it based on its consideration in the TMDL process for the Mouth of Chollas Creek. Hence, these eight polygons, at minimum, should also be included in the Remedial Footprint for the Shipyard Sediment Site.

D. Expert Opinion #2: Alternative Clean-Up Levels

Limitations on the establishment and implementation of the Alternative Clean-Up Levels make it difficult to determine if San Diego Bay beneficial uses will be unreasonably affected by the post-remedial contamination levels. To assure that beneficial uses are protected, Remediation Monitoring and Post Remedial Monitoring must be improved to ensure that the Shipyard Sediment Site is remediated to the Alternative Clean-Up Levels.

D.1 Overview of Methods Used to Establish Alternative Clean-Up Levels

The methods that were used to develop the Alternative Clean-Up Levels for the Shipyard Sediment Site are described in Section 32 of the TCAO and Finding 32 of the DTR. The Alternative Clean-Up Levels for aquatic life is a narrative statement that indicates that all areas determined to have sediment pollution levels likely to adversely affect the health of the benthic community are to be remediated. The procedures for identifying the polygons with sediment pollution levels likely to adversely affect the health of the benthic community are described in Findings 15, 16, 17, and 18 of the DTR. In contrast, numerical Alternative Clean-Up Levels for human health and aquatic-dependent wildlife were established for the five primary COCs at the Shipyard Sediment Site: copper, mercury, HPAH, PCBs, and TBT. The DTR claims that these Alternative Clean-Up Levels, which represent surface-area weighted averaged concentrations (SWACs) of the five primary COCs, were established at the lowest levels that were considered to be technologically and economically achievable at the Shipyard Sediment Site. The DTR also claims that the Alternative Clean-Up Levels are protective of human health and aquatic-dependent wildlife.

D.2 Uncertainties Associated with the Alternative Clean-Up Levels

The appropriateness and protectiveness of the Alternative Clean-Up Levels described in Section 32 of the TCAO and Finding 32 of the DTR are uncertain for several reasons, including:

D.2.1 The Alternative Clean-Up Levels are substantially higher than background levels of the primary COCs in San Diego Bay.

Clean-Up Levels that correspond with background conditions in San Diego Bay would provide the highest, practically achievable, level of protection to ecological receptors utilizing habitats in the vicinity of the Shipyard Sediment Site. In recognition of the importance of establishing background conditions in San Diego Bay, the San Diego Water Board selected a group of reference stations located within relatively cleaner areas of San Diego Bay considered to be unaffected by the Shipyard Sediment Site. While there has been substantial debate regarding which stations should be included in the reference pool, it is certain that clean-up to the background sediment chemistry levels identified in Table 1 of the TCAO would provide ecological receptors with a higher level of protection than would clean-up to the Alternative Clean-Up Levels presented in Table 2 of the TCAO. The Alternative Clean-Up Levels are 19 to 500% higher than the background sediment chemistry levels.

D.2.2 Neither the TCAO nor the DTR explicitly identify numerical Alternative Clean-Up Levels for the protection of aquatic life.

Table 2 of the TCAO and Section 32 of the DTR present the numerical Alternative Clean-Up Levels for aquatic-dependent wildlife and human health. More specifically, these tables present the numerical Alternative Clean-Up Levels for copper, mercury, HPAHs, PCBs, and TBT in sediment.

In contrast, the Alternative Clean-Up Levels for aquatic organisms is a narrative statement that directs the Dischargers to “remediate all areas determined to have sediment pollutant levels likely to adversely affect the health of the benthic community.” Application of this narrative statement requires evaluation of multiple lines-of-evidence that are focused on assessing effects on benthic invertebrates. No information was presented in the TCAO or the DTR on how the potential for adverse effects on fish were explicitly considered in development of the Alternative Clean-Up Levels. Although the DTR does address fish bile data and fish histopathology, the results of those analyses were not incorporated into the Alternative Clean-Up Levels. The DTR should have considered effects on fish other than the inconclusive data that were collected on the bile and histopathology of fish with large home ranges. Without evidence in the record demonstrating that potential for adverse effects on fish were considered, I conclude that the Alternative Clean-Up Levels were developed without considering the potential for adverse impacts on fish. Therefore, the Alternative Clean-Up Levels do not ensure that fish are protected. Because fish are key receptors in San Diego Bay, effects on fish need to be addressed during development of the Proposed Remedial Footprint.

D.2.3 The Alternative Clean-Up Levels fail to include numerical limits to protect benthic invertebrates.

The DTR employs a procedure for evaluating risks to aquatic life associated with exposure to contaminated sediments that relies on sediment chemistry, sediment toxicity, and benthic invertebrate community data. While reliance on multiple lines-of-evidence is generally recommended for assessing contaminated sediments, the procedures that were used to interpret individual lines-of-evidence do not correctly identify all of the sediment samples that would adversely affect benthic invertebrate communities. Specific examples of limitations in the data interpretation procedures include:

- The metric for evaluating sediment chemistry data in the non-Triad samples is not effects-based. The DTR fails to explain why the SS-MEQ is used to evaluate sediment chemistry in the non-Triad sediment samples, when the metric used for the Triad sediment samples (SQGQ1) is reliable. This disconnect between the evaluations of the Triad and non-Triad sediment samples adds to the uncertainty in the identification of “Likely” impacted samples.

- The criteria that were established for interpreting amphipod toxicity data rely upon establishment of a 95% lower prediction limit for the reference pool to classify sediment samples into risk categories. Yet, several samples were included in the reference pool that did not meet criteria for negative control samples, which is that at least 80% survival is required for an acceptable negative control sample. This same criterion is routinely applied to identify reference sediment samples (Sustainable Fisheries Foundation 2007; MacDonald et al. 2009). Inclusion of samples that had amphipod survival lower than 80% in the reference pool results in calculation of a 95% lower prediction limit—72.9%—that is too low. See Table 18-7 of the DTR. As a result, sediment samples are identified as toxic only if survival is less that 72.9%. Application of the biological criteria for identifying acceptable reference sediment samples would have resulted in a threshold of about 82% control-adjusted survival for amphipods. The following polygons would have been identified as toxic to amphipods using a more appropriate procedure for establishing reference conditions: NA01, NA04, NA06, NA07, SW11, SW18, and SW27.

- Only four samples were included in the reference pool for the bivalve development toxicity test. This does not represent a robust data set and its use results in calculation of a 95% lower prediction limit of 37.4% normal. See Table 18-7 of the DTR. This number is substantially lower than the result for any of the samples included in the reference pool, where percent normal development ranged from 66 to 101%. Therefore, the procedure that was used to identify toxic samples relative to bivalve development is invalid.

- The data that were used to establish the reference envelope for the sea urchin fertilization test included samples that have fertilization rates below test acceptability criteria (70% for negative controls). This results in the calculation of a 95% lower prediction limit of 41.9%, which is inappropriately low. Hence many of the samples from the site could be misclassified as not toxic using this threshold.

Because the procedures used to interpret individual lines-of-evidence are not protective, it is likely that determinations of risks to benthic invertebrates associated with exposure to sediment from the Shipyard Sediment Site will not provide an adequate basis for protecting benthic invertebrate communities. Hence, the Alternative Clean-Up Levels are unlikely to provide an adequate level of protection to the benthic community and are likely to be only minimally protective of benthic invertebrates.

D.2.4 The Alternative Clean-Up Levels fail to include numerical limits to protect fish.

This is a serious limitation of the Alternative Clean-Up Levels because many of the contaminants present at the Shipyard Sediment Site have the potential to accumulate in the tissues of benthic fish and adversely affect their survival, growth, or reproduction. My analysis of data from the Shipyard Sediment Site indicates that benthic fish are at risk throughout portions of the site and at least seven polygons were not included in the Proposed Remedial Footprint that had unacceptable risks to fish (MacDonald 2009). This finding demonstrates that risks to fish are not effectively addressed by the Alternative Clean-Up Levels.

