CEQA Scoping Meeting
Informational Document

DEVELOPMENT OF SEDIMENT QUALITY OBJECTIVES FOR ENCLOSED BAYS AND ESTUARIES

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State Water Resources Control Board
Division of Water Quality

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1.0 INTRODUCTION

1.1 Purpose

This document summarizes State Water Resources Control Board (State Water Board) staff's method for developing sediment quality objectives (SQOs) and a preliminary process that could be used to apply and implement the objectives. SQOs would provide a mechanism to differentiate sediments impacted by toxic pollutants from those that are not.

Sediments in enclosed bays and estuaries are with few exceptions the most highly polluted exposed sediments in the State. Historically, bays and estuaries were the first heavily industrialized regions in the State; and, as a result, wastes have been discharged into bays either directly as point sources, indirectly as runoff, or accidentally through releases and spills for many years. Sediment carried down rivers and creeks also contributes to the contaminant loading into bays and estuaries. Many contaminants, such as metals and pesticides, readily attach to the sediments. Through this mechanism, contaminants from inland sources can be transported long distances. Poor flushing and low current speeds allow the sediments and contaminants to settle out in the bays and estuaries before reaching the open ocean.

In 2003, the State Water Board initiated a program to protect these water bodies through the development of SQOs for enclosed bays and estuaries.

The purpose of this California Environmental Quality Act (CEQA) Scoping Meeting Informational Document is to present a summary of the progress and direction of this program for the public and interested parties in preparation for the CEQA Scoping Meeting. The CEQA Scoping Meeting will initiate the State Water Board's formal water quality planning process. After the CEQA Scoping Meeting, State Water Board staff will prepare and circulate a draft Substitute Environmental Document[1] (dSED).

1.2 Background

Few states have attempted to develop SQOs because of the lack of ecologically relevant tools, difficulties interpreting and integrating the results, and an inability to establish causality.

In 1989, the Porter-Cologne Water Quality Control Act (Porter-Cologne) was amended to require the State Water Board to develop SQOs as part of a comprehensive program to protect existing and future beneficial uses within California's enclosed bays and estuaries (Section 13393). In 1991, the State Water Board prepared a seven year conceptual approach to developing SQOs in a Workplan for the Development of Sediment Quality Objectives for Enclosed Bays and Estuaries of California (91-14 WQ) (1991 Workplan). The 1991 Workplan included a schedule and specific tasks to develop direct effects tools that would protect benthic communities and an element to assess the human and ecological risk in bays and estuaries from pollutants in sediments.

A number of factors resulted in the significant delay of this program, and, in 1999, a lawsuit was filed against the State Water Board for failing, among other things, to adopt SQOs in accordance with Porter-Cologne. In 1999, the superior court ruled against the State Water Board and ordered that the State Water Board develop SQOs in accordance with a compliance schedule.

[1] The title of the State Water Board's primary planning document has been changed from Functional Equivalent Document (FED) to Substitute Environmental Document (SED). There is no substantive difference in the content of the document.

The State Water Board initiated a multi-phase effort to develop SQOs in 2003. The State Water Board supported the first phase of this effort with a budget of two and one-half million dollars. However, this phase was severely time-limited due to the court mandated compliance schedule. Because time was a critical factor, this effort focused primarily on the improvement of existing tools and methodologies that had been applied with success in California.

1.3 CEQA Compliance

State agencies are subject to the environmental impact assessment requirements of CEQA (Public Resources Code, §21000 et seq.). However, CEQA authorizes the Secretary of the Resources Agency to exempt specific State regulatory programs from the requirements to prepare Environmental Impact Reports (EIRs), Negative Declarations, and Initial Studies, if certain conditions are met (Public Resources Code, §21080.5). The Water Quality Control (Basin)/208 Planning Program of the State Water Board has been certified by the Secretary for Resources as meeting the requirements for exemption (California Code of Regulations (CCR), Title 14, §15251(g)). Agencies qualifying for this exemption must comply with CEQA's goals and policies; evaluate environmental impacts; consider cumulative impacts; consult with other agencies with jurisdiction; provide public notice and allow public review; respond to comments on the draft environmental document; adopt CEQA findings; and provide for monitoring of mitigation measures. State Water Board regulations (CCR Title 23, Chapter 27, section 3777) require that a document prepared under its certified regulatory programs must include:

- A brief description of the proposed project;
- Reasonable alternatives to the proposed project; and
- Mitigation measures to minimize any significant adverse environmental impacts of the proposed activity.

Accordingly, the State Water Board prepares Substitute Environmental Documents (SEDs) in lieu of EIRs or other environmental document. These documents were formerly titled Functional Equivalent Documents.

1.4 Proposed Activity

The State Water Board is proposing the following project: the adoption of a water quality control plan for sediment quality for enclosed bays and estuaries, or "Sediment Quality Plan for Enclosed Bays and Estuaries."

1.5 Program Goals

The goals of this program are:

- Establish narrative receptor-specific SQOs.
- Establish a condition that is considered protective for each targeted receptor.
- Develop, refine, and validate the tools so that the condition of each station can be measured relative to the protected condition.
- Build a regulatory framework around these tools to promote the protection of sediment quality related beneficial uses.

1.6 Acknowledgements

State Water Board staff wish to thank the members of the Scientific Steering Committee for their valuable time, their critical assessment of each technical element, and their commitment and support to ensure that every aspect was scientifically supported.

Staff wishes to thank the Sediment Quality Technical Team for their expertise, knowledge, and commitment to this effort. Finally staff also wishes to thank members of the Sediment Quality Advisory Committee, Agency Coordination Committee, and interested parties for input and advice on both technical and policy-related issues.

1.7 Development of Implementation Measures

The Sediment Quality Advisory Committee and Agency Coordination Committee have presented many conceptual approaches and ideas to staff. While some of these approaches have been addressed or included within this document, this document does not represent any member or member's specific viewpoint(s).

1.8 Document Organization

This document is organized as follows. Section 2 describes many of the key programmatic issues and alternatives under consideration. Where staff has identified an alternative for further consideration, an example of regulatory language is provided in Section 3. Some issues have not been resolved to the extent that a suggested alternative is identified. In these cases, no preliminary regulatory language is presented.

2.0 ISSUES AND ALTERNATIVES

This section describes the major policy related issues identified to date and alternatives that have been considered by staff during the development of a preliminary draft document presented in Section 3.0. Each issue analysis contains the following sections:

Issue: A brief question framing the issue is presented in bold text. Many of the more complex technical issues such as the selection and validation of test methods or derivation of thresholds are not discussed within this document. These issues will be summarized in the dSED and described in detail within the program technical reports in preparation.

Issue Description: A description of the issue or topic and (if appropriate) any additional background information, list of limitations and assumptions, descriptions of related programs or other information.

Baseline: A description of how the State and Regional Water Quality Control Boards (Regional Water Boards) currently act on the issue.

Alternatives: For each issue or topic, at least two alternatives are provided for consideration. Each alternative is evaluated with respect to the program needs and the appropriate sections within Division 7 of the California Water Code (CWC). For those issues that address scientific questions, the SQO Scientific Steering Committee's position is also stated.

Staff Recommendation: In this section, a recommended alternative (or combination of alternatives) is identified and proposed for adoption by the State Water Board.

Example Language: Following each recommendation, the reader is directed to example language within the draft plan if applicable (Section 3.0)

2.1 What Primary Issues Should the Plan Address?

At a minimum, the State Water Board is required to comply with CWC §§13240 through 13247in adopting SQOs. In particular, section 13241 lists the factors that the State Water Board must consider when adopting objectives, and section 13242 specifies the elements that must be included in a program to implement the objectives. State Water Board staff believes that sediment quality protection is significantly different from the tools and methods commonly applied to water quality protection. Therefore, additional information and implementation guidance should be provided to provide greater understanding and consistency when the SQOs are applied within the various regions.

> **Baseline**: Not applicable.
> **Alternative 1:** Include only the SQOs and tools and thresholds needed to implement the objectives.
> **Alternative 2**: Include the narrative objectives and tools and thresholds needed to implement the objectives and additional language that describes monitoring and stressor identification.

Staff Recommendation: Alternative 2.

Example Language: See Section 3.I.B.

2.2 To What Waters Should the SQOs be Applied?

Chapter 5.6, Division 7 of the CWC, requires the State Water Board to develop SQOs for bays and estuaries. Since 2003, State Water Board staff and the technical team have been developing SQOs and associated tools and thresholds for embayments in California. This focus on bays was based upon the available data and understanding of aquatic communities. Sediment quality within bays has been a priority since the 1980's when the State Water Board initiated the Bay Protection Program.

Through the State Water Board's Bay Protection Program, the U.S. Environmental Protection Agency (U.S. EPA) EMAP, the San Francisco Estuary Institute Regional Monitoring Program (RMP), and the Southern California Coastal Water Research Project (SCCWRP) Bight 94, 98, and 03, and various site cleanup and dredging projects, a large volume of coupled biological effects and chemistry data exists for the major embayments in California. The technical team has relied on this data extensively to evaluate potential tools and methods for use in this program and has selected appropriate thresholds that could be applied to each tool. The database created for this program included over 150 studies and approximately 5,000 data points. In comparison, very little coupled data sets are available for estuaries to perform similar analysis.

The tools, methods and thresholds developed for bays cannot be applied to estuarine water without undergoing rigorous assessment for a variety of reasons. Chapman et al. (2001) provides a detailed explanation of the fundamental physical and chemical differences between the two types of water bodies. The bioavailability of both hydrophobic organic and inorganic pollutants is strongly influenced by salinity. Chemical equilibrium may not exist within the highly dynamic environments of estuaries. While many of the organisms present in bays are also found in estuaries, their tolerance to external stressors may vary greatly. Within embayments, even during wet years, the denser salt water can provide protection from osmotic shock to marine benthic organisms while estuarine organisms could be exposed to wide variations in salinity through tidal fluctuations.

Baseline: Not applicable.
Alternative 1: Develop SQOs for both bays and estuaries as mandated under Chapter 5.6, Division 7 of CWC.
Alternative 2: Develop SQOs for those bays where enough data has been collected to support the development of appropriate tools and thresholds only. Data is available for San Francisco Bay south of the San Rafael Bridge, and all enclosed bays south of Point Conception to support development of these tools. However, this alternative would not comply with Chapter 5.6, Division 7 of the CWC.
Alternative 3: Develop SQOs and an implementation policy for bays first, followed by estuaries in a phased approach. This alternative would provide the State Water Board with the time needed to collect data and develop appropriate tools and thresholds for estuarine habitats. The draft policy could require the collection of data from those water bodies where data is needed to develop appropriate indicators and thresholds. However, interim measures would still be required to meet the intent of Chapter 5.6. Interim measures are discussed in Section 2.19.

Staff Recommendation: Alternative 3.

Example Language: See Sections 3.II.B and 3.V.C.

2.3 To What Sediments Should the SQOs Apply?

Sediment quality programs are designed for specific needs. For example, dredged materials are frequently evaluated by collecting samples from multiple depths. This is performed because the properties of the sediment differ at depth, and characterization is required before an appropriate disposal site can be selected.

For dredged materials characterization, the U.S Army Corps of Engineers (USACE) in coordination with U.S. EPA have designed a series of methods and tools to assess risk associated with these materials relative to the disposal sites. Because of the need to assess deep samples, one of the tools used to assess surface sediments, benthic community is of little utility to USACE/U.S. EPA Dredged Material program. The goal of the State Water Board objectives is to assess the condition of surficial sediments, which is within the biologically active layer, where the presence of pollutants has the greatest potential to affect beneficial uses.

Baseline: Not applicable.
Alternative 1: Do not identify specific sediments applicable within the proposed plans.
Alternative 2: Surficial sediments only. The tools that have been developed are intended solely to assess the biologically active layer.

Staff Recommendation: Alternative 2.

Suggested Language: See Section 3.II.C.

2.4 Should the Plan Address the Applicability to Sediment Cleanup Actions?

The SQOs and supporting tools could be applied to determine what sediments within a specific area are protected or degraded for benthic communities. However, these tools may not protect all species in a water body.