D.2.5. The shortcomings of the Alternative Clean-Up Levels lead to uncertainty in the protectiveness of the remediation. This problem can be addressed, at least in part, by setting stringent Remediation and Post Remedial Monitoring requirements.

Short of going back to the drawing board and developing new Alternative Clean-Up Levels, the best way to address uncertainties in the protectiveness of the Alternative Clean-Up Levels is to strengthen the Remediation Monitoring and Post Remedial Monitoring requirements. Without stringent Remediation and Post Remedial Monitoring to ensure that the Alternative Clean-Up Levels are actually achieved throughout the entire Shipyard Sediment Site, it is highly likely that existing and/or future beneficial uses in San Diego Bay may be unreasonably affected.

D.2.6 The TCAO provides no evidence that "clean-up of the remedial footprint will restore any injury, destruction, or loss of natural resources."

While Section 32 of the TCAO concludes that the proposed remedial action will restore any natural resources that may have been injured by releases of hazardous substances at the Shipyard Sediment Site, neither the TCAO nor the DTR includes any evidence to support this assertion. Importantly, the San Diego Regional Water Quality Control Board has not conducted a natural resource damage assessment at the Shipyard Sediment Site and, hence, has no basis for making this assertion. More importantly, the San Diego Regional Board does not have authority for conducting natural resource damage assessments. Rather, the Natural Resources Trustees have authority to conduct natural resource damage assessments and to draw conclusions regarding injury to natural resources and the effectiveness of remedial actions in terms of restoring natural resource values. Therefore, all statements regarding the injury to natural resources, natural resource service losses, and associated damages must be removed from the TCAO and the DTR.

D.3 Conclusions Regarding the Alternative Clean-Up Levels

Collectively, these limitations on the establishment and implementation of the Alternative Clean-Up Levels mean that these Alternative Clean-Up Levels cannot ensure that beneficial uses will not be unreasonably affected at the Shipyard Sediment Site. The results of the foregoing evaluation indicate that the clean-up within the Proposed Remedial Footprint will likely leave harmful levels of contaminants in place throughout portions of the Shipyard Sediment Site because the clean-up will be minimally protective of benthic invertebrates and fish. Therefore, I conclude that:

D.3.1 It is essential that the Remediation Monitoring program provide a reliable basis for documenting that water quality standards have been violated outside the construction area during remedial activities.

D.3.2 It is essential that the Remediation Monitoring program that is conducted during the remedial activities provide a reliable basis for documenting that the target clean-up levels for sediment have been reached within the remedial footprint and that remedial activities have not further contaminated areas located outside the remedial footprint.

D.3.3 It is essential that the Post Remedial monitoring program provide data and information of sufficient quality and quantity to determine if the Alternative Clean-Up Levels have been met at the Shipyard Sediment Site following implementation of remedial measures.

D.3.4 It is essential that the San Diego Regional Board be prepared to require additional remediation if the Alternative Clean-Up Levels have not been met following completion of the remedial activities at the site.

D.3.5 Regardless of the assertions made in the TCAO regarding the effectiveness of the clean-up for restoring any injury, destruction, or loss of natural resources, the Natural Resources Trustees may conduct a natural resource damage assessment to evaluate injuries to natural resources, to estimate the ecological service losses and other service losses associated with such injuries, and to calculate any damages to the public associated with natural resource service losses. Such damages would cover damages that have accrued between 1981 (the year that CERCLA was enacted) and the time that the remedial activities are completed. In addition, residual damages to natural resources will also be evaluated if the remedial measures are not sufficient to restore injured natural resources. Residual damages would be lower if a more protective clean-up was implemented at the Shipyard Sediment Site.

E. Expert Opinion #3: Remediation Monitoring

The requirements for Remediation Monitoring, as specified in Section B.1.l of the TCAO and in Section 34.1 of the DTR, do not mandate development and implementation of a Remediation Monitoring Plan that will provide the data and information needed to assess compliance with water quality standards, to evaluate the effectiveness of remedial measures, or to identify the need for further dredging to achieve clean-up goals at the Shipyard Sediment Site. Therefore, the Remediation Monitoring requirements must be revised to address each of these issues.

E.1 Overview of Remediation Monitoring Requirements

A Remediation Monitoring program is an environmental monitoring program that is implemented while remedial activities are being conducted. In this case, Remediation Monitoring is the monitoring that will be conducted during dredging of sediments at the Shipyard Sediment Site. Remediation Monitoring is an essential element of any sediment remediation because it provides the data and information needed: ***(1)*** to confirm, while the work is being done, whether or not the sediment is being appropriately remediated so that the levels of contaminants in sediment following dredging meet the clean-up goals; and, ***(2)*** to determine if sediment and/or pore water disturbed during dredging are impacting water quality, causing violations of water quality standards, or are traveling to areas not slated for remediation.

Based on the information presented in Section B1 of the TCAO, the Dischargers must develop a Remediation Monitoring Plan consisting of water quality monitoring, sediment monitoring, and disposal monitoring consistent with Section 34.1 of the DTR. The water quality monitoring must be sufficient to demonstrate that implementation of the selected remedial activities does not result in violations of water quality standards outside the construction area. The sediment monitoring must be sufficient to confirm that the selected remedial activities have achieved target clean-up levels within the remedial footprint specified in Directive A.2. The disposal monitoring must be sufficient to adequately characterize the dredged sediments in order to identify appropriate disposal options.

E.2 Deficiencies of the Remediation Monitoring Requirements—Water Quality

Section B.l.1 of the TCAO and Section 34.1 of the DTR indicate that water quality monitoring must be conducted to demonstrate that implementation of the selected remedial activities do not result in violations of water quality standards outside the construction area and to confirm that the selected remedial activities have achieved target clean-up goals within the remedial footprint. The water quality component of the

Remediation Monitoring program specified in the TCAO and the DTR is inadequate for the following reasons:

E.2.1 The DTR allows water quality impacts to be assessed through modeling and turbidity measurements alone, but water quality impacts can be adequately assessed only by comparing results of real-time monitoring of turbidity and dissolved oxygen and sampling of contaminants of concern to the water quality standards included in the San Diego RWQCB Basin Plan and/or state water quality standards.

The DTR requires water quality monitoring during remediation to assess compliance with “water quality monitoring goals.” The DTR’s water quality monitoring approach presents several problems. First, the DTR fails to explicitly define “water quality monitoring goals.” Although the DTR states that the goal of water quality monitoring “is to demonstrate that remedy implementation does not result in violations of water quality standards outside the construction area,” the DTR fails to explicitly state the water quality standards. To address this problem, the DTR should explicitly include the numeric water quality standards that must be achieved during remediation.

Second, the DTR gives the Dischargers discretion to measure compliance with ambiguous water quality monitoring goals through two separate measures. The first method involves developing a model of turbidity and synoptic water quality measures prior to remedy implementation to determine if monitored turbidity would likely result in unacceptable water quality. Under this method, turbidity would be used as the only indicator of water quality conditions. The second method involves real-time monitoring of turbidity and dissolved oxygen at locations 250 feet from the dredge zone, 500 feet from the dredged zone, and at ambient locations.

Modeling with turbidity measurements alone is not an appropriate method to accurately gauge water quality impacts as they are occurring because such information cannot demonstrate compliance with numeric water quality standards for dissolved oxygen or other contaminants of concern which may be released during dredging. To assess compliance with numeric water quality standards during remediation, the Dischargers must conduct real-time monitoring of turbidity and dissolved oxygen, and collect surface water samples for analysis of all primary and secondary contaminants of concern. The information collected must be compared to numeric water quality standards established in the San Diego RWQCB Basin Plan—and listed in the DTR—to determine whether the Dischargers are complying with applicable water quality standards during remediation.

E.2.2 The DTR allows Dischargers to take all water quality samples from up-current locations, which would mask true water quality impacts.

The water quality monitoring program specifies that Dischargers must collect four water samples on each of two arcs outside the construction area, with one arc located at 250 feet and the other arc located at 500 feet from the construction area. However, the DTR is silent as to where along the arcs the samples need to be collected. This means that Dischargers are free to collect all the samples from up-current locations. Collecting samples only from up-current locations will mask the true water quality impacts that are experienced down-current form the dredging. To address this problem, the DTR must require that sampling locations be determined according to the impact of tidal flow on the plume from the construction area. Specifically, the DTR should require that all samples be collected in locations that are down-current from the dredging.

E.2.3 The DTR’s failure to define the size of the construction area means that samples can be collected far from the locus of the dredging activity.

The DTR’s failure to define the construction area is a problem because the DTR directs Dischargers to collect water quality monitoring data at specific distances from the construction area: 250 feet and 500 feet, respectively. This could, for example, result in early warning water samples being collected 250 feet, 500 feet, or 1250 feet from the dredging location if the construction area was defined as having a radius of 0 ft, 250 ft, or 1000 ft. To address this problem, the DTR must explicitly define the boundaries of the construction area. By doing so, water sampling locations on the 250 and 500 foot arcs can be consistently identified. To provide the best protection for water quality, DTR should define the “construction area” as a point at the center of the construction activity for the day on which the samples are taken.

E.2.4 The DTR fails to provide the rationale for collecting water samples at a depth of 10 feet.

According to the DTR, water samples must be collected from a depth of 10 feet below the water surface. However, the DTR provides no rationale for selection of the 10 foot water depth for collecting these samples. To best protect water quality, the DTR should require Dischargers to collect water samples at multiple water depths early in the sampling program to identify the depths that have the highest levels of monitored variables. This is an easy and inexpensive solution to the problem because water quality sensors will likely be used to provide real time measurements of turbidity and dissolved oxygen in the field. Alternatively, the results of turbidity measurements taken throughout the water column on each sampling date should be used to identify the water depth that has the highest turbidity. Grab samples for analysis of COCs in surface water should be taken at the water depth with the highest turbidity.

E.2.5 The DTR’s failure to specify the time that water samples need to be collected each day means that Dischargers are free to collect samples at times when daily water quality impacts are likely to be the lowest and mask the true water quality impacts during remediation.

The DTR generally requires that water quality sampling be conducted on a daily basis, but fails to specify when during the day such water samples need to be collected. This is a problem because water samples could be collected early in the day, when dredging has just been initiated, or even prior to dredging beginning. In this case, the plume from the dredging activities may not have had time to reach the 250 or 500 sampling arcs. In addition, water samples could be collected at slack tide when the plume is least likely to reach the 250 or 500 foot sampling arcs. To address this problem, the DTR must specify when during the day water quality samples need to be collect. To best protect water quality, I recommend that samples be collected half-way through a flooding or ebbing tide at least four hours after dredging activities are initiated for the day.

E.2.6 The DTR fails to require collection of water samples on at least a daily basis.

The DTR generally requires water quality sampling to be conducted on a daily basis. But if three days of daily monitoring show that no samples exceed water quality targets, the Dischargers can abandon daily water quality monitoring in lieu of weekly monitoring. Sampling would only return to daily monitoring if a “significant change in operations occurs.” However, neither the DTR nor the TCAO define the term “a significant change in operations.” This is a problem because it is not clear what criteria will be used to trigger a resumption of daily water quality sampling. This is also a problem because it assumes that variability in turbidity or dissolved oxygen levels is associated primarily with operation of the dredge. This is incorrect. Other sources of variability in water quality conditions include variability in the effectiveness of silt curtains or other best management practices, changes in the timing of tidal cycles, alteration of current velocity, and other factors. A project of this size and importance requires a full time monitor (i.e., a person or persons who are dedicated to conducting the remediation monitoring) to evaluate water quality and other conditions, such as the status of silt curtains and other best management practices, on a daily basis. To best protect water quality, the DTR should require daily water quality monitoring and should not sanction weekly monitoring.

E.2.7 The DTR fails to define best management practices for dredging activities.

While the DTR alludes to the application of best management practices (BMPs), no guidance is provided that defines BMPs for dredging activities. Therefore, the DTR should explicitly state that measures to reduce or eliminate the transport of sediments that are resuspended during dredging must be used throughout the dredging program. Such measures may include the use of silt curtains, gunderbooms, mechanical dredge operational controls, use of a closed or environmental bucket, measures that apply to barge operation, and selected work windows.

E.3 Deficiencies of the Remediation Monitoring Requirements—Sediment

Section B.l.1 of the TCAO and in Section 34.1.2 of the DTR indicate that sediment monitoring must be conducted during dredging activities to confirm that remediation has achieved target clean-up levels within the remedial footprint. The sediment component of the Remediation Monitoring program specified in the TCAO and the DTR is inadequate for the following reasons:

E.3.1 The DTR allows Dischargers to collect only one sediment sample from each polygon in the Proposed Remedial Footprint, which will not provide sufficient data to assess compliance with clean-up goals.

The DTR requires that Dischargers conduct sediment monitoring in each of polygons within the remedial footprint. But because the DTR is silent on how many sediment samples Dischargers must collect from within each polygon, Discharges are free to collect only one sample from each polygon.

There is ample evidence in the record demonstrating the variability in sediment chemistry within a given polygon,[6] meaning that collecting only a single sample within each footprint polygon or sediment management unit (SMU), ignores that variability and fails to provide sufficient information to assess compliance with clean-up goals.

In order to collect sufficient information to assess compliance with clean-up goals during remediation, I recommend that each SMU be divided into a number of sediment confirmation sampling areas (SCSAs) that have an area of 2500 ft^2 each (50 feet by 50 feet) or less. A total of nine surficial sediment samples should be collected within each SCSA, including one sediment sample collected from the middle of the SMU and two sediment samples collected north, south, east, and west of the original sampling location, at 25 foot intervals. The sediment sample collected from the middle of the SCSA should be analyzed for the primary COCs identified in the TCAO and the resultant COC concentrations compared to the clean-up goals. If the concentration of one or more of the primary COCs exceeds the corresponding clean-up goal, then additional sediment samples should be analyzed to evaluate the spatial extent of contamination. In this way, the areas that require additional dredging to achieve clean-up goals can be identified with greater certainty.

E.3.2 The DTR fails to identify the locations that must be sampled to confirm that clean-up goals have been met.

This is a problem because sediment sampling may target the historic sampling locations, for which data are already available. Other locations within the remedial footprint that have not been sampled to date may not be characterized. As a result, sediments with elevated levels of contaminants may be missed during sediment monitoring. I recommend that the DTR require that the Discharger must sample in locations that have not previously been sampled. This will be the case if the concept of sampling within sediment confirmation sampling areas is adopted.

E.3.3 The TCAO and the DTR provide inconsistent requirements on sampling depth.

The TCAO requires that samples be collected deeper than the upper 5cm, while the DTR requires that samples be collected deeper than the upper 10cm. The TCAO and the DTR must be revised to provide consistent guidance on target sampling depths.

E.3.4 The DTR's sampling guidance will be difficult, if not impossible to apply systematically at all sampling locations. The DTR should specifically require that samples be collected within the top 10 cm.

[6] For example, see Table A32-30 of the DTR

Instead of identifying specific sampling depths that must be addressed, the DTR provides a narrative that will be difficult, if not impossible, to apply systematically at all sampling locations. Specifically, the DTR provides the following direction: "sample sediments deeper than 10 cm and sample the first undisturbed depth beneath the dredge depth; sample just deep enough to collect a sufficient volume for analysis." This type of narrative requires the sampling team to visually examine each sediment sample and try to identify "undisturbed sediments." It is unlikely that this guidance can be consistently followed. More, importantly, this guidance is inappropriate and its application will ensure that the data needed to determine if the clean-up goals have been met will not be collected by the Dischargers.