Baseline: Regional Water Boards require human health or ecological risk assessments to assess the exposure to all receptors. The relative risks posed to each receptor are calculated to determine which receptors are most sensitive to the pollutants of concern.
Alternative 1: Do not specifically address the application of SQOs to sediment cleanup actions. The Regional Water Boards retain the discretion to apply the SQOs and supporting tools to cleanup activities, where appropriate.
Alternative 2: Prepare language describing how and when the SQOs could be applied to cleanup actions. This policy could be applied to assist in characterizing risk at cleanup action sites when the receptors of interest, the exposure type, and scale of effort are identical or similar to those protected by this policy. The exposure receptor scenarios not protected by this policy would need to be evaluated using ecological and human health risk assessment guidance such as that prepared by the Department of Toxic Substances Control (DTSC), the Office of Environmental Health Hazard Assessment (OEHHA), and U.S. EPA.

Staff Recommendation: Alternative 1.

2.5 How Should the Policy Apply to Dredged Materials?

Section 13396, Division 7, CWC states that the State and Regional Water Boards shall not grant approval for a dredging project that involves the removal or disturbance of sediment that contains pollutants at or above the (SQOs) established pursuant to Section 13393 unless the board determines all of the following:

(a): the polluted sediment will be removed in a manner that prevents or minimizes water quality degradation.
(b): polluted dredge spoils will not be deposited in a location that may cause significant adverse effects to aquatic life, fish, shellfish, or wildlife or may harm the beneficial uses of the receiving waters, or does not create maximum benefit to the people of the State.
(c): the project or activity will not cause significant adverse impacts upon a federal sanctuary, recreational area, or other waters of significant national importance.

California SQOs for enclosed bays and estuaries are being developed to protect sensitive aquatic organisms and other beneficial uses from the adverse effects of exposure to pollutants present in in-place surficial sediments. Section 13396, Division 7 makes it clear that SQOs apply to dredged material. However, Section 13396 also allows dredged material that exceeds SQOs to be approved for discharge into waters of the State of California when conditions (a)-(c) are met. One difficulty is that some of the procedures used by California to determine the SQOs are not technically applicable to sediments below the biologically active layer (e.g., benthic community analysis). Dredged material, however, is typically composed *primarily* of sediments from below the biologically active layer. In addition, some of the test species used to determine the California SQOs are not necessarily appropriate to use for dredged material testing in all cases. The federal evaluation procedures discussed below were specifically developed to characterize the full spectrum of dredged material (not just surface sediments) in order to determine suitability for aquatic discharge in a variety of disposal or placement scenarios. Furthermore, the federal procedures emphasize conducting these dredged material evaluations in a nationally consistent manner.

Under the authority of the federal Clean Water Act (CWA) and the Marine Protection, Research, and Sanctuaries Act (MPRSA), and their implementing regulations, the USACE and U.S. EPA jointly developed national testing guidance manuals for dredged material (the Inland Testing Manual or ITM for non-ocean waters, USACE and U.S. EPA 1998; and the Ocean Testing Manual or OTM for ocean waters, USACE and U.S. EPA 1991). These manuals utilize a tiered, effects-based evaluation scheme to determine the suitability of dredged material for aquatic placement or disposal. Each of these national sediment-testing manuals is implemented under a national Technical Framework for Dredged Material Management ("Framework") also jointly published by the USACE and U.S. EPA. (1992). The purpose of the Framework is to facilitate consistency in how the sediment evaluation procedures are applied within and between various areas of the United States. In addition, the Framework describes the broader regulatory context within which sediment evaluations conducted under the ITM or OTM are carried out so as to meet the overall goals of the CWA and MPRSA. In particular, under the Framework, suitability determinations for aquatic discharge of dredged material take into account not only the technical sediment test results from the ITM or OTM, but also the characteristics of the individual disposal sites and the practicability of alternatives to aquatic disposal (including beneficial reuse alternatives).

Certain other federal programs that otherwise address contaminated sediments generally defer to this Framework when it comes to management of dredged material. For example, in U.S. EPA Region 9, U.S. EPA regularly allows navigation dredging to continue within the boundaries of sediment remediation study areas for projects in the Remedial Investigation/Feasibility Study (RI/FS) stage under the Comprehensive Environmental Recovery, Cleanup, and Liability Act (CERCLA), provided that the dredged material is first specifically evaluated under the Framework, and its discharge is managed under a CWA Section 404 or MPRSA Section 103 permit. Similarly, at the national level, U.S. EPA excluded dredged material from the definition of hazardous waste under Subtitle C of the Resource Conservation and Recovery Act (RCRA), when it is subject to a CWA Section 404 or MPRSA Section 103 permit. As U.S. EPA noted in the Hazardous Remediation Waste Management Requirements (HWIR-Media) Final Rule (U.S. EPA 1998A):

> "Dredged material that is subject to the requirements of a permit that has been issued under 404 of the Federal Water Pollution Control Act (33 U.S.C.1344) or section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972 (33 U.S.C. 1413) is not a hazardous waste."
>
> "Testing procedures under the CWA and MPRSA … are better suited to the chemical and biological evaluation of dredged material disposed of in the aquatic environment… These tests are specifically designed to evaluate effects such as the potential contaminant-related impacts associated with the discharge of dredged material into oceans and waterways of the United States… The Agency believes that the CWA and MPRSA permit programs protect human health and the environment from the consequences of dredged material disposal to an extent

> that is at least as protective as the RCRA Subtitle C program. These programs incorporate appropriate biological and chemical assessments to evaluate potential impacts on water column and benthic organisms, and the potential for human health impacts caused by food chain transfer of contaminants. As improved assessment methods are developed, they can be incorporated into these procedures. The programs also make available appropriate control measures (for example, 40 CFR 230.72) for addressing contamination in each of the relevant pathways."

Under the federal Framework (USACE and U.S. EPA, 1992) the ITM and OTM provide for application of relevant chemical sediment quality criteria (SQC) or Sediment Quality Standards (SQS) issued by U.S. EPA or by a state, respectively, as screening step in "Tier I" or "Tier II" of their evaluation procedures. Exceedance of SQC or SQS indicates the need for direct effects-based testing at a higher tier. Any numeric chemical SQOs that California promulgates could be applied in this manner. Section 13396 Division 7 provides that even when California SQOs are exceeded, dredging and discharge may still be allowed when conditions (a)-(c) are met. As described below, the higher-tier evaluation procedures of the ITM or OTM, and other considerations of the CWA and MPRSA as described in the Framework, provide an appropriate and consistent basis for the State to determine whether conditions (a)-(c) have in fact been met.

> Condition (a) requires that the polluted sediment will be removed in a manner that prevents or minimizes water quality degradation. This condition focuses on the dredging (or removal) site itself, as opposed to the dredged material disposal site. It is addressed by any Best Management Practices (BMPs) or special conditions, incorporated in the dredging permit(s) or other authorizations, that federal or State agencies (including the State and Regional Water Boards) determine to be necessary for the protection of water quality and beneficial uses. These may include monitoring; constraints on dredging equipment type; operation; and timing, control technologies such as silt curtains, etc. The federal evaluation Framework generates specific information relevant to making determinations about the need for any controls at the dredging site, via physical-chemical characterization and via the water column (suspended-liquid phase) bioassays conducted on dredged material samples.
>
> Condition (b) focuses on the discharge of dredged material at the disposal or placement site. The evaluation procedures in the ITM and OTM were specifically designed to address each of the relevant pollutant exposure pathways that may be associated with dredged material discharges at aquatic disposal sites. These procedures provide for the comprehensive physical, chemical, and biological evaluation of the specific sediments to be dredged and discharged. Biological testing includes both liquid-suspended phase and solid phase sediment testing using appropriately sensitive indicator organisms that cover a range of functional feeding types. There is flexibility to use appropriate species for different dredged material types and situations. When necessary, information from the bioaccumulation tests can be readily used to assess the environmental risk of food web transfer of pollutants to different trophic levels. The national testing manuals also provide for updating the specific tests used; for example, to include regionally important species or as more sensitive tests (possibly including chronic/sublethal assays) are developed sufficiently for reliable regulatory use nationwide.
>
> Another important consideration is that dredged material that may pose a risk at a particular disposal site or when managed in a particular manner, may not pose such a risk at a different disposal site or if managed in a different manner. The overall federal Framework incorporates CWA and MPRSA provisions that ensure suitable determinations take into account all relevant sediment-specific and disposal site-specific factors, and any management actions necessary to minimize adverse impacts. SQOs as stand-alone factors cannot do this.

Condition (c) is consistent with already existing requirements of the CWA and MPRSA programs. In particular, the USACE generally may not authorize the discharge of dredged (or fill) material into waters of the United States that would cause the kinds of impacts listed in 40 Code of Federal Regulations (CFR) Part 230.10, including significant impacts to designated Marine Sanctuaries, whether such impacts are caused by pollutants associated with the sediments or simply by the physical discharge of the sediments. In addition, the CWA program focuses on identifying and, to the maximum extent possible, avoiding impacts to "aquatic resources of national importance."

Baseline: USACE, under the authority of the federal CWA and MPRSA and in coordination with U.S. EPA, prepared the ITM (USACE and U.S. EPA 1998) and the OTM (USACE and U.S. EPA 1992) to address the suitability of dredged material for disposal. These manuals are not intended to assess in-place sediments; rather, these methodologies were designed to assess potential effects that may occur during or after disposal of the dredged materials. At the regional level, USACE, U.S. EPA, State Water Board staff, and staff from other State agencies have also prepared water body specific guidance and formed dredged materials management teams to streamline the onerous multi-jurisdictional regulatory process (USACE et al, 2001).

Alternative 1: SQOs should be applicable to dredged material. The proposed SQOs could be applied to dredged materials; however, collection of this information would not eliminate the need to perform the suitability tests described in the ITM or the OTM in accordance with the federal CWA or MPRSA.
Alternative 2: SQOs should not be applicable to dredged materials. These SQOs and supporting tools were intended to evaluate beneficial uses protection and, as a result, only focus on the in-place biologically active layer. The Dredged Materials program was designed to measure average bulk properties of sediment to determine both the appropriate method of disposal or reuse and assess potential effects caused by the dredging and disposal action. While some tools are similar, the application and implementation of the tools differs significantly.
Alternative 3: SQOs would only apply under specific conditions specified in section 13396.

Staff Recommendation: Alternative 3.

Suggested Language: See Section 3.II.D.

2.6 What Beneficial Uses Should be Specifically Addressed within the Proposed SQO Plan?

Chapter 5.6, Division 7 of the CWC, requires the State Water Board to develop SQOs for the reasonable protection of beneficial uses. State and Regional Water Boards are required to protect all beneficial uses designated within each water body. Beneficial uses established for bays and estuaries are presented in Table 1. Within the context of this program, State Water Board staff considered those beneficial uses that met the following criteria.

- Relationship between the beneficial uses and pollutants in sediment. Some beneficial uses are unaffected by pollutants in sediments. Other beneficial uses are clearly affected by pollutants in sediment but are also highly influenced by natural and anthropogenic water quality factors. Other beneficial uses are linked to pollutants in sediments that have not been considered within the context of this program such as indicator bacteria.

- Ability to utilize robust indicators to measure the potential risk to each beneficial use.

- Ability to consistently assess the risk to the beneficial use within the context of a sediment quality regulatory program.

Table 2.1 Beneficial Uses for Enclosed Bays and Estuaries

Beneficial Uses	Description
Industrial Service Supply	Uses of water for industrial activities that do not depend primarily upon water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection and oil well repressurization.
Navigation	Uses of water for shipping, travel, or other transportation by private military or commercial vessels.
Water Contact Recreation (1):	Uses of water for recreational activities involving body contact with water where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, waterskiing, skin and scuba diving, surfing, whitewater activities, and fishing, and uses of natural hot springs.
Non-contact Water Recreation (2):	Uses of water for recreational activities involving proximity to water but not normally involving contact with water where water ingestion is reasonably possible. These uses include, but are not limited to, picnicking, camping, boating, tide pool and marine life study, hunting, and sightseeing, or aesthetic enjoyment in conjunction with the above activities.
Ocean Commercial and Sport Fishing	Uses of water for commercial or recreational collection of fish, shellfish, or other organisms in oceans, bays, and estuaries including, but not limited to, uses involving organism intended for human consumption.
Aquaculture	Uses of water for aquaculture or mariculture operations including, but not limited to, propagation, cultivation, and maintenance or harvesting of aquatic plants and animals for human consumption or bait purposes.
Estuarine Habitat	Uses of water that support estuarine ecosystems including, but not limited to, preservation and enhancement of estuarine habitats, vegetation, shellfish or wildlife (e.g., estuarine mammals, waterfowl, shorebirds), and the propagation sustenance and migration of estuarine organism.
Marine Habitat	Uses of water that support marine ecosystems including, but not limited to, preservation or enhancement of marine habitats vegetation such as kelp, fish, shellfish, or wildlife habitats (e.g., marine mammals, shorebirds).
Preservation of Biological Habitats of Special Significance	Includes uses of water that support designated areas or habitats such as established refuges, parks, sanctuaries, ecological reserves, or Areas of Special Biological Significance where the preservation or enhancement of natural resources requires special protection.
Rare Threatened or Endangered Species	Uses of water that support habitats necessary for the survival and successful maintenance of plant or animal species established under State/or federal law as rare, threatened, or endangered.
Migration of Aquatic Organism	Uses of water that support habitats necessary for the migration, acclimatization between freshwater and salt water, and the protection of aquatic organism that are temporary inhabitants of waters within the region.
Spawning, Reproduction and/or Early Development	Uses of water that support high quality aquatic habitats suitable for the reproduction and early development of fish.
Shellfish Harvesting	Uses of water that support habitats suitable for the collection of crustaceans and filter-feeding shellfish (e.g., clams, oysters, and mussels) for human consumption and commercial or sport purposes

The beneficial uses that best meet these criteria consist of Marine and Estuarine Habitat, Commercial and Sport Fishing, Rare and Endangered Species. All of these beneficial uses can be severely affected by pollutants in sediment and assessed using the indicators described in the following Section.