To ensure the Dischargers collect sediment samples that will assess impacts to benthic invertebrates exposed to surficial sediments, the DTR should require Dischargers to collect sediment samples within the top 10 cm. Failure to collect surficial sediment samples will ensure that insufficient data are available to determine if beneficial uses at the site are unacceptably affected by contaminated sediments. To address future impacts in areas prone to erosion, the DTR should direct the Dischargers to collect additional samples of deeper sediment in those erosion-prone areas.

E.3.5 The DTR's "120% of background" trigger level for additional dredging is ambiguous and arbitrary.

The DTR states: "If concentrations of COCs in subsurface sediments (deeper than 10 cm) are above 120% of background sediment chemistry levels, then additional sediments will be dredged by performing an additional pass with the equipment." There are three main problems with this approach.

First, the DTR's direction is ambiguous. The DTR could be interpreted to mean additional dredging is required either ***(1)*** if the concentrations of <u>all</u> COCs exceed 120% of background levels or ***(2)*** if the concentrations of <u>one</u> or more COCs exceed 120% of background. This is an important distinction that has the potential to influence the extent of re-dredging at the Shipyard Sediment Site and it must be clarified.

Second, the DTR's additional dredging trigger is arbitrary. The DTR fails to present any evidence or provide any explanation of how requiring an additional dredging pass when the 120% of background sediment chemistry concentrations are exceeded will ensure that the post-remedial SWACs—the Alternative Clean-Up Levels—will actually be met for the entire Shipyard sediment Site.

Third, by establishing decision criteria for evaluating dredge performance that are 20% higher than the background sediment chemistry levels, it is possible that surficial sediments following remediation will have COC concentrations that are higher than the clean-up goals. In turn, the presence of elevated levels of COCs in surficial sediments may lead to calculation of post-remedial SWACs that exceed those predicted in the TCAO and the DTR. Hence, use of decision criteria that are inconsistent with the background sediment chemistry levels could lead to implementation of a clean-up that does not provide adequate protection for beneficial resources (i.e., the Alternative Clean-Up Levels may not be achieved in the near term; i.e., within the next 10 years). The DTR should show the results of calculations that demonstrate that post-remediation SWACs will be met if the concentrations of COCs in all of the remediated areas are equal to 120% of background levels (i.e., equal to 120% of the post-remedial dredge area concentrations listed in Section A2.a of the TCAO).

To address these very real concerns, the DTR language should read: "If the concentrations of one or more COCs in any surficial sediment sample exceed background sediment chemistry levels, then additional sediments will be dredged by performing an additional pass with the equipment over the entire area represented by that sediment sample. The area that was re-dredged must then be re-sampled to confirm that the clean-up goals have been met." In addition, these thresholds for additional pass dredging, or "Triggers for Redredging," should be explicitly presented in the DTR, as follows:

TABLE 3. LIST OF TRIGGERS FOR REDREDGING

Priority COC	Triggers for Redredging
Copper	121 mg/kg DW
Mercury	0.57 mg/kg DW
HPAHs	663 µg/kg DW
PCBs	84 µg/kg DW
TBT	22 µg/kg DW

E.3.7 The DTR fails to specify the criteria when a sand cap would be necessary and who would make such a determination.

The second decision rule indicates that “a sand cap will be placed on the sediment surface, if necessary.” Yet, the DTR fails to describe the criteria that would need to be met to justify placement of a sand cap. In addition, the DTR fails to identify who would be responsible for determining if such a sand cap is needed. The third decision rule states that “if no sample can be collected because the equipment cannot penetrate a hard substrate, then this area will be evaluated to determine whether a sand cap is required.” However, the DTR fails to describe how such an evaluation should be conducted or who would be responsible for making a decision on the need for, and design criteria for, a sand cap. This decision rule also fails to recognize that sediment samples in areas with hard substrate can frequently be collected by divers. Failure to establish clearly interpretable decision rules that consider the various possible outcomes will almost certainly result in decisions that are not consistent with the expectations of the San Diego Regional Board and other participants in the process.

E.4 Conclusions Regarding the Remediation Monitoring Program

The requirements for conducting Remediation Monitoring are described in Section 34.1 of the DTR. Based on the results of this review of the requirements described in the DTR, the remediation monitoring program that is implemented during remedial activities at the Shipyard Sediment Site will not provide the data and information needed to:

- Assess compliance with water quality standards;
- Evaluate the effectiveness of remedial measures; or,
- Identify the need for further dredging to achieve clean-up goals.

Sections E.2 and E.3 document numerous problems with the remediation monitoring requirements specified in the DTR. These problems are serious because the clean-up activities described in the TCAO are likely to be only minimally protective of beneficial uses at the Shipyard Sediment Site. Accordingly, effective Remediation Monitoring is required to provide the data and information needed to document that water quality standards have not been exceeded during remediation and that clean-up levels have been achieved within the remedial footprint. Failure to collect the necessary and sufficient data on water quality conditions in the vicinity of the construction area and on sediment quality conditions within the remedial footprint will make it impossible to manage the clean-up operations in a way that will assure that the clean-up goals are met. Therefore, it is essential that the Remediation Monitoring program be revised to address each of these critically important issues. The key changes that need to be made to the Remediation Monitoring program include:

E.4.1 The DTR must include detailed requirements for surface-water sampling. These requirements should:

1. Require daily real-time monitoring of turbidity and dissolved oxygen,

2. Require daily water sampling of each primary and secondary COCs;

3. Define the "construction area" as a point in the center of the construction activity;

4. Mandate that water samples be collected half-way through a flooding or ebbing tide at least four hours after dredging activities have initiated for the day at locations down-current from the dredging;

5. Require Dischargers to collect water samples at multiple water depths early in the sampling program to identify the depths that have the highest levels of monitored variables and then require that water be sampled at those depths thereafter;

6. Explicitly list the water quality standards for dissolved oxygen, turbidity, and each primary and secondary contaminant concern and risk-driver that must be met at compliance monitoring locations;

7. Mandate the use of Best Management Practices that include, but are not limited to, silt curtains, gunderbooms, mechanical dredge operational controls, use of a closed or environmental bucket dredge, measures that apply to barge operation, and selected work windows; and

8. Require a full-time monitor to evaluate water quality and Best Management Practices on a daily basis.

E.4.2 The DTR must make the following changes to the sediment portion of the Remediation Monitoring program:

1. Set the required sediment sampling depth at 0-10cm in both the TCAO and DTR;

2. Divide each sediment management unit into a number of sediment confirmation sampling areas (SCSAs) that have an area of 2500 ft^2 each (50 feet by 50 feet) or less. A total of nine surficial sediment samples should be collected within each SCSA, including one sediment sample collected from the middle of the SMU and two sediment samples collected north, south, east, and west of the original sampling location, at 25 foot intervals. The sediment sample collected from the middle of the SCSA should be analyzed for the primary COCs identified in the TCAO and the resultant COC concentrations compared to the clean-up goals. If the concentration of one or more of the primary COCs exceeds the corresponding clean-up goal, then additional sediment samples should be analyzed to evaluate the spatial extent of contamination. This information will be used to determine the scope of additional pass dredging for each SCSA;

3. Specify that an additional dredging pass is required if any priority COC is greater than background and add a table with the explicit triggers provided in Table 3.