Baseline: Not applicable.
Alternative 1: All beneficial uses: Municipal, Industrial, Rec1&2, spawn/reproduction/development.
Alternative 2: Beneficial uses linked to specific receptors (Examples: Marine and Estuarine Habitat, Commercial and Sport Fishing, Rare and Endangered Species).

Staff Recommendation: Alternative 2.

Suggested Policy Language: Section 3.III.A.

2.7 What Receptors Should be Targeted for Protection?

Selection of appropriate receptors is a critical element of every standards development proposal. Potential sediment-related receptors include demersal fish, benthic macro-invertebrates, aquatic macrophytes, marine birds, and mammals. Each of these receptors is essential to support a healthy ecosystem. Humans are also potentially affected through the consumption of fish tissue containing contaminant residues. Selecting a receptor as a primary indicator of beneficial use protection is relatively straightforward. For example, human health is an obvious receptor to assess Commercial and Sportfishing. Endangered species such as the Least Tern could be an appropriate receptor to assess Rare and Endangered Species Beneficial Uses protection. Selection of appropriate receptors to assess risk to other beneficial uses is more difficult because of the broad nature of these beneficial uses (See Table 1). For beneficial uses such as Estuarine Habitat and Marine Habitat, many different receptors could be applied. Within the context of this program, receptors were considered based upon the following criteria:

- Ecological Importance.
- Potential for direct or significant exposure.
- Strong link to pollutants in sediment.
- Response to pollutant exposure understood.
- Availability of tools that can reliably measure response.
- Successfully applied in sediment monitoring programs within other sediment monitoring programs in the country.

Fish are an important receptor that can be affected by pollutants in sediments and pollutants that bioaccumulate up the food chain. Fish are ecologically and economically important and provide a source of food to many people. Fish are relatively long lived and exhibit a variety of responses to stress. In terms of a sediment specific receptor, fish exhibit many characteristics that limit their utility in a regulatory framework. Many fish are highly mobile, and, as a result, they can avoid highly impacted areas (Gibson et al 2000). Their mobility also limits the ability to qualitatively assess exposure without detailed long-term studies. Mobility within unconfined water bodies such as bays and estuaries also makes it difficult to utilize community attributes as a measure of fish health. Fish populations also respond rapidly to environmental disturbance or habitat changes. External anomalies such as fin erosion, lesions, and external parasites can be more sensitive indicators of contaminant effects than community integrity and have been utilized within monitoring programs by coastal Publicly Owned Treatment Works (POTWs) or regional monitoring programs in the Southern California Bight (Schiff et al 2001). However, these effects cannot be directly linked to pollutants in specific sediments without significant and detailed site-specific studies.

Aquatic macrophytes are the most important primary producers and provide stability to the substrate as well as critical habitat for fish and invertebrates. Aquatic macrophytes can respond to pollutants in sediments; however, water quality factors may play a more significant role (Gibson, 2000).

Benthic communities are recognized as the optimal sediment receptor for several reasons. They play a critical role in aquatic ecosystem health because they:

- Digest a significant portion of the organic detritus that settles out in bays and estuaries.
- Significantly enhance sediment mixing and oxygenate deeper sediments that stimulate bacteria driven biogeochemical processes.
- Create habitat that enhances recruitment for other organisms.
- Provide food for most fish species that utilize bays and estuaries. Waterfowl and wetlands birds also rely on benthic invertebrates as a primary food source.

As an aquatic life indicator of sediment quality, benthic communities also exhibit the following characteristics (Jackson et al 2000, Gibson et al 2000):

- Benthic communities are an in-situ measure of actual conditions and biological effects that *are or have* occurred within surface sediments. Other tools commonly applied such as laboratory toxicity tests are at best surrogate measures that may or may not be reflective of actual conditions.

- Benthic invertebrates typically spend at least one or all life stages in direct contact with bottom sediments and characteristically exhibit limited range or mobility. This long-term exposure scenario allows for sublethal toxic effects to cause subtle changes in community structure. Other receptors such as fish and birds are more difficult to utilize because of their mobility and migratory.

- The great variety of taxa within a healthy benthic community represents many different feeding and reproductive strategies that create a great range in sensitivity or tolerance to pollutants and other stressors. These tolerances can be used collectively to identify relatively subtle community responses above reference conditions creating a very robust tool.

- A variety of tools have been used to support the assessment of benthic community health in addition to community measures. These tools include sediment toxicity tests and empirical sediment quality guidelines (SQGs).

- Benthic communities are used by many State and federal agencies to evaluate the effects associated with impaired sediments, and to assess the effectiveness of mitigation actions. Existing data and assessment tools have been developed for many water bodies throughout the nation. While variability is always a factor when evaluating biological communities, compared to other indicators, the analysis of benthic community data does not rely on complex food web fate and transport studies and models to link a pollutant or stressor to a specific region or trophic level.

The State Water Board is required to protect all receptors associated with a specific beneficial use. However, many receptors are not understood well enough to develop tools and define appropriate thresholds for measuring the health of the receptor, or the linkage to pollutants in sediments is easily overshadowed by other factors.

Baseline: Selection of appropriate receptors for the assessment of sediment quality is site or water body specific with the final decision approved by the Regional Water Board.
Alternative 1: All potential receptors including aquatic plants, plankton, bacteria. In order to protect all receptors, detailed ecological risk assessments would be required for each water body of concern.
Alternative 2: Variety of important and ecologically relevant receptors. The process could focus on only the most sensitive organisms; however, sensitivity is specific only to types or groups of pollutants. As with Alternative 1, the application of different indicators would require extensive use of best professional judgment and is counter to the argument for statewide consistency of assessment tools.

Alternative 3: Important, relevant, and understood receptors (benthic invertebrates, and human health) exposed either directly or indirectly to pollutants in sediments. This alternative focuses on those sensitive and ecologically relevant receptors that have been evaluated and applied as sentinel organisms in sediment quality programs throughout the nation. This alternative would utilize the following three sediment-related exposure receptor relationships:

1. Benthic communities exposed directly to pollutants in sediment.
2. Human health exposed indirectly through fish and shellfish tissue.

The receptors and corresponding exposures must be clearly described in the policy. The selection of these receptors is not intended to trivialize the importance of other receptors. Receptors such as fish and wildlife are assessed often during the assessment of contaminated sediments through ecological risk assessment. These detailed site-specific studies are the appropriate mechanism to evaluate risk to those receptors not considered within the proposed plan. Additional receptors can be evaluated in later phases of the program.

Staff Recommendation: Alternative 3.

Suggested Policy Language: See Section 3.III.A.

2.8 How Should the Protected Condition be Defined for Benthos?

The protected condition establishes the standard or level of integrity that must be maintained. The protected condition is typically defined for benthic community by a reference condition. However, the reference condition is itself a source of disagreement. To some, reference condition should represent a hypothetical pristine community that could have existed prior to of the industrial age. In the past, Regional Water Boards have defined reference on a site-specific basis to determine impacts from specific source areas. The State Water Board has defined reference condition in the Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List "*as the characteristics of water body segments least impaired by human activities. As such, reference conditions can be used to describe attainable biological or habitat conditions for water body segments with common watershed/catchment characteristics within defined geographical regions.*"

Baseline: The protected condition is established on a water body or site-specific basis depending upon the programmatic goals of the action (site cleanup versus water body listing).
Alternative 1: Do not define the protected condition. This alternative would allow the Regional Water Board staff to continue establishing the protected condition on a site-specific or water body specific basis.
Alternative 2: Define reference condition on a site-specific basis. This approach does not attempt to identify the healthiest or least affected community within a habitat; rather, this approach is used to distinguish impacts associated with a specific source from other impacts within a broader area.
Alternative 3: Utilize the definition from the State Water Board's Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List and define reference communities based upon habitat. Benthic communities are defined by habitat condition such as salinity, grain size, and depth. This concept can be utilized to develop sensitive and robust tools with significant utility and broad applicability. The disadvantage of this approach is the need for large data sets to ensure that the reference condition is well understood.

Staff Recommendation: Alternative 3:

Suggested Policy Language: See Section 3.V.F.3 and 3.V.G.4.

2.9 How Should the Protected Condition be Defined in Phase I for Human Health?

The benchmark for protecting human health from the consumption of carcinogens in fish tissue is based upon the exposure (consumption rate) and the acceptable cancer risk.

Consumption Rate: The State Water Board and U.S. EPA have consistently established human health based water quality objectives based upon consumption rates of the general population and sportfishers. OEHHA, which is responsible for establishing fish consumption advisories in California, also bases its advisories on general population and Sportfishing consumption rates. These consumption rates vary from 6.5 grams per day established by U.S. EPA for California under the California Toxics Rule (CTR) to 21 to 22 grams per day utilized by OEHHA (1999) and the State Water Board's California Ocean Plan (2004).

> **Baseline:** The general population and Sportfisher consumption rates are used in the Regional Water Boards' Water Quality Control Plans (Basin Plans), and Total Maximum Daily Loads (TMDLs). These consumption rates range from 6.5 grams per day (CTR) to 32 grams per day (Regional Water Quality Control Board – San Francisco Bay Region, 2004)
> **Alternative 1:** General population (examples: 6.5, 17.5 grams per day).
> **Alternative 2:** Sportfishers (examples: 6.5, 16, 22, 32 grams per day).
> **Alternative 3:** Sensitive populations (example: 160 grams per day).
> **Alternative 4:** Propose two consumption rates for assessing risk that consider both the general population (17.5 grams per day) and sportfishers (32 grams per day).
> **Alternative 5:** Do not specify a consumption rate.
> **Alternative 6:** Specify consumption rates utilized by OEEHA for fish consumption risk assessment and advisories for bays and estuaries.

Staff Recommendation: Alternative 6.

Suggested Policy Language: See Section 3.VI.

Cancer Risk: U.S. EPA states that cancer risk factors ranging from 10^{-4} to 10^{-6} are protective of human health (U.S. EPA 1995A) and are consistent with the federal CWA. OEHHA utilizes a cancer risk factor of 10^{-5} when establishing fish tissue advisories for legacy pollutants considered carcinogenic (OEHHA, 1999). Recently, OEHHA proposed using a cancer risk factor of 10^{-4}. U.S. EPA also supports this 10^{-5} risk factor in the development of fish tissue advisories (U.S. EPA, 2000B).

> **Baseline:** Variable 1 in 100,000, to 1,000,000.
> **Alternative 1:** Cancer risk 1 in 10,000.
> **Alternative 2:** Cancer risk 1 in 100,000.
> **Alternative 3:** Cancer risk 1 in 1,000,000.
> **Alternative 4:** Cancer risk factor 1 in 100,000 with guidance for the selection of site-specific risk factors.
> **Alternative 5:** Do not specify a cancer risk.
> **Alternative 6:** Specify cancer risk factors utilized by OEHHA for fish consumption risk assessment and advisories for bays and estuaries.

Staff Recommendation: Alternative 6.

Suggested Policy Language: See Section 3.VI.

Environmental Justice

Environmental Justice (EJ) is defined by California statute as: "The fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of all environmental laws, regulations, and policies." A principal goal of the State and Regional Water Boards' Environmental Justice Programs is to integrate environmental justice considerations into the development, adoption, implementation, and enforcement of Board decisions, regulations, and policies. Identifying, assessing, and managing environmental justice-associated risks is a very difficult process because these issues frequently involve a very small portion of the population that has unique dietary habits. In order to develop a plan that is responsive to environmental justice issues, staff at the State Water Board will need to work hand in hand with the Regional Water Boards, OEHHA, and DTSC to develop approaches that can effectively identify those populations at risk and the specific diets that increase those risks. Although resource intensive, this would allow management decisions to be made based on what the true risks are rather than the assumptions used currently, which are based upon more general consumption surveys. As a result, decisions can be made with confidence that will protect specific individuals at high risk. Addressing this issue in Phase I is problematic because the technical team has not been able to address all the human health implementation issues in time for inclusion within Phase I.

> **Baseline:** Regional Water Boards respond to EJ issues at the local level.
> **Alternative 1:** Do not address EJ in the plan.
> **Alternative 2:** Develop a proposed approach that addresses EJ issues in Phase II amendments, after staff has more fully developed human health-based SQOs and robust implementation tools and thresholds.

Staff Recommendation: Alternative 2.

Suggested Policy Language: Not applicable.

2.10 What Lines of Evidence are Needed to Assess Sediment Quality?

Water quality is routinely assessed based on a single line of evidence (LOE), chemical-specific concentration-based thresholds developed from toxicological studies. A single LOE is appropriate in the water column because the binding effects of other water column constituents are well understood, and the performance of these chemical-specific criteria is reproducible under a variety of conditions (U.S. EPA, 1985, 1991). Moreover, there is a single predominant means for chemical exposure in the water column, transport across the gills. As a result, scientists have been able to integrate this information to describe site-specific bioavailability of chemical contaminants using tools such as the Biotic Ligand Model (Paquin et al, 2002).

Sediment, however, is a more complex matrix that makes establishment of an objective based on chemical concentration alone problematic. There are two primary factors that create this complexity: variations in the bioavailability of sediment-associated contaminants, and multiple pathways of exposure resulting in both direct effects (from contact with the sediment) and indirect effects (as a result of bioaccumulation and transfer to higher trophic levels). Bulk measures of chemical concentration fail to differentiate between the fraction that is tightly bound to sediment and that which is found in interstitial waters and more available for transport across the gill. Further complicating interpretation of chemical data is that transport of chemicals in interstitial waters across the gill is not the only mechanism for exposure, as many benthic organisms ingest the sediment and can uptake chemicals sorbed onto particles. Thus, even chemical measurement approaches that attempt to differentiate interstitial chemical concentrations, such as using equilibrium partitioning models or direct measurement of pore water chemistry, do not fully describe chemical bioavailability in the sediment. Only the bioavailable fraction of pollutant has the potential to alter basic functional processes such as oxygen transfer or reproduction

Factors that affect bioavailability of contaminants in sediment include the proportion of organic matter, grain size, hydrogen ion activity (pH), and aerobic state, salinity, chemical form of the pollutants, and the composition and mineralogy of the sediment itself (Chapman et al 2001, U.S. EPA 2000A). These factors can create large spatial and temporal differences in pollutant bioavailability within a given region or water body (Chapman et al, 2001, U.S. EPA 2001A).

Assessing the indirect effects of sediment contamination presents additional challenges besides those identified for direct effects. As predators consume many prey throughout their lifespan, bioaccumulative pollutants with an affinity for fatty tissue, such as DDT, polychlorinated biphenyls (PCBs), and methyl mercury can build up to levels many times greater then those observed in lower trophic levels or in the sediment (biomagnification). Numerous studies have demonstrated that the biomagnification of sediment-associated compounds can cause deleterious effects in fish and in wildlife or human consumers of seafood (Beyer et al. 1996). The presence of multiple trophic levels and different types of receptors for effects creates additional complexity and uncertainty in the interpretation of sediment contamination data.

A thorough understanding of fish communities, trophic structure and uptake, and the pollutant contribution from all sources must be assessed in order to quantifiably link sediment and fish tissue contaminant levels. Fish are highly mobile; at a given site, a portion of an organism's contaminant body burden may result from uptake from other locations, or from other sources such as the overlying water column. Although specific case studies indicate that certain contaminants are accumulated from the sediments (Gobas et al, 2002), this could vary on a site-by-site basis. Variation in home range can affect the relative impact of contamination at a specific site as a result of the heterogeneous distribution of chemicals in the sediment. Variations in food web structure among locations can also cause differences in contaminant bioaccumulation (Gobas et al, 2002).

As a result of the factors described above, sediment quality indicators based on pollutant concentrations in sediment have only limited utility when used by sediment managers unless bolstered by effects data such as toxicity and benthic community disturbance (Chapman 1990, Ingersoll et al 2002c, Wenning et al 2002). This limitation is acknowledged in the ecological risk assessment process, where measures of both chemical exposure and effects are required in order to evaluate the potential for adverse impacts due to either the direct or indirect effects of contaminants.

Other LOE applied to sediments also have potential flaws that make them inappropriate for establishment of SQOs when used alone. Toxicity tests improve in some ways on chemical measurements because they integrate the effects of multiple contaminants- even those chemicals that are not routinely measured. Toxicity tests are problematic, though, because the presence of natural factors such as ammonia, hydrogen sulfide, or physical abrasion can lead to spurious results. Moreover, toxicity tests are typically conducted under laboratory conditions using species that may not occur naturally at the test site, making it difficult to interpret ecological significance of the results when used alone (Chapman et al 2001). This interpretational difficulty is compounded by the demonstrated difference in sensitivity among different types of toxicity tests and test species.

Benthic community condition is a good indicator because the benthos are directly exposed to sediment contamination and are one of the target biological resources the SQOs are intended to protect. However, their use alone is problematic because they are potentially affected by a large number of factors other than chemical contamination. Without chemistry or toxicity data for confirmation, it is difficult to distinguish whether degraded benthic communities resulted from chemical exposure or from physical disturbance, such as an anchor or prop-wash.

Bioaccumulation is also a useful measure, but sediments classified based on only a tissue uptake/bioaccumulation LOE would not account for toxicants that tend not to bioaccumulate in tissues of biota. Most trace metals and polynuclear aromatic hydrocarbons (PAHs) do not bioaccumulate in tissues, so their presence and toxicity would not be accounted for in such an approach. In addition, impacts from readily biotransformed pollutants would not be addressed by this LOE. The measurement of fish or shellfish tissue contamination provides an important measure of potential effects to wildlife or human consumers, but the mobility and varied life histories of the species makes it difficult to associate the effects with sediment contamination in specific locations.

For these reasons, multiple lines of evidence (MLOE) that represent both contaminant exposure and effects are frequently used in sediment assessments. The State Water Board's Bay Protection and Toxic Hotspots Cleanup Program relied primarily on MLOE to make critical decisions regarding management of sediment in bays and estuaries throughout the State (Anderson et, al 1997, 1998, Fairey, R, 1998, Hunt et al, 1998).

Virtually all of the estuarine ambient monitoring programs in this country rely on some form of the sediment quality triad, where chemistry and multiple measures of biological effect are used together to assess sediment quality (Crane, J.L., et al 2000, Ingersoll, C. et al. 2002, MacDonald et al, 2003, U.S. EPA, 1998, 2004). These include the two largest nationwide estuarine monitoring programs, U.S. EPA's Environmental Monitoring and Assessment Program and the National Oceanic and Atmospheric Administration's (NOAAs) National Status and Trends Program, as well numerous regional monitoring programs, including those for the Great Lakes, Puget Sound, San Francisco Bay, Chesapeake Bay, Southern California Bight, Tampa Bay, and New York/New Jersey harbors.

The triad concept has been used and published in the United States, Canada, Australia, United Kingdom, France, the Netherlands, and Brazil, among others. Most regulatory programs, including those that control open water disposal of dredged material, require tests of sediment chemistry, toxicity, and bioaccumulation. Comprehensive ecological risk assessments invariably use a weight of evidence approach from multiple kinds of assays and tests to estimate and manage risks at waste sites. Even the national chemical benchmarks issued by U.S. EPA that rely on one LOE encourage users to apply them in concert with other sediment assessment tools in making management decisions.

While various MLOE approaches have been used to describe and classify sediment quality, they have typically been applied for site-specific or regional assessments. Moreover, MLOE applications are often based on use of best professional judgment (BPJ) for combining the individual LOE. BPJ will be ineffective for use in SQOs because the expertise of the individuals applying them will vary considerably across the State, and there is a need for statewide consistency in their application. While there is no direct precedent for translation of MLOE into criteria, standards, or objectives, there are some applications that move in that direction from which lessons can be learned. The State of Washington SQSs have provisions to use chemical, toxicological, and benthic composition data to classify sediments for multiple purposes, including disposal of dredged material. The Tampa Bay Estuary Program has adopted a triad of measures of sediment quality for management purposes there. The States of Minnesota and Illinois, in partnership with the U.S. EPA Assessment and Remediation of Contaminated Sediment (ARCS) Program of the Great Lakes National Program Office, use the triad of measures to assess sediment quality for management in the Great Lakes.

Baseline: Sediment quality assessment programs throughout the nation rely on MLOE to assess impacts to beneficial or designated uses.
Alternative 1: Do not specify LOE.
Alternative 2: Base policy on application of a single LOE. This alternative would base the policy on a single LOE, such as sediment toxicity, chemistry, or benthic community. Such an approach would

be very simple to implement; however, any single LOE is affected by confounding factors, measurement errors, and variability and would contradict the approach recommended by U.S. EPA.
Alternative 3: Base policy on application of MLOE. The suite of tools and LOE would be specific to each receptor.

Staff Recommendation: Alternative 3.

Suggested Policy Language: See Sections 3.1.A, 3.IV.A, 3.V.A and B.

2.11 What Type of Objectives Should be Utilized in the Proposed Policy?

The State Water Board has the option of establishing narrative or numeric objectives, or some combination of the two. In order to implement an approach based upon MLOE, consideration must be given to the importance of each tool. Sediment quality is assessed with a combination of tools and results, in contrast to a numeric water quality objective for which a single specific measurement may be used. Within this approach, a narrative objective can be proposed that can be implemented with a high degree of confidence using a robust suite of tools; the MLOE approach. This approach would also minimize potential conflicts associated with discordant results. In addition, as better tools are developed to support the narrative objectives, these tools could be added under amendment while maintaining a consistent narrative objective.

Baseline: Some Basin Plans include narrative requirements; however, implementation is limited and typically relies on BPJ applied on a case-by-case basis.
Alternative 1: Do not adopt SQOs. This alternative would conflict with Chapter 5.6, which requires the State Water Board to adopt SQOs.
Alternative 2: Numeric objectives could be developed and proposed for each LOE. However, each numeric objective would need to be integrated into a weight of evidence approach. The numeric objective would be meaningless without the other LOE.
Alternative 3: Narrative objectives could be proposed that would be implemented using MLOE and corresponding thresholds coupled to a data integration process.

Staff Recommendation: Alternative 3.

Suggested Policy Language: See Sections 3.IV.A and B.

2.12 Should a Pass/Fail or Ordinal System be Utilized in the Evaluation of Each LOE?

A pass/fail system based on a comparison to a single threshold is simple and easily implemented within a regulatory program. The pass-fail approach is frequently applied to water quality assessment and is appropriate in this situation where the dose response relationship is well documented in the laboratory and validated in surface waters (U.S. EPA 1991). Some applications of the sediment quality triad also use a pass/fail system to evaluate each LOE. Use of a pass/fail system requires a high level of confidence that the threshold used is appropriate and protective. The evaluation sediment quality data is complex, and the available tools do not always provide the high level of confidence needed for establishment of a single pass/fail threshold (Chapman 1990, Ingersoll et al 2002c, Wenning et al 2002). BPJ is often used to determine whether a LOE result represents an adverse response, which makes it difficult to establish a consistent threshold for pass/fail determination. An ordinal system of evaluation has also been used in many sediment assessment programs. Ordinal systems use multiple thresholds to classify the LOE result into several categories that reflect the magnitude of response and certainty that an effect is present. Use of an ordinal system also retains more scientific information regarding the LOE, which provides greater utility for review of the assessment and use of the classification in planning and prioritizing subsequent management actions.

Baseline: Sediment thresholds are currently established using a combination of BPJ and applying existing SQGs that are available only for pollutant concentrations in sediment.

Alternative 1: Thresholds should only be developed for pass/fail determination.
Alternative 2: Ordinal thresholds should be developed that consider both magnitude and confidence. This alternative is consistent with the Scientific Steering Committee's position requesting that the technical team include magnitude and confidence in threshold development.