4. Specify the criteria for placing a sand cap on the sediment surface.

F. Expert Opinion #4: Post Remedial Monitoring

The requirements for Post Remedial Monitoring, as specified in Section D of the TCAO and in Section 34.2 of the DTR, do not mandate development and implementation of a Post Remedial Monitoring Plan that will provide the data and information needed to determine if the remaining pollutant concentrations in the sediments will not unreasonably affect San Diego Bay beneficial uses. In other words, the current Post Remedial Monitoring requirements do not require collection of the data and information needed to evaluate the effectiveness of remedial measures and identify the need for further remediation to achieve clean-up goals at the Shipyard Sediment Site. Therefore, Post Remedial Monitoring results will not provide a comprehensive basis for objectively evaluating the effectiveness of the remedial measures or the need for further remediation to achieve the clean-up goals at the Shipyard Sediment Site.

F.1 Overview of Post Remedial Monitoring Requirements

As stated in Section D of the TCAO and in Section 34.2 of the DTR,[7] the Dischargers must submit a Post Remedial Monitoring Plan to the San Diego Water Board within 90 days of adoption of the TCAO. The Post Remedial Monitoring Plan must be designed to verify that the remaining pollutant concentrations in the sediments will not unreasonably affect San Diego Bay beneficial uses. Post Remedial Monitoring is to be conducted after the remedial activities have been completed. It is a key component of any sediment remediation because it provides the data and information needed to confirm that the remedial work has been successfully completed and, therefore. to confirm that the clean-up goals have been met.

According to the requirements specified in the TCAO, the Post Remedial Monitoring Plan must include a Sampling and Analysis Plan and a Quality Assurance Project Plan. The TCAO mandates that composite sediment sampling be conducted to confirm that the post-remedial SWACs for the five primary COCs have been met. Accordingly, sediment samples must be "collected at all 65 sampling stations used to develop Thiessen polygons and composited on a surface-area weighted basis" to prepare six sediment samples (that correspond to six polygon groups) for analysis of the five primary COCs. The Post Remedial Monitoring Plan must also include bioaccumulation testing of nine sediment samples using 28-day bioaccumulation tests with the bivalve, *Macoma nasuta*. Furthermore, chemical analysis, toxicity testing, and benthic community assessment must be conducted for sediment samples collected at five locations at the site.

F.2 Deficiencies of the Post Remedial Monitoring Requirements

The post-remediation monitoring program specified in the TCAO and the DTR is inadequate for the following reasons:

F.2.1 Neither the TCAO nor the DTR establish narrative remedial action objectives (RAOs) for each San Diego Bay beneficial use.

The TCAO concludes that the remaining pollutant concentrations in the sediments will not unreasonably affect San Diego Bay beneficial uses. However, neither the TCAO nor the DTR defines the term "will not unreasonably affect San Diego Bay beneficial uses." Without a clear definition of what the remedial actions are intended to achieve, it is difficult to determine if the clean-up was successful in terms of protecting or restoring beneficial uses in San Diego Bay. Therefore, the TCAO and the DTR should be revised to include narrative RAOs and numerical targets so that it can be determined if those objectives are attained.

[7] While the TCAO refers to "Post Remedial Monitoring," (pages 25-31, Attachment 6), the DTR refers to "Post-Remediation Monitoring" (see Section 34.2). This report uses the term "Post Remedial Monitoring" to refer to requirements in both the TCAO and DTR.

For example, one ROA that should be adopted is "to prevent exposure to whole sediments that are sufficiently contaminated to pose moderate or high risks to benthic invertebrates." The numerical targets that should be established to assess attainment of the RAO would be the SQGQ1 values that were used in the SQT evaluation (i.e., 0.25-1.0 for moderate exposure and ≥1.0 for high exposure) and/or the revised thresholds for sediment toxicity set out in Table 6 of this document.

F.2.2 It is not clear that attainment of the Remedial Goals presented in Section D.3.c.1 (Year 2), D.3.c.2 (Year 5), and D.3.c.3 (Year 10) of the TCAO ensure that San Diego Bay beneficial uses will not be unreasonably affected by sediment-associated contaminants at the Shipyard Sediment Site.

The stated Remedial Goals are inadequate for several reasons, including:

- Statistical comparison of the toxicity testing results to the results obtained for reference stations is likely to underestimate sediment toxicity because several stations were included in the reference pool for amphipods and sea urchins that did not meet negative control criteria and because the reference pool for bivalve development is limited to four samples. *See* Finding 17 of the DTR. In short, the thresholds for identifying toxic sediment samples are inappropriate. In addition, some of the protocols for conducting these toxicity tests have been refined since the reference data were generated. Therefore, a better approach would be to generate Sediment Quality Triad data for at least six reference stations as part of the Post Remedial Monitoring program. In this way, the reference data would be directly comparable to the data collected at the site. Toxicity testing should be conducted within numerous polygons located within and outside the Proposed Remedial Footprint to determine if benthic invertebrates are adequately protected. Sediment samples for defining current reference conditions and for evaluating

- Reduction of bioaccumulation levels below the pre-remedial levels would not ensure that aquatic organisms utilizing habitats at the site would have tissue COC concentrations low enough to support beneficial uses. In other words, implementing the remedial goal for bioaccumulation to achieve lower tissue concentrations does not ensure that the bioaccumulation levels are low enough. Therefore, the bioaccumulation data should be evaluated relative to the risks that are posed to aquatic-dependent wildlife and human health associated with exposure to COCs in the tissues of aquatic organisms.

F.2.3 The procedures that are prescribed for calculating Site-Wide SWACs will not provide the data required to determine the concentrations of COCs within each polygon at the Shipyard Sediment Site.

This is important because certain ecological receptors—including benthic invertebrates and certain benthic fish species, such as gobies—have small home ranges and are therefore exposed to contaminants that occur within small geographic areas. The sediment sampling requirements described in paragraphs 1 to 5 of Section D.1.c of the TCAO will provide data on the average levels of COCs in the top 2 cm of sediment contained within six polygon groups only. Additional data on COC concentrations will be generated only if archived sediment samples are analyzed in the future. This means that the data needed to evaluate the spatial extent of attainment of conditions that support beneficial uses will not be available. Importantly, neither the TCAO nor the DTR adequately explain the rationale for when additional data will be generated for the polygon groups.

F.2.4 Compositing surface sediment into six polygon groups is inappropriate because it will mask the true extent of contamination remaining at the Shipyard Sediment Site.

The DTR explains that the goal of the Post Remedial Monitoring program is to verify that remaining pollutant concentrations in the sediments will not unreasonably affect San Diego Bay beneficial uses. The DTR divides the Shipyard Sediment Site into six sampling areas and then directs the Dischargers to use a compositing scheme to evaluate the efficacy of the remediation. This process has significant problems for several reasons.

First, only two of the six groups represent areas where remedial actions will be taking place, and these areas represent a relatively small proportion of the site as a whole. Therefore, the assessment of how successful the clean-up has been will largely rest on composite data from sites that were not remediated. This is an inappropriate basis for evaluating the efficacy of remedial actions.

Second, the six sampling areas are arbitrary. Neither the TCAO nor the DTR provide any explanation of how the six sampling areas were selected, nor do the documents describe how this is a scientifically-defensible method to assess remediation success. I am not aware of any other sediment-contaminated site in the United States that has utilized an investigative sampling program, confirmation sampling program, or post-remedial sampling program that relies on preparation of composite sediment samples using the procedures described in the TCAO. Without a detailed, scientifically-based explanation of how the sites were selected and how it would accurately gauge remediation success, this sampling method is not scientifically justified and is arbitrary.

Third, the Post Remedial Monitoring plan is likely to create a number of practical challenges for a field sampling team. These challenges include ensuring that the correct volume of material is collected from each of the sampling stations and ensuring that these materials are correctly mixed to create six composite sediment samples. Such a program would require careful oversight by regulators to ensure that it is conducted correctly and is unlikely to provide reliable information for determining if the clean-up goals have been met.