Staff Recommendation: Alternative 2.

Suggested Policy Language: See Sections 3.V.F.3, 3.V.G.4, and 3.V.H.2.

2.13 Should Sediment Toxicity be Used as One of the Suite of Tools Used to Implement the Direct Effects of SQOs for the Protection of Benthic Communities?

Sediment toxicity tests are considered an important component of sediment quality assessments (U.S. EPA 2001a, 2004a, 2004b, 2005, DEQ 1995, Wenning et al 2002). Much of the testing has employed acute amphipod survival methods using protocols established by U.S. EPA (U.S. EPA 1994). Many of the projects have also included a measure of sublethal toxic effects in sediments using a wide variety of test methods, including long-term growth tests, elutriate toxicity tests, porewater toxicity tests, and tests of toxicity at the sediment-water interface. The Environmental Mapping and Assessment Program of U.S. EPA has used amphipod acute testing in conjunction with a variety of sublethal methods in different parts of the country (Ringwood *et al.* 1996, Bay *et al.* 1998). The State of Washington has a program for monitoring and assessing sediments that has been in place for nearly two decades using a combination of acute amphipod tests, polychaete growth tests, and modified elutriate testing with invertebrate larvae (Puget Sound Water Quality Authority 1995).

Laboratory toxicity tests consist of exposing test organisms to sediments within a controlled environment. The toxicity test response provides a direct measure of the combined effects of all chemicals present in the sample and can thus indicate the presence of toxic quantities of chemicals that were not detected or analyzed for in a chemical analysis. Because toxicity tests are conducted using sediments from the environment, the results incorporate the effects of sediment characteristics such as organic carbon that can alter the biological availability of the contaminant. The laboratory environment of the toxicity test allows for the control of confounding factors such as salinity, temperature, or dissolved oxygen that may vary in the field, thus permitting a distinction between toxic effects and effects due to natural habitat variability. The toxicity test result may overestimate or underestimate effects occurring in the field due to variations in the sensitivity of the test organism or to changes in chemical exposure caused by sediment handling in the laboratory. Sediment toxicity tests are considered an important component of sediment quality assessments (U.S. EPA 2001a, 2004a, 2004b, 2005, DEQ 1995, Wenning et al 2002). Laboratory toxicity tests consist of exposing test organisms to sediments within a controlled environment.

Baseline: The State and Regional Water Boards have relied upon sediment toxicity tests.
Alternative 1: Do not consider sediment toxicity tests for measuring direct effects.
Alternative 2: Propose sediment toxicity tests for inclusion in the implementation of direct effects narrative SQOs.

Staff Recommendation: Alternative 2.

Suggested Policy Language: See Section 3.V.A.

2.14 Should the State Water Board Specify the Sediment Toxicity Tests for Use in Implementing the Narrative SQO?

Various methods for measuring sediment toxicity are available. Key differences between tests include: species, life history stage, duration, endpoint, and mode of exposure. Different species vary in their sensitivity to contaminants as a result of physiological differences, body type, and degree of exposure to the sediment. Crustaceans, bivalves, or polychaete worms are commonly used in toxicity tests, and there is no single species that is consistently the most sensitive to all contaminants of interest. Various life history stages, including embryos, juveniles, and adults, are used in toxicity tests. Embryos and juveniles are generally more sensitive to contaminants than adults, but adult test organisms may be less sensitive to confounding factors that complicate test interpretation. There are a variety of endpoints that are specific to each test. The simplest endpoint is survival or lethality which is the endpoint associated with acute tests. Sublethal test endpoints include growth, reproduction, egg fertilization, embryo development, and biochemical responses such as DNA damage or cellular stress.

Test duration varies widely among toxicity test methods; tests generally range from 48 hours to 28 days in length. Longer duration tests may be more sensitive to the effects of chemicals that require bioaccumulation before toxicity is caused, but they also are more difficult and expensive to conduct. The method of exposure can also affect the sensitivity of the toxicity test or the data interpretation. Many tests expose the organism directly to whole sediment, which provides potential chemical exposure from direct particle contact, the pore water, and from sediment ingestion. Other test methods expose the organism to pore water extracted from the sediment, an elutriate, overlying water, or a solvent extract of the sediment. These variations in exposure method are used to facilitate tests with organisms that cannot tolerate sediment contact (e.g., embryos) or to investigate specific mechanisms of exposure.

Because toxicity test responses are governed by so many different factors, a suite of standard test methods is often used to measure sediment toxicity in various assessment or regulatory programs. By requiring the use of specific test methods, (1) consistency is established throughout the State, (2) statewide thresholds can be developed that minimize subjective decision making, and (3) inappropriate tests will not be performed.

The process of selecting the recommended toxicity methods for the SQO program included reviewing the literature and consulting with other scientists to identify a set of candidate sediment toxicity protocols that had the following characteristics: adopted or approved by U.S. EPA, USACE, American Society for Testing and Material Standards (ASTM), or other states; tolerance of expected sediment physical characteristics; diversity of taxonomic groups; association between response and sediment exposure; sensitivity to individual contaminants; and representative of benthic community species.

The selection process resulted in a candidate test method list consisting of acute methods with the four commonly used amphipod species (*Ampelisca abdita*, *Eohaustorius estuarius*, *Rhepoxynius abronius,* and *Leptocheirus plumulosus*) plus six sublethal methods using amphipods (*Leptocheirus plumulosus),* polychaete worms *(Neanthes arenaceodentata),* sea urchins *(Strongylocentrotus purpuratus),* bivalves (*Mytilus galloprovincialis, Mercenaria mercenaria, Crassostrea virginica*), and copepods (*Amphiascus tenuiremis*).

Toxicity tests on sediment pore water or elutriate samples were not considered for evaluation because of technical limitations in the methods. Pore water tests are widely used for testing sediment toxicity (Carr and Nipper 2003), but it is difficult to collect enough sample for testing. Other characteristics of pore water toxicity tests make these methods less suited for use in the SQO program, including potential changes in metal toxicity due to oxidation, change in sample pH, sorption of contaminants to test chambers, confounding effects of ammonia toxicity, and elimination of sediment ingestion as a route of uptake (Ho *et al.* 2002).

Elutriate tests were also not included in the list of candidate methods. These tests, where sediments are added to water with agitation, allowed to settle, and then the water is removed for testing, are often used for testing the effects of sediment resuspension during dredged material disposal. The elutriate sample is subject to many of the confounding factors associated with pore water, and the relationship of the results to direct sediment exposure is not known.

Each of the candidate methods was ranked relative to the following characteristics: organism availability, method documentation, technical difficulty, sensitivity, precision, and cost. *Eohaustorius, Rhepoxynius* and *Leptocheirus* are recommended as the best choices for acute testing in California. *Eohaustorius* and *Rhepoxynius* have a substantial history of use in California for both monitoring and assessment studies. The *Leptocheirus* 10-day test has been conducted in California on a much more limited basis. However, it has long been used in other parts of the country, especially on the Gulf coast for monitoring and assessment studies. *Leptocheirus* is also easily cultured in the laboratory and available year round from commercial suppliers.

Two sublethal test methods are recommended for use in the SQO program: a 28-day growth test using the polychaete worm *Neanthes arenaceodentata* and a 2-day development test using embryos of the mussel *Mytilus galloprovincialis* exposed at the sediment-water interface. These two tests had the best combination of characteristics related to test feasibility, method documentation, and sensitivity. The recommended tests complement the ability of the acute tests to detect toxicity by providing diversity in test species, length of exposure, and mode of exposure. The other sublethal tests were not recommended for a variety of reasons, including incomplete documentation of the method, high cost, and relatively low sensitivity to contaminated sediments.

> **Baseline:** The State and Regional Water Boards have relied upon sediment toxicity tests, and the State Water Board selected from methods used in past studies.
> **Alternate 1**: Do not specify toxicity methods.
> **Alternate 2**: Measure acute toxicity as an indicator of benthic condition.
> **Alternate 3**: Measure sublethal toxicity as an indicator of benthic condition.
> **Alternate 4**: Specify combination of acute and sublethal toxicity methods.

Staff Recommendation: Alternative 4.

Suggested Policy Language: See Section 3.V.F.

2.15 Should Chemical Concentrations in Sediment be Used as One of the Suite of Tools to Implement the Direct Effects of SQO for the Protection of Benthic Communities?

Sediment chemistry is considered a well-established and proven sediment quality assessment tool when applied appropriately with other LOE. Studies have shown that chemical (SQGs) are predictive of the incidence and magnitude of biological effects, especially in instances of high/low contaminant concentrations. Predictions of the biological effect based on SQGs have the highest error rates when applied to samples containing intermediate levels of contamination (Long *et al.* 1998, Fairey *et al.* 2001). The predictive ability of SQGs has also been shown to vary among datasets from different regions (Fairey *et al.* 2001, Crane *et al.* 2002), which complicates the selection of the most reliable approach and thresholds for a given application.

Misuse of sediment chemistry guidelines has caused considerable concern over the use of this tool within a Regional Water Board Basin Plan. The use of chemical SQGs is often accompanied by substantial uncertainty and controversy, as no single SQG approach is able to account for all of the factors that influence contaminant effects. In sediments, if pollutant concentrations are very low or not detected but significant effects are observed, two possible scenarios exist: (1) a non pollutant related stressor such as physical disturbance or habitat alteration is the cause of impairment; or (2) a pollutant is present that was not identified by the suite of analytical methods selected (Chapman 1990, Ingersoll C. et al, 2002c). Both scenarios assume that the effects data and the chemistry data accurately reflect the conditions at the station. Conversely, if pollutant concentrations are elevated but effects are not observed, the pollutant may not be bioavailable. Simple effective approaches to quantify bioavailable fraction of a pollutant in sediment are not currently available and are not likely to be developed in the near future (U.S. EPA 2005).

> **Baseline**: Sediment chemistry is frequently used as an indicator to assess potential impacts. In this role, sediment concentrations are compared to various SQGs (ERLs, ERMs, PELs, AETs) either independently or in conjunction with other LOEs to determine if the pollutants in sediment pose a risk. In California, there are no current plans or policies that define what guidelines shall be used, how the guidelines should be applied, or what the appropriate conclusion is that can be made based solely on chemistry.
> **Alternative 1**: Do not consider sediment chemistry as a direct-effects implementation tool. As described previously, sediment chemistry is not a measure of the bioavailable fraction of pollutants in sediment. As a result, this tool would have little or no utility within a state sediment quality program.
> **Alternative 2**: Propose specific sediment chemistry indicators for inclusion in the implementation of direct effects narrative SQOs. Within the draft policy, sediment chemistry would be proposed as a surrogate measure of exposure and used only with other LOEs.

Staff Recommendation: Alternative 2.

Suggested Policy Language: See Section 3.V.A.

2.16 What Sediment Chemistry Indicators Should the State Water Board Use to Support the Proposed SQO?

A variety of sediment chemistry-based guidelines has been developed from empirical or mechanistic relationships with biological effects (Barrick *et al.* 1988, Long *et al.* 1995, Swartz 1999, Di Toro and McGrath 2000, Fairey *et al.* 2001, Field *et al.* 2002). These "sediment quality guidelines" have been applied within sediment assessment programs throughout the nation. Empirical guidelines are based on field data containing paired information on contaminant concentrations and biological effects. Various statistical approaches are used to relate the chemical concentrations to the frequency or magnitude of biological effects. Empirical SQGs have broad applicability and can be applied using routine monitoring data, but these guidelines do not identify the cause of effects. Mechanistic SQGs use an understanding of chemical and biological processes to predict toxicity and can help identify the cause of effects. Current mechanistic approaches are based on equilibrium partitioning theory, where sediment chemical concentrations are related to pore water concentrations. Mechanistic SQGs apply to a limited suite of contaminants, and their application often requires the collection of specialized information on sediment binding phases that is not readily available for many sites in California embayments. For potential application in a SQO policy setting, several empirical SQGs were evaluated, including existing guidelines; regional guidelines calibrated to California data; and newly developed guidelines.

The guideline approaches evaluated include:

Effects Range Median (NOAA ERM)
The Effects Range Median (ERM) approach (Long *et al.*, 1995) is one of the most commonly used SQGs. This method is used to identify adverse effects to sediment dwelling marine organisms. The ERM values

were created from a national database of paired biological effects and sediment contaminant data. Multiple biological effects indicators were included in the database (this approach is not endpoint specific) and evaluated for the degree of concordance between chemical and different types of biological responses. Only the data for which a biological effect was observed in association with elevated chemical concentrations were used for ERM derivation.

The ERMs were calculated by sorting the data in ascending order of concentration to calculate percentiles. The ERM corresponds to the 50th percentile (median value) for each chemical and represents the concentration above which adverse effects are frequently observed. Individual ERMs were combined as a mean quotient to represent chemical mixture effects. The quotients were calculated by normalizing each chemical to its respective ERM and subsequently averaging them for each sample.

Mean Sediment Quality Guideline Quotient 1 (SQGQ1)
The mean SQGQ1 is a subset of chemical-specific SQGs from various empirical and mechanistic approaches (Fairey *et al*. 2001). The chemical suite includes five metals and four organics. This suite of chemicals was selected to obtain the strongest relationship to adverse biological effects. SQGQ1 quotients are calculated by normalizing each chemical value by its corresponding SQG. Then the normalized values for the suite of chemicals are averaged.

Consensus Median Effect Concentration (Consensus)
The Consensus guidelines represent the integration of different types of SQGs. This approach collated existing SQGs for chemicals of interest and evaluated them to determine their applicability (Swartz, 1999). Consensus SQG values have been developed for three levels of biological effect: the threshold effect concentration (TEC), representing contaminant concentrations below which harmful effects on organisms are expected to occur infrequently; the median effect concentration (MEC), which represents contaminant concentrations above which harmful effects are frequently observed; and the extreme effect concentration (EEC), which represents concentrations where effects are always expected.

Consensus MEC values were calculated by determining the geometric mean of three or more SQGs. Consensus values were previously derived for PAHs and PCBs in marine and freshwater systems, as well as for metals and several pesticides in freshwater systems (Swartz, 1999; McDonald et al., 2000). The State and Regional Water Boards' program also used Consensus MEC values calculated by SCCWRP for other chemicals: DDTs, dieldrin, arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc (Vidal and Bay, 2005). The Consensus chemical indicator evaluated in this project was the mean quotient of the individual Consensus MECs. Individual chemical values were normalized by dividing them by their corresponding Consensus MEC value, then the normalized values where averaged for each sample.

Logistic Regression Modeling (National Pmax)
The Logistic Regression Modeling (LRM) approach is based on statistical analysis of matching chemistry and biological effects for amphipod toxicity (Field *et al.*, 1999). Chemistry and toxicity data from national databases were used for this approach. The LRM method does not yield specific SQG values for each chemical but, rather, describes the relationship between contaminant concentrations and the probability of toxicity. This relationship can be used to calculate SQGs based on the level of protection desired.

In the LRM approach, data for individual sediment samples were sorted by ascending concentrations for each particular contaminant. The data were screened to reduce the influence of samples that did not contribute to the toxic effects associated with the specific contaminant of interest. A LRM was then applied to the screened data that described the relationship between the concentration of a selected contaminant and the probability of observed toxicity. Individual chemical regression models were combined into a single mixture effects model based on the maximum probability of effects or P_{max} (Field et al., 2002). The maximum probability obtained from the individual chemical models is selected to represent the chemical mixture present in a sample.

California Effects Range Median (CA ERM)
SQGs analogous to ERMs were calculated using California data. The data were screened to identify toxic samples ($\geq$ 20 percent mortality) with chemical concentrations > 2x median concentration of non-toxic samples. After screening, the data were sorted in ascending order, and the median concentration for each chemical was calculated (for chemicals with $\geq$ 10 samples). CA ERM values were calculated for 27 chemicals.

California Logistic Regression Modeling (CA Pmax)
Development of California SQGs based on LRMs followed the methods described in Field et al. (2002). California-specific models were selected from a library of models that included national models as well as models derived using the California data sets. The selected models were developed and evaluated based on amphipod toxicity. The selected models were chosen based on the goodness of fit with the observed probability of toxicity. Models with high false/positive rates were not used for analysis.

Individual chemical regression models were combined into a single mixture effects model based on the maximum probability of effects or P_{max} (Field et al., 2002). The maximum probability obtained from the individual chemical models is selected to represent the chemical mixture present in a sample.

Mean Weighted Chemical Category Score (CCS)
The mean weighted chemical category score is a new SQG based on the association between chemicals and the magnitude of biological response (i.e., category prediction based on toxicity or benthic community disturbance). Three chemical concentration values defining the biological response levels of no effect are: (1) low effect, (2) moderate effect, (3) high effect, and (4) a weighting factor reflecting the strength of association were calculated for each chemical. The chemical values and weighting factor were determined for each chemical by a statistical process that identified the chemical ranges producing the best agreement with the biological response categories.

Each constituent's predicted effect level is then multiplied by its respective weighting factor to produce a CCS. Individual CCSs were combined as a weighted mean to represent chemical mixture effects. The scores were summed across all constituents in the sample and divided by the sum of weighting factors to produce the mean weighted CCS.

> **Baseline:** Sediment chemistry is typically evaluated by comparison to one or more national empirical SQGs, with little consistency in approach among regions.
> **Alternate 1:** Establish narrative guidance.
> **Alternate 2:** Use existing national empirical SQGs without consideration of actual predictive ability when applied to California data.
> **Alternate 3:** Use either existing, regional, or new empirical SQGs derived from California data. Methodologies and thresholds for applications would be selected based upon how the approach performs within the SQO framework.

Staff Recommendation: Alternative 3.

Suggested Policy Language: See Section 3.V.H.

2.17 Should the State Water Board Specify the Method or Index Used to Assess Community Data?

Benthic communities are found almost universally in aquatic soft sediments and are indicators of choice for monitoring and assessing anthropogenic effects for two main reasons. First, they possess many attributes considered desirable in indicator organisms, including limited mobility, diversity of organism types, life histories that are short enough to reflect recent changes in stressors, and direct exposure to sediment contamination. Second, they are important components of aquatic food webs, transferring carbon and nutrients from suspended particulates in the water column to the sediments by filter feeding and serving as forage for bottom-feeding fishes.

Despite these appealing characteristics, benthic infaunal monitoring data are maximally useful in a regulatory context only when they can be interpreted in relation to scientifically valid criteria or thresholds that distinguish “healthy” from “unhealthy” benthic communities. While reducing complex biological data to index values has disadvantages, the resulting indices remove much of the subjectivity associated with data interpretation. Such indices also provide a simple means of communicating complex information to managers, tracking trends over time, and correlating benthic responses with stressor data (Dauer *et al.* 2000, Hale *et al.* 2004).

During the past decade, several scientifically valid measures of marine and estuarine benthic community condition, often called benthic indices, have been developed for regulatory use. Benthic indices are increasingly accepted by regulators and incorporated into regulatory processes. The U.S. EPA’s guidance for biocriteria development (Gibson *et al.* 2000) recognizes all three types of benthic indices, and the agency included benthic assessments in a recent report on nationwide coastal condition to Congress (U.S. EPA 2004). In Maryland and Virginia, the Index of Biotic Integrity is one of the measures used to report on the condition of Chesapeake Bay waters under sections 305(b) and 303(d) of CWA. In California, benthic indices were one of the factors used by the State Water Board to designate toxic hotspots (California State Water Resources Control Board 1999) and by the San Diego Regional Water Quality Control Board to make clean-up decisions for three toxic hot-spots in San Diego Bay (Exponent 2002, SCCWRP and Space and Naval Warfare Systems Center San Diego 2004). Due to the presence of benthic communities in good condition as measured by the Benthic Response Index (BRI) and other reasons, Santa Monica Bay, which previously was listed as impaired under section 303(d) of CWA due to sediment concentrations of six metals, was removed from the list in 2003. The BRI has also been used in southern California to assess the extent of bottom area supporting unhealthy benthic communities since 1994 (Bergen *et al.* 1998, Bergen *et al.* 2000, Ranasinghe *et al.* 2003).

There are several impediments to applying benthic indices statewide in California’s bays and estuaries. First, the number of unique habitats and benthic assemblages that exist and the corresponding number of benthic indices to be developed are unknown; species and abundances of benthic organisms vary naturally from habitat to habitat and comparisons to determine altered states should vary accordingly. Second, different benthic indices have been used in California at different times and different places, and results cannot be compared across regions because the various indices have not yet been rigorously compared and intercalibrated. Third, initial development of each existing benthic index was constrained by data limitations, and they would all benefit from refinement with additional data as well as independent validation. In addition, there is a lack of knowledge of the effects of differences in: (1) sampling procedures traditional in different regions, (2) habitat factors such as seasonality and sediment type, and (3) accuracy of identification of benthic organisms on performance of California benthic indices. As a result, significant work is required to develop benthic tools for all bays and estuarine habitats. Five index approaches that had been calibrated to California data were evaluated for potential application in a SQO policy setting. These approaches were:

Benthic Response Index (BRI)

The Benthic Response Index (BRI) was originally developed for the southern California mainland shelf by Smith *et al.* (2001) and extended into California bays and estuaries by Smith *et al.* (2003) and Ranasinghe *et al.* (2004). The BRI is the abundance-weighted average pollution tolerance score of organisms occurring in a sample.

Relative Benthic Index (RBI)
The RBI was originally developed for estuarine applications in California's Bay Protection and Cleanup Program (Hunt *et al.* 2001). The RBI is the weighted sum of (a) several community parameters (total number of species, number of crustacean species, number of crustacean individuals, and number of mollusc species) and abundances; (b) three positive; and (c) two negative indicator organisms.

Index of Biotic Integrity (IBI)
The IBI was developed for freshwater streams and adapted for estuarine applications by Weisberg *et al.* (1997), Van Dolah *et al.* (1999) and Thompson and Lowe (2004). The IBI identifies community measures that have values outside a reference range.

River Invertebrate Prediction and Classification System (RIVPACS)
The RIVPACS was originally developed for British freshwater streams by Wright *et al.* (1993) and applied in estuaries and bays for the first time in this project. The approach compares the assemblage at a site with an expected species composition determined by a multivariate predictive model that is based on species relationships to habitat gradients (Van Sickle *et al.* 2006).

Benthic Quality Index (BQI)
The BQI was originally developed for the west coast of Sweden by Rosenberg *et al.* (2004) and applied in the United States for the first time in this project. The BQI is the product of the logarithm ($base_{10}$) of the total number of species and the abundance-weighted average tolerance of organisms occurring in a sample. Species tolerance scores are calculated differently than for the BRI; instead, they are based on relationships of the abundance distributions to Hurlbert's (1971) expected number of species.

These indices were evaluated by comparison with the consensus of nine benthic experts, who classified the condition of 36 samples from California into one of four condition categories: reference, low disturbance, moderate disturbance, or high disturbance. Individually, none of the indices fared as well as the experts, but all of them had at least a 75 percent correct status classification, in which the benthic condition was expressed as good (reference or low disturbance) or bad (moderate or major disturbance). Index combinations generally performed better than individual indices, and combinations of three or more indices generally performed the best.

> **Baseline**: No methods have been approved or adopted by the State or Regional Water Boards for the habitats under consideration. However, several tools have been applied by the State and Regional Water Boards for the purposes of hot spot identification, water body assessment and site assessments.
> **Alternative 1**: Do not specify the methods.
> **Alternative 2**: Select a single method for all applicable water bodies.
> **Alternative 3**: Select multiple methods for applicable water bodies.

Staff Recommendation: Alternative 3.

Suggested Policy Language: See Section 3.V.G.

2.18 How Should the Data from Each Direct Effects LOE be Integrated?

The use of MLOE in the assessment of sediment is the most robust method available to resource and water quality managers. However, as discussed in Section 2.11, this approach is rarely if ever applied within the context of a water quality control program. Risk assessments and monitoring programs have used a wide variety of methods to integrate MLOE for the purpose of determining the likelihood of adverse effects from sediment contamination (Chapman et. al., 2002). These methods include reliance solely on BPJ, the use of statistical methods such as ratios or multivariate analyses to rank and classify different combinations of LOEs, and the use of logic systems where the cause and certainty of ecosystem impairment is inferred based on the characteristics of each LOE.

BPJ relies on the use of expert opinion to evaluate the data on a site- and situation-specific basis. The approach is flexible and can be adapted to a wide array of data types and quality. Within a large and densely populated state, the utility of BPJ is limited for many reasons. Its use:

- May result in inconsistent decisions within a single region and from region to region.
- Can be time consuming and resource intensive.
- May not always lead to transparent and unbiased decisions.
- May not allow Regional Water Board staff, permittees, or interested parties to assess the outcome independently.