Fourth, the Post Remedial Monitoring plan only requires samples for 65 of the 66 polygons in the Shipyard Sediment Site. The Post Remedial Monitoring plan does not require collection of samples from NA22 and excludes NA22 wholesale from the Post Remedial Monitoring plan. NA22 must be included in any Post Remedial Monitoring because it is a part of the Shipyard Sediment Site, regardless of the decision to exclude it from the remedial footprint in the hope that after the Chollas Creek TMDL is completed, another process may be initiated to address existing contamination within NA22.

F.2.5 The 0-2 cm horizon is not the appropriate sediment depth to sample to evaluate attainment of conditions that support beneficial uses.

At most sites, the 0 - 10 cm horizon is sampled to represent conditions in the biologically-active zone. Without further information on the depth of the biologically-active zone within San Diego Bay—not just within the contaminated portions of the Shipyard Sediment Site—is selection of the 0-2 cm horizon as the target sampling depth is not scientifically justified and is arbitrary. The Post Remedial Monitoring program should require samples be collected in the 0-10 cm horizon.

F.2.6 Collecting replicate sub-samples of composite sediment sample is not an appropriate method of evaluating the effectiveness of remedial monitoring COC.

The goal of the Post Remedial Monitoring plan, as described in section 34.2.1 of the DTR, is to verify whether the remediation has been effective in protecting human health and aquatic-dependent wildlife. However, the plan described will not provide the data to draw these conclusions. As written, the plan relies on sub-sampling sediments that have been composited from multiple polygons. This approach will only provide information on the consistency of the homogenization process that is applied to the composite sediment samples. It is therefore an acceptable part of a lab quality assurance plan but it is not an effective approach to analyze variability of COCs at the site post-remediation. Thus, this sub-sampling approach will not provide Regional Board staff with the information necessary to determine whether remediation has been effective at protecting human health or aquatic-dependent wildlife. Any monitoring required should include data that evaluates the level of variability of COC concentrations within individual polygons, within polygon groups, and within the site as a whole.

F.2.7 Trigger Concentrations for Primary COCs that are presented in Section D.1.c.6 of the TCAO and Table 34-1 of the DTR will not effectively identify conditions at the Shipyard Sediment Site that unreasonably affect San Diego Bay beneficial uses.

The Trigger Concentrations are likely to be relatively unhelpful in this respect because they are not based on the concentrations of COCs that need to be achieved to support attainment of the beneficial uses. Rather, they represent a statistical construct that is rationalized based on the assumed variability in COC concentrations at the site. The ineffectiveness of the triggers is demonstrated by the Trigger Concentration for mercury, which is higher than the pre-remedy SWAC of mercury at the Shipyard Sediment Site. It does not make any sense to have Trigger Concentrations, that are intended to provide a basis for determining if further action is needed, that exceed existing concentrations. Even though mercury bioaccumulation is a serious concern at this site, the only way further action can be triggered based on mercury concentrations is if the dredging somehow made the polygons more contaminated than they are today. It is more logical to set the Trigger Concentrations at the predicted post-remedy SWACs, particularly since the triggers are being compared to SWACs calculated based on compositing of sediment samples from 66 sampling stations.

F.2.8 Neither the TCAO nor the DTR provided the rationale for collecting sediment samples at nine sampling stations—SW04, SW08, SW13, SW21, SW28, NA06, NA11, NA12, and NA20—to support bioaccumulation testing.

The TCAO and the DTR should be revised to provide the underlying rationale that was used to select the nine sampling stations for bioaccumulation testing. In addition, there is a need to measure the concentrations of bioaccumulative COCs in both tissue and sediment to interpret the results of these tests. If a 56-day time-to-steady-state bioaccumulation test has not yet been conducted at the Shipyard Sediment Site, such a test should be conducted on one or more sediment samples to support interpretation of the data generated from the 28-day bioaccumulation tests.

F.2.9 The criteria presented in the TCAO for interpreting the results of the bioaccumulation tests—"bioaccumulation should be below pre-remediation levels"—are not effects-based. Because the criteria are not effects-based, they will not be useful for determining if conditions at the Shipyard Sediment Site will be unreasonably affecting San Diego Bay beneficial uses two years, five years, or ten years after the completion of remedial actions.

In addition, it is not clear how the results of these bioaccumulation tests would be used to inform decisions on the need for further actions at the site. Therefore, the TCAO and the DTR should be revised to describe how the bioaccumulation testing results will be used to identify conditions at the Shipyard Sediment Site that unreasonably affect San Diego Bay beneficial uses. In addition, these documents need to describe how the results from bioaccumulation testing will be used to determine if further action is required at the site.

F.2.10 The requirements for collecting and analyzing sediment samples for evaluating sediment chemistry for benthic exposure and sediment toxicity are inadequate.

The TCAO and DTR indicate that sediment samples are to be collected at a total of five sampling stations—SW04, SW13, SW22, SW23, and NA06—and analyzed for total metals, PAHs, PCBs, and TBT. This is inadequate because it will provide data on only about eight percent of the polygons at the Sediment Shipyard Site. No data for assessing benthic exposure will be collected for 61 of the 66 polygons at the site. As there is substantial potential for resuspension, transport, and deposition of fine sediment during the implementation of the remedy, recontamination of remediated areas or further contamination of unremediated areas could occur.

Therefore, this component of the Post Remedial Monitoring program must be expanded to provide a more robust basis for evaluating exposure of benthic invertebrates to contaminants at the site and for assessing sediment toxicity. To do so, sediment samples must be tested from appropriate selected reference areas. The DTR and TCAO should explicitly identify which protocols need to be used to evaluate toxicity to each indicator species. It addition, the list of analytes should be expanded to include simultaneously-extracted metals, acid-volatile sulfides, additional organotins, and organochlorine pesticides. These additional variables need to be measured to support a robust evaluation of the potential for adverse effects on benthic invertebrates.

F.2.11 Neither the TCAO nor the DTR present decision rules that describe how the sediment chemistry data generated in the Post Remedial Monitoring program will be used to inform decisions on the need for further actions at the site.

While the TCAO indicates that sediment chemistry should be below the SS-MEQ and 60% LAET thresholds, no decision rules are presented that describe the actions that must be taken if the thresholds are exceeded. Therefore, the TCAO and the DTR should be revised to describe how the sediment chemistry results will be used to identify conditions at the Shipyard Sediment Site that unreasonably affect San Diego Bay beneficial uses and to determine if further action is required at the site. In addition, these documents need to list the triggers that will be used for evaluating sediment chemistry for benthic exposure; they should explicitly identify the SS-MEQ thresholds and 60% LAET thresholds that trigger further action. Again, it is unclear why the remedial tools used to evaluate sediment chemistry for the Triad stations—SQGQ1 and frequency of exceedance of SQGs–have been abandoned in favor of the SS-MEQ and 60% LAET values.

F.2.12 Neither the TCAO nor the DTR present decision rules that describe how the sediment toxicity data generated in the Post Remedial Monitoring program will be used to inform decisions on the need for further actions at the site.

While the DTR describes the procedures that were used to interpret sediment toxicity for the purpose of establishing the remedial footprint, no decision rules are presented that describe the actions that must be taken if toxicity to one or more species is observed. Therefore, the TCAO and the DTR should be revised to describe how the sediment toxicity results will be used to identify conditions at the Shipyard Sediment Site that unreasonably affect San Diego Bay beneficial uses and to determine if further action is required at the site. In addition, these documents need to list the triggers that will be used to evaluate the sediment toxicity data. See Table 6 of this document for recommended thresholds for sediment toxicity.