Statistical integration methods such as ratios or other indices can result in the compression and loss of relevant information about the nature of the response and relationship among the various LOE. Multivariate methods can retain more information describing the relationship among different LOEs. The result of most statistical approaches is a relative ranking of the sites, but there is little basis for distinguishing among levels of impact. A comparison to a reference condition is often needed to determine the presence of an impact; the selection of suitable reference sites is often contentious and may be difficult for some water bodies that have been extensively altered by urbanization. Logic systems are frequently used to integrate MLOE data; the sediment quality triad was one of the first examples of the use of a logic system to evaluate sediment quality data. Tabular decision matrices that provide an interpretation of various MLOE scenarios are used to apply a logic system. These logic systems are based on a transparent set of criteria used to infer the likelihood of causality for contaminant-related impacts and the system can accommodate various types of scoring systems within each LOE. The rules applied in a logic system can also be modified to reflect specific policy objectives or scientific assumptions, such a giving greater weight to benthic community disturbance relative to toxicity.

The State Water Board's technical team developed a logic system for integrating MLOE to make a station level determination of the likelihood of biological effects due to sediment contamination. This system was developed in consultation with a stakeholder advisory committee and an independent scientific steering committee. Three levels of integration of sediment chemistry, toxicity, and benthic community data are involved in the system (Figure 1). First, the results for multiple indicators within each LOE are evaluated and classified into one of four categories of response (no effect; low, moderate, or high effect). Each category reflects a change in the level of certainty that an adverse response is present or in the severity of effect. In the second level of integration, the LOE are combined to provide corroborating evidence of biological effect or chemical exposure at a site. For evidence of biological effect, the benthos and toxicity LOE are integrated into "Severity of Effect" categories (Table 1). Benthos is given greater weight for determining effects. To determine evidence of chemical exposure, the sediment chemistry and toxicity LOE are combined into "Potential that Effects are Chemically Mediated" categories (Table 2). The benthos LOE is not used to assess linkage to chemistry because benthic disturbance can be caused by noncontaminant factors, such as grain size, temperature, and recruitment.

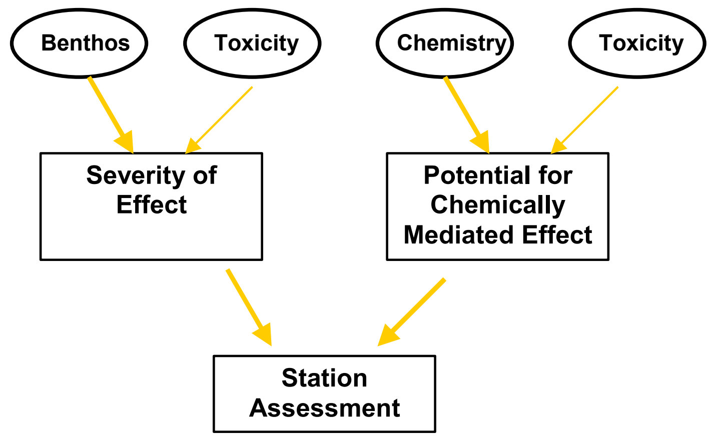

Figure 1. Schematic of multiple lines of evidence (MLOE) integration framework.

Table 2.2 Severity of effect classifications, derived from benthos and toxicity LOE.

		Toxicity			
		Nontoxic	Low toxicity	Moderate toxicity	High toxicity
Benthos	Reference	Unaffected	Unaffected	Unaffected	Low effect
	Low disturbance	Unaffected	Low effect	Low effect	Low effect
	Moderate disturbance	Moderate effect	Moderate effect	Moderate effect	Moderate effect
	High disturbance	Moderate effect	High Effect	High Effect	High Effect

Table 2.3 Potential that effects are chemically-mediated categories, derived from chemistry and toxicity LOE.

		Toxicity			
		Nontoxic	Low toxicity	Moderate toxicity	High toxicity
Chemistry	Minimal exposure	Minimal potential	Minimal potential	Low potential	Moderate potential
	Low exposure	Minimal potential	Low potential	Moderate potential	Moderate potential
	Moderate exposure	Low potential	Moderate potential	Moderate potential	Moderate potential
	High exposure	Moderate potential	Moderate potential	High potential	High potential

The final data integration step combines the intermediate classifications for severity of effect and potential for chemically-mediated effect to result in six categories of impact at the station level:

- **Unimpacted.** Confident that any sediment contamination present at the site is not causing significant adverse direct impacts to aquatic life. The sediment conditions support a benthic community composition that is similar to that attained in reference areas representing the best available conditions in the region. High agreement among the LOE is present.
- **Likely unimpacted**. Sediment contamination present at the site is not expected to cause significant adverse direct impacts to aquatic life. Some disagreement among the LOE is present, which indicates uncertainty in the classification.
- **Possibly impacted.** Sediment contamination present at the site may be causing significant adverse direct impacts to aquatic life, but these impacts may be moderate or variable in nature. The LOE may agree in indicating a minor level of effect, or there may be substantial disagreement among the LOE.
- **Likely impacted.** Confidence that sediment contamination present at the site is causing significant adverse direct impacts to aquatic life. There may be disagreement among the LOE, but the evidence for a contaminant-related impact is persuasive.
- **Clearly impacted.** Confidence that sediment contamination present at the site is causing severe adverse direct impacts to aquatic life.
- **Inconclusive.** Unable to classify the site. Extreme disagreement among the LOE indicate that either the data are suspect or that additional information is needed before a classification can be made.

The decision matrix for determining the station assessment category is shown in Table 3. Two key principles provide the foundation for this matrix. First, there must be some evidence of biological effect (severity of effect = low, moderate, or high) in order to classify a station as impacted. Second, there must be some evidence of elevated chemical exposure (e.g., low, moderate, or high potential for effects) in order to classify a station as impacted.

Table 2.4 Multiple lines of evidence station classifications.

		Severity of Effect			
		Unaffected	Low effect	Moderate effect	High effect
Potential that effects are chemically-mediated	Minimal potential	Unimpacted	Likely unimpacted	Likely unimpacted	Inconclusive
	Low potential	Unimpacted	Likely unimpacted	Possibly impacted	Possibly impacted
	Moderate potential	Likely unimpacted	Possibly impacted or Inconclusive*	Likely impacted	Likely impacted
	High potential	Inconclusive	Likely impacted	Clearly impacted	Clearly impacted

* Inconclusive category when chemistry = minimal exposure, benthos = reference, and toxicity= high.

The State Water Board's logic system was evaluated by comparison to the results obtained from six independent experts using various types of MLOE integration systems. The logic system had a similar accuracy in classifying the stations (compared to the median of the experts) as most of the individual experts. The logic system also showed a low degree of bias, indicating that errors in classification were balanced with respect to predicting a greater or lesser degree of impact.

Baseline: MLOE is integrated based upon BPJ on a case-by-case basis.
Alternative 1: Support an approach based upon BPJ.
Alternative 2: Select an integration method that is based upon a transparent logic-based framework that has been evaluated for accuracy relative to experts and is supported by independent scientific peer review.

Staff Recommendation: Alternative 2.

Suggested Policy Language: See Section 3.V.I.

2.19 What are Some of the Interim Tools that Could be Applied to the Delta and Other Estuaries?

The State Water Board initiated development of SQOs in 2003 in order to comply with Section 13393 of Division 7 of CWC and a Court ordered compliance schedule (See Section 1.2). The schedule the State Water Board is currently proposing would require circulation of draft objectives and an implementation policy by August 2006 and approval by the State Water Board and submission to the Office of Administrative Law by February 2008.

Section 13393 of CWC requires the State Water Board to develop SQOs for bays and estuaries of California. As described in Section 2.2, the State Water Board Phase I effort focused on those water bodies where chemical and biological data were available to develop indicators and tools to assess sediment quality. Only within southern California bays and most of San Francisco Bay was enough data available to evaluate exposure and effects relationships. Most estuaries including the Sacramento-San Joaquin Delta have not been monitored routinely to assess the impact of toxic pollutants to sediment dwelling organisms; therefore, very little combined effects and exposure data exists within these water bodies. Where data is available, it often consists of only one to three data points. Clearly, the robust data sets required to assess the relationship between exposure and biological effects to benthic communities are far too sparse for the development of assessment tools.

Generally, the type of data required would consist of sediment chemistry-sediment toxicity and benthic community data that encompasses the range of pollutant impact expected within these water bodies. With such a data set, effects measures such as toxicity and community degradation can be assessed relative to pollutant loading and other disturbances. This is the general approach that has been applied to develop SQOs within California's embayments and is supported by the SQO Scientific Steering Committee. Although the State Water Board recognizes the need to collect additional data and provide funding to achieve this goal, the technical team will not have the data necessary to complete the appropriate analyses until late 2007. As a result, there is a need to consider other interim options in order to comply with the court's decision.

Single LOE Chemistry or Toxicity

The State Water Board could propose the use of Sediment Chemistry Guidelines such as the ERMs (See Section 2.17) or apparent effects thresholds as a single LOE indicator of sediment quality in estuaries: SQGs are existing chemical thresholds that have been applied to assist managers when making decisions about sediment quality. Some of these approaches were developed in part from estuarine data. This approach would require little or no resources to prepare as existing sediment thresholds could be proposed and could be applied to determine whether sediment meet the narrative objective. As stated previously, there are significant problems when this LOE is used without the benefit of the other LOE.

Sediment toxicity could be proposed as a stand-alone tool for the assessment of sediment quality. There are two species within the proposed embayments suite of toxicity test methods that perform within the desired salinity range of estuarine waters. As described above, this approach could be applied to determine whether sediment meet the narrative objective described in Section 2.11, or a toxicity specific narrative objective could be proposed. Sediment toxicity has been applied within many different water bodies; however, similar limitations persist with this tool as well. Confounding factors and uncertainty also limit the ability to use this single LOE to assess sediment quality.

Combination of Sediment and Toxicity

Sediment chemistry and toxicity could be integrated into a two-line of evidence approach. This approach requires two lines of evidence and would provide greater confidence. However, the selection of appropriate thresholds would be difficult. Thresholds could be adopted from those proposed for sediment chemistry and toxicity in embayments. However, there may be little or no correlation between organism response in embayments and that in estuaries. The toxicity and chemistry lines of evidence could be interpreted relative to site-specific reference sites, providing only possible outcomes for each LOE: good or bad.
However, determination of reference sites is often contentious and typically requires a large amount of data to support the hypothesis. This approach gives more flexibility and responsibility to local agencies, and may be inconsistently applied.

Clearly, the State Water Board will need to establish some thresholds to reduce the use of BPJ, which does not promote statewide consistency and promotes adversarial science. While it may not be possible to develop

discriminatory tools such as those being developed for embayments, the State Water Board could provide thresholds that would enable a manager to respond quickly to relatively high level of effects.
This approach would be developed based on the following considerations.

- Develop an integration approach that accounts for greater uncertainty associated with application in estuaries.
- Utilize fewer categories of effect or exposure to reflect present lack of knowledge.
- May require a greater number of inconclusive categories for situations where LOE are not in agreement, additional data collection (e.g., benthos) or analysis is needed before an assessment can be made. Current embayment chemical indicators and thresholds have not been validated for use in estuaries, and as a result may not be accurate or effective.
- Additional toxicity test methods that are compatible with freshwater (e.g., Hyallella and Chironomus) may be needed, depending on salinities at time of collection.

Baseline: Not applicable.
Alternative 1: Do not propose any tools for implementing the narrative SQOs until data is collected in Phase II, and the technical team has the time to develop appropriate tools.
Alternative 2: Propose the use of a single LOE for delta waters.
Alternative 3: Propose using sediment toxicity and chemistry to implement the narrative objective. Additional development and evaluation will be required before a detailed approach is proposed. The Scientific Steering Committee was critical of this approach.

Staff Recommendation: Alternative 3.

Suggested Policy Language: See Section 3.V.J.

2.20 Should Interim Tools Sunset in SQO Plan?

Some stakeholders have expressed concern that the State Water Board could adopt interim tools for the Delta and other estuaries without providing any guarantee that these tools will not be replaced by more fully developed implementation measures scheduled for development under Phase II. Although the State Water Board provided additional funding to develop Phase II tools, there is always some uncertainty associated with future planning efforts.

Baseline: Not applicable.
Alternative 1: Do not provide sunsetting language in the draft SQO plan for the water bodies with less robust tools.
Alternative 2: Provide language that sunsets interim implementation tools if the State Water Board has not developed more robust tools by a specific date.
Alternative 3: Provide language in the resolution adopting Phase I that the State Board will revisit the interim implementation tools in Phase II

Staff Recommendation: Alternative 3.