F.3 Conclusions Regarding the Post Remedial Monitoring Requirements

Post Remedial Monitoring represents an essential component of any sediment remediation project. While the requirements set forth in Section D of the TCAO provide some of the guidance needed to ensure that the Dischargers develop and implement an effective Post Remedial Monitoring program, these requirements have a number of deficiencies that, if not corrected, will result in data gaps and uncertainties relative to the effects of contaminated sediments on San Diego Bay beneficial uses. Therefore, the requirements for Post Remedial Monitoring presented in the TCAO and DTR must be revised. Some of the revisions that are needed include:

F.3.1 Narrative remedial action objectives and specific indicators of attainment of those objectives (i.e., targets for specific metrics) should be included in the TCAO.

F.3.2 Sediment samples should be collected from all 66 polygons and evaluated for sediment chemistry to provide the data needed to determine if the site-wide SWAC for the five priority COCs have been met. The sediment samples should not be composited.

F.3.3 Sediment samples for evaluating attainment of the Alternative Clean-Up Levels should be collected from the 0 - 10 cm horizon to better reflect the biologically-active zone in San Diego Bay.

F.3.4 Trigger concentrations should be revised to correspond to the post-remedy SWACs for the five primary COCs.

F.3.5 The rationale for selecting the nine sampling locations for bioaccumulation testing should be provided. In addition, bioaccumulation testing should include a 56-day time-to-steady-state test to support interpretation of the bioaccumulation data.

F.3.6 Biological-effects based criteria should be established for interpreting the results of the bioaccumulation tests.

F.3.7 The number of polygons that are sampled for evaluating sediment chemistry, sediment toxicity, and benthic invertebrate community structure must be increased to include all of the polygons included in the Proposed Remedial Footprint and all of the polygons that are located adjacent to the footprint polygons. Such sampling is required to demonstrate that the Alternative Clean-Up Levels for aquatic organisms have been met throughout the site, not just at five pre-selected locations.

F.3.8 The decision rules that will be used to determine the need for further actions, based on the results of the Post Remedial Monitoring Program, must be clarified. It is inappropriate to empower the Dischargers to make recommendations ***after*** the Post Remedial monitoring data have been collected. This is not in the public interest.

G. Expert Opinion #5: Trigger Exceedance Investigation

The Trigger Exceedance Investigation and Characterization process, described in Section D.4 of the TCAO, will not provide a basis for compelling the Dischargers to conduct further remediation to achieve clean-up goals at the Shipyard Sediment Site.

G.1 Overview of the Trigger Exceedance Investigation and Characterization Process

Section D.4 of the TCAO describes the process that will be undertaken by the Dischargers if one or more exceedances of the post-remediation Site-Wide SWAC Trigger Concentrations are observed based on the results of Post Remedial Monitoring. In this event, the Dischargers must conduct a trigger exceedance investigation and characterization study to determine the cause(s) of the exceedance. The approaches that may be used in the study include:

- Recalculating the 95% UCL by incorporating more recent sampling data;
- Identifying specific sub-areas that caused the exceedance;
- Evaluating changes in site conditions that could have resulted from disturbances since the previous sampling; and/or,
- Analyzing archived samples used to prepare composite samples for the specific COC(s) that exceed the 95% UCL.

After completing the study, the Dischargers are to submit a report that describes the results of the investigation and, if the exceedances are deemed to be significant, include recommendations for addressing the exceedances. Approaches for addressing exceedances could include re-sampling the affected area, re-dredging, natural recovery, re-analysis following the next scheduled sampling event, or other appropriate methods.

G.2 Deficiencies of the Trigger Exceedance Investigation and Characterization Process

The TCAO sets out the process that the Dischargers must follow if the Post Remedial Monitoring Program shows exceedances of the Site-Wide SWAC Trigger Concentrations. The Trigger Exceedance Investigation and Characterization process is an important enforcement tool because it provides a mechanism for addressing any issues that arise after remediation is completed, if the remedial measures were not sufficiently effective to achieve the clean-up goals for the site. This process is essential at the Shipyard Sediment Site because the proposed clean-up is likely to be only marginally protective of beneficial uses and the requirements for Remediation Monitoring are not sufficiently rigorous to ensure that the clean-up goals have been met at the site. However, the Trigger Exceedance Investigation and Characterization process as set forth in the TCAO and DTR fails to function as an effective enforcement mechanism for the following reasons:

G.2.1 Exceedance of the Trigger Concentrations does not trigger further remedial actions.

Exceedance of one or more Trigger Concentrations triggers an investigation to identify the specific sub-areas that are causing the exceedance(s), instead of automatically triggering additional clean-up. The investigation could involve one or more of the four approaches described in the TCAO, such as recalculating 95% UCLs, identifying specific subareas that are causing exceedances, evaluating the effects of spills and other sources, and analyzing archived samples. The results of such investigations must be described in a Trigger Exceedance Investigation and Characterization report. The report must include recommendations for addressing the exceedances, such as conducting additional sampling, re-dredging, natural recovery, continued Post Remedial Monitoring, or other methods. By giving the Dischargers discretion to follow-up on exceedances of Trigger Concentrations using various methods other than additional clean-up, it is virtually certain that additional remedial work will not be conducted at the site following completion of the remedy.

G.2.2 The DTR and TCAO fail to establish Trigger Concentrations based on the Alternative Clean-Up Levels for aquatic life.

The DTR and TCAO only establish Trigger Concentrations based on the Alternative Clean-Up Levels for aquatic-dependent wildlife and human health. As a result, the Trigger Exceedance Investigation and Characterization process ignores exceedances of the effect thresholds for benthic invertebrates and the potential effects on fish associated with exposure to contaminated sediments and/or consumption of contaminated prey.

G.2.3 Trigger Concentrations have been established for five COCs only.

The Trigger Exceedance Investigation and Characterization process ignores exceedances of toxicity thresholds for other chemicals that could be adversely affecting aquatic organisms or other ecological receptors. This is important because arsenic, lead, and zinc were identified as risk drivers for aquatic-dependent wildlife and/or human health. In addition, Trigger Concentrations were established for HPAHs, yet benzo(a)pyrene (BAP) was identified as a key risk driver for aquatic-dependent wildlife and human health. By considering all HPAHs, rather than BAP alone, the potential effects associated with exposure to BAP may be masked.

G.2.4 The Trigger Concentrations that have been established may not provide an effective basis for evaluating the potential for adverse effects on San Diego Bay beneficial uses because they are statistically-based values, rather than effect-based values.

This limitation is emphasized by the Trigger Concentration for mercury (0.78 mg/kg DW), which is higher than the pre-remedy SWAC for this substance (0.75 mg/kg DW). By establishing a Trigger Concentration that is higher than existing concentrations, it is certain that no additional work will be conducted to address issues related to mercury at the site. Yet, mercury is known to be a problem at the Shipyard Site. This example emphasizes that insufficient care and attention has been used to establish the Trigger Concentrations.

G.3 Conclusions Regarding the Trigger Exceedance Investigation and Characterization Process

The Trigger Exceedance Investigation and Characterization process is the one tool that the San Diego Regional Board has to compel the Dischargers to implement the remedial activities set forth in the TCAO and DTR. However, the Trigger Exceedance Investigation and Characterization process, as described in

Section D.4 of the TCAO, does not provide a basis for compelling the Dischargers to conduct further remediation to achieve clean-up goals at the Shipyard Sediment Site. Added to the inadequacies of Remediation Monitoring and Post Remedial Monitoring requirements, the impotence of the Trigger Exceedance Investigation and Characterization process results in a proposed clean-up that is likely to be only marginally protective of beneficial uses. Therefore, this process needs to be revised to ensure that the San Diego Regional Board has the tools it needs to protect the public interest at the Shipyard Sediment Site. Key refinements that are needed to this process include:

TABLE 4. RECOMMENDED TRIGGER CONCENTRATIONS

Metric	Concentration/Value
Copper	159 mg/kg[1]
Mercury	0.68 mg/kg[1]
HPAHs	2,451 µg/kg[1]
PCBs	194 µg/kg[1]
TBT	110 µg/kg[1]
Arsenic	8.7 mg/kg[1]
Cadmium	0.2 mg/kg[1]
Lead	66 mg/kg[1]
Zinc	221 mg/kg[1]
Control-Adjusted Survival of Amphipods	82%[2]
Control-Adjusted Normal Development of Bivalves	76%[2]
Control-Adjusted Fertilization of Echinoderms	70%[2]

[1]From DTR Table 33-8
[2]From Table 6 of this document

G.3.1 The Dischargers should not be given authority to make recommendations regarding the actions that will be taken to address exceedances of the Trigger Concentrations. Rather, the San Diego Regional Board must retain the authority to review the data and make such decisions.

G.3.2 To the extent possible, the TCAO should clearly identify the actions that need to be taken if the Trigger Concentrations are exceeded. While it may not be possible to identify the required actions for all contingencies on an *a priori* basis, certain decision rules should be established in the TCAO. For example, step-out sampling to determine the size of the area that requires re-dredging should be required if conditions sufficient to impact the benthic community are identified within one or more polygons.

H. Summary of Recommendations

The TCAO and the DTR provide a great deal of valuable information for identifying the remedial actions needed to address impacts on designated uses associated with the presence of contaminants at the Shipyard Sediment Site. However, there are a number of important deficiencies in these documents that have the potential to compromise the effectiveness of the clean-up and the monitoring programs that will be conducted to assess its sufficiency. The following recommendations are provided to assist the San Diego Regional Board in revising the TCAO and DTR in a manner that serves the long-term public interest relative to the Shipyard Sediment Site:

H.1 Expand the Proposed Remedial Footprint to include all of the polygons that meet the selection criteria established in the TCAO and DTR. The highest priority additional polygons for inclusion in the remedial footprint include: NA01, NA04, NA07, NA16, NA22, SW06, SW18, SW29.

H.2 Revise the Remediation Monitoring requirements to dictate surface-water sampling locations and timing, to compel the Discharger to collect data on additional chemicals, to identify the water quality standards that must be met for each chemical, and to establish the steps that must be taken if the water quality standards for one or more chemicals are exceeded during remediation.

H.4 Revise the Remediation Monitoring requirements to dictate sediment sampling locations, to specify target sampling depths, and to require that multiple samples be collected from each SMU.

H.5 Revise the Remediation Monitoring requirements to clarify the decisions rules that will be used to determine if sufficient dredging has been conducted within each SMU.

H.6 Revise the Post Remedial Monitoring requirements to clearly state narrative remedial action objectives, to eliminate the collection of composite sediment samples, to include collection and analysis of sediment samples from each polygon, to modify the target sampling depth to 0 - 10 cm, to include chemical analysis of sediment samples collected from all 66 polygons, and to require toxicity for all polygons located within and adjacent to the Proposed Remedial Footprint.

H.7. Revise the Trigger Exceedance Investigation and Characterization process to ensure that the triggers are not higher than existing levels of contaminants at the site, that triggers for additional contaminants are included, that triggers that consider effects on benthic invertebrates and fish are established, and that the remedial actions that must be undertaken if the triggers that are exceeded are clearly described.

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TABLE 5. CHEMICAL AND TOXICOLOGICAL CHARACTERISTICS FOR POLYGONS THAT POSE UNACCEPTABLE RISKS TO FISH

Metric	Threshold Value	NA01	NA04	NA07	NA16	SW06	SW18	SW29
Composite SWAC Ranking Value[1]	5.5	6.8	6.4	9.9	6.7	7.2	6.7	7.5
SS-MEQ[2]	0.9	0.73	0.62	0.97	0.71	0.7	0.68	0.8
P_{max} for Sediment Chemistry[3]	0.49	0.76 (H)	0.74 (H)	0.72 (H)	0.77 (H)	0.69 (H)	0.69 (H)	0.66 (H)
Substances Exceeding SQGs for Sediment[4]	0	mercury, PCBs	mercury	mercury, PCBs	mercury, PCBs	mercury, PCBs	mercury, PCBs	mercury, PCBs
Substances Exceeding WQCs in Pore Water[5]	0	copper, PCB	ND	ND	lead, PCBs	ND	ND	ND
Control-Adjusted Survival of Amphipods[5]	82%	80% (S)	80% (S)	74% (S)	90% (S)	ND	74% (S)	ND
Control-Adjusted Normal Development of Bivalves[3]	76%	49% (S)	84% (S)	88% (S)	3% (S)	ND	64% (S)	ND
Control-Adjusted Fertilization of Echinoderms[3]	70%	86% (S)	88% (S)	102% (S)	84% (S)	ND	83% (S)	ND
Hazard Quotient for Fish ([PCB]/TRV)[3]	1	.25	.77	.16	.24	.05	1	2.59
Number of Criteria Exceeded		7	5	6	6	4	6	4

ND = no data; S = survival; TRV = tissue residue value; SQGs = sediment quality guidelines; WQC = water quality criteria; PCB = polychlorinated biphenyls; H = high; SWAC = surface-area weighted average concentration; P_{max} = maximum probability model.
[1]From Table A33-1 of DTR
[2]Calculated independently using the data in Table A33-3 of the DTR
[3]From MacDonald (2009)
[4]From DTR

TABLE 6. INDIVIDUAL STATION CHARACTERISTICS, SUMMARY STATISTICS, AND 95% LOWER PREDICTIVE LIMITS FOR CONTROL ADJUSTED AMPHIPOD SURVIVAL (%), BIVALVE DEVELOPMENT (% NORMAL), AND URCHIN FERTILIZATION (%) IN THE REFERENCE POOL (TABLE 18-7 OF THE DTR).

Station	Amphipod Survival	Bivalve Development[1]	Urchin Fertilization
CP 2231	76		66
CP 2238	90		36
CP 2243	84		97
CP 2433	84		100
CP 2441	82		102
SY 2231	84	93	99
SY 2243	92	66	92
SY 2433	96	101	79
SY 2441	95	70	90
2235	7		
2241	98		
2242	92		
2243	96		
2256	100		
2257	91		
2258	92		
2260	73		
2265	85		
N	18	4	9
Minimum	71	66	36
Maximum	100	101	102
Mean	88	82.5	85
Std Dev	8.4	17.1	22
RSD	10%	21%	26%
95% PL	72.9	37.4	41.9

[1]The 95% predictive limit for bivalve endpoint is calculated using the same methodology described in SCCWRP and U.S. Navy 2005b. The supporting calculation is provided in the Appendix to Section 18

TABLE 7. RECALCULATION OF REFERENCE ENVELOPES FOR THE TOXICITY TESTS USED AT THE SHIPYARD SEDIMENT SITE [1]

Station	Amphipod Survival	Bivalve Development	Urchin Fertilization
CP 2231	76 (excluded)		66 (excluded)
CP 2238	90		36 (excluded)
CP 2243	84		97
CP 2433	84		100
CP 2441	82		102
SY 2231	84	93	99
SY 2243	92	66	92
SY 2433	96	101	79
SY 2441	95	70	90
2235	7 (excluded)		
2241	98		
2242	92		
2243	96		
2256	100		
2257	91		
2258	92		
2260	73 (excluded)		
2265	85		
N	15	4	7
Minimum	82	66	79
Maximum	100	101	102
San Diego Bay Reference Envelope[2]	82-100%	Insufficient Data	79-102%
California SQOs - Non Toxic or Low Toxicity	82-100%	77-100%	None Available

SQOs = sediment quality objectives

[1]Sediment samples from the site with lower survival, development or fertilization than the lower of the reference envelope would be classified as toxic.

[2] Lower limit of reference envelope was calculated as the minimum survival for samples that met test acceptability criteria (i.e., 80% control-adjusted survival).