2.21 How Could the SQOs be Applied?

The narrative SQOs and implementation tools have been developed for the purposes of assessing whether pollutants in sediments pose risk or are causing or contributing to the degradation of ecologically important and sensitive sediment dwelling organisms directly exposed to the pollutants in sediment. As a result, the SQO and tools will provide a robust measure of ambient sediment quality that directly relates to beneficial use protection.

2.22 How Should an Exceedance of the SQOs be Defined?

Exceedance of the SQO could be determined station-by-station or by considering multiple stations or through a combination that gives greater weight to the magnitude of the impact. Individual station exceedance could be based upon any station that is classified as possibly impacted, likely impacted, or clearly impacted.

Alternative 1: Single station using the MLOE integration approach.
Alternative 2: Magnitude and extent would be used to make a determination.

Staff Recommendation: Alternative 2.

2.23 How Should the SQOs be Used to Determine if a Water Body is Impaired?

A multi-station assessment tool will integrate the results of many single station assessments into a single watershed-based or water body assessment. This tool will help determine whether the water body is consistent with the narrative SQOs. The proposed MLOE approach uses evidence from chemistry, toxicity, and the benthic community structure to make a single station assessment. At each station, sediment quality will be categorized into one of five ordered categories: “unimpacted” < “likely unimpacted” < “possibly impacted” < “likely impacted” < “clearly impacted.” This type of ordinal data is interpretable in terms of its arrangement in a given order, e.g., from lowest to highest.

Results measured on an ordinal scale, however, may limit the types of appropriate statistical methods that can be applied during a multi-station assessment. Nonparametric methods are usually used with ordinal data, while parametric methods are usually used with interval or ratio data (Stevens 1946). Some researchers, however, have concluded that treating ordinal data as if they were interval data is unlikely to lead to improper conclusions (Gardner 1975). The following is a list of preliminary ideas for statistical tests that could be used to assess multiple station sediment data:

1. Tests of Exceedance. Convert each single station assessment into binary yes-or-no type data value. A water body would then be characterized by a count of the number of exceedances and the number of non-exceedances. A binomial test can then be used to determine if the proportion of exceedances is significantly excessive. This is the approach taken in the State’s current 303(d) listing policy (SWRCB 2004). This approach does not consider the magnitude of the exceedance.

2. Goodness of Fit Tests. The observed frequencies in each assessment category are compared to frequencies expected in each category under a specified null distribution. Sufficiently large deviations from the expected frequencies will support the conclusion that the data did not come from the hypothesized distribution. Chi-squared and Kolmogorov-Smirnov one-sample goodness-of-fit tests are examples. This option does not fully utilize the ordinal scale of the data.

3. Tests of Location. These tests work by subjectively assigning numeric integer values to ordinal data. For example, a value of 1 is assigned to stations classified as “unimpacted,” a value of 2 is assigned to stations classified as “likely unimpacted,” and so on. A one-sample parametric *t*-test can be used to test for a significant difference between the observed mean and the hypothesized mean. Similarly, a one-sample non-parametric Wilcoxon signed rank test can be used to test for a significant difference between the observed median and the hypothesized median. These tests of location account for magnitude.

Alternative 1: Do not consider the SQOs for listing purposes.
Alternative 2: Utilize the existing approach described in 303(d) listing policy (SWRCB 2004).

Alternative 3: Evaluate a variety of approaches described above for applying SQOs to the listing process.

Staff Recommendation: Alternative 3.

2.24 Could the SQOs be Applied within National Pollutant Discharge Elimination System (NPDES) Permits?

Water quality objectives are frequently translated into effluent limits when there is reasonable potential that discharge of specific pollutants can cause or contribute to water quality standards exceedances. During the late 1980's, the State Water Board assessed the relationship between sediment deposition, pollutant loading, and effluent quality (Hendricks 1990) in an attempt to develop a process for deriving sediment based effluent limits. The Washington Department of Ecology developed similar tools to calculate effluent limits based upon chemical concentrations in sediments within Puget Sound (Bailey 2005). Application of these tools to derive effluent limits has been limited for several reasons.

- Chemical concentrations in sediment do not represent the bioavailable fraction.
- Chemical thresholds are not based upon causal association.
- Pollutants discharged undergo chemical processes that vary depending upon the chemistry and physical properties of the effluent and receiving water.
- Sediment fate and transport must be well characterized.

Water quality objectives can also be applied within NPDES permits as receiving water limits. Receiving water limits are typically used when the water quality objective cannot be directly translated to effluent limits or when there is a clear need to monitor compliance within the receiving water. Examples include biological narratives and bacteria receiving water limits described in the California Ocean Plan (SWRCB, 2005). As receiving water limits, the narrative SQOs and implementation tools can be applied to NPDES permits within bays and estuaries if discharge of a toxic pollutant has the reasonable potential to cause or contribute to a violation of an applicable SQO within bays and estuaries.

Baseline: Not applicable.
Alternative 1: Do not address implementation of SQOs in NPDES permits.
Alternative 2: Develop translator tools that would enable the calculation of effluent limits from chemistry-based sediment thresholds.
Alternative 3: Propose that the narrative SQOs be applied in NPDES permits as receiving water limits.

Staff Recommendation: Alternative 3.

Suggested Policy Language: See Section 3.VII.A.

2.25 Should the Plan Include Follow-up Actions for Permitees When an Exceedance Occurs?

The direct effect tools were specifically developed to identify toxic pollutant related impacts. However, the information obtained from this MLOE does not lead to the identity of a specific stressor. Additional studies would be required to identify the specific cause and initiate appropriate and effective actions. This effort requires stressor identification studies similar to the Toxicity Identification Evaluation process developed and utilized by U.S. EPA for the Whole Effluent Toxicity (WET) program (U.S. EPA 1999) and the process described in U.S. EPA's aquatic stressor identification guidance document (U.S.EPA 2002).

Baseline: Not applicable.
Alternative 1: Do not propose any additional guidance in the plan.
Alternative 2: Develop an approach similar to U.S. EPA's WET program guidance consisting of an evaluation of the extent of the impact and identification of the stressors that are causing or contributing to the degradation of sediment quality.

Staff Recommendation: Alternative 2.

Suggested Policy Language: See Section 3.VII.C.

3.0 PRELIMINARY DRAFT PLAN

This document prepared by State Water Board staff provides a preliminary draft Sediment Quality Plan for Enclosed Bays and Estuaries. This preliminary draft Plan proposes a process for assessing sediment quality within a regulatory framework. Because the CEQA scoping document is the first step in the State Water Board's formal planning process, it must be emphasized that this proposal is preliminary in nature. Staff believes that the SQOs and technical tools described in the following pages represent those tools that will likely be supported when the draft Plan and SED is circulated, following the scoping process. Furthermore, certain sections will continue to undergo analysis and amendment based upon input from members of the Advisory Committees, Agency Coordination Committee, and interested parties. Finally, some tools and numeric thresholds will also continue to be evaluated by the Technical Team and reviewed by the Scientific Steering Committee.

This document does not reflect the State Water Board's support or approval of the approaches described on the following pages. A meeting to adopt the draft Plan will be scheduled at a later date.

I. INTENT AND SUMMARY

A. Intent of the Sediment Quality Plan for Enclosed Bays and Estuaries (Plan)

It is the goal of the State Water Board to comply with the legislative directive in Water Code §13393 to adopt SQOs that protect both the sediment quality dependent resources living in California's bays and estuaries and human health. In order to meet this goal, this Plan integrates chemical and biological measures to determine if the sediment dependent biota are protected or degraded as a result of exposure to toxic pollutants in sediment and to protect human health

B. Summary of Plan

This Plan includes:

1. Narrative SQOs for the protection of aquatic life and human health;
2. Identification of the beneficial uses that these objectives are intended to protect;
3. A program of implementation that contains:

    a. Specific indicators, tools and implementation provisions to determine if the sediment quality at a station or multiple stations meets the narrative objectives;
    b. Monitoring, stressor identification and corrective action guidance.

C. Review of Plan

This Plan shall be reviewed every three years to ensure that the standards and tools are adequate and appropriate to protect beneficial uses.

II. USE AND APPLICABILITY OF SQOS

A. Ambient Sediment Quality

The SQOs and supporting tools shall be utilized to assess ambient sediment quality.

B. Applicable Waters

This Plan applies to enclosed bays[2] and estuaries[3] only. This Plan does not apply to ocean waters including Monterey Bay, Santa Monica Bay, or inland surface waters.

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[2] ENCLOSED BAYS are indentations along the coast which enclose an area of oceanic water within distinct headlands or harbor works. Enclosed bays include all bays where the narrowest distance between headlands or outermost harbor works is less than 75 percent of the greatest dimension of the enclosed portion of the bay. This definition includes, but is not limited to: Humboldt Bay, Bodega Harbor, Tomales Bay, Drakes

C. Applicable Sediments

This Plan applies to surficial sediments that have been deposited or emplaced below the intertidal zone. This Plan does not apply to:

1. Sediments characterized by less than 10 percent of fines or substrates composed of gravels, cobbles, or consolidated rock.
2. Sediment as the physical pollutant that causes adverse biological response or community degradation related to burial, deposition, or sedimentation

D. Applicability to Dredged Materials Testing Program

1. This Plan shall not apply to:

    a. Dredge material suitability determinations. Suitability determinations shall be based upon USACE and U.S. EPA methodologies developed for ocean, inland and upland disposal, and guidance developed by regional dredging teams and approved by the Regional Water Boards.
    b. The management of active, designated, or permitted aquatic dredged material disposal or placement sites. This provision does not prevent the State or Regional Water Boards from taking future action on placement sites if the site itself is harming beneficial uses.

2. The Regional Water Boards shall not approve a dredging project that involves the dredging of sediment that exceeds the objectives in this plan, unless the Regional Water Boards determine that:

    a. The polluted sediment is removed in a manner that prevents or minimizes water quality degradation.
    b. The polluted sediment is not deposited in a location that may cause significant adverse effects to aquatic life, fish, shellfish, or wildlife or may harm the beneficial uses of the receiving waters, or does not create maximum benefit to the people of the State.
    c. The activity will not cause significant adverse impacts upon a federal sanctuary, recreational area, or other waters of significant national importance.

Estero, San Francisco Bay, Morro Bay, Los Angeles Harbor, Upper and Lower Newport Bay, Mission Bay, and San Diego Bay.

[3] ESTUARIES AND COASTAL LAGOONS are waters at the mouths of streams that serve as mixing zones for fresh and ocean waters during a major portion of the year. Mouths of streams that are temporarily separated from the ocean by sandbars shall be considered as estuaries. Estuarine waters will generally be considered to extend from a bay or the open ocean to the upstream limit of tidal action but may be considered to extend seaward if significant mixing of fresh and salt water occurs in the open coastal waters. The waters described by this definition include, but are not limited to, the Sacramento-San Joaquin Delta as defined by Section 12220 of CWC, Suisun Bay, Carquinez Strait downstream to Carquinez Bridge, and appropriate areas of the Smith, Klamath, Mad, Eel, Noyo, and Russian Rivers.

E. Discharges

This Plan applies only to direct discharges into bays and estuaries.

III. BENEFICIAL USES

A. Beneficial uses protected by this policy and corresponding target receptor are identified in Table 1.

Table 3.1 Beneficial Uses and Target Receptors

BENEFICIAL USES	TARGET RECEPTORS[1]
Estuarine Habitat	Benthic Community
Marine Habitat	Benthic Community
Commercial and Sport Fishing	Human Health
Aquaculture	Human Health
Shellfish Harvesting	Human Health

IV. SEDIMENT QUALITY OBJECTIVES

A. Aquatic Life

Pollutants in sediments shall not be present in quantities that, alone or in combination, are toxic to benthic communities in bays and estuaries of California. This narrative objective shall be implemented using MLOE as described in Section V of the policy.

B. Human Health

Pollutants shall not be present in sediments at levels that will bioaccumulate in aquatic life to levels that are harmful to human health. This narrative objective shall be implemented as described in Section VI of the policy.

V. BENTHIC COMMUNITY PROTECTION

A. General Intent

The methods and procedures described below must be used to implement the Narrative Objective described in Section IV.A. The tools described below are intended to assess the condition of benthic communities and the potential for exposure to toxic pollutants in sediments. Exposure to toxic pollutants at harmful levels will result in some combination of a degraded benthic community, presence of toxicity, and or elevated chemical concentrations.

B. Limitations

None of the individual LOE has sufficient reliability for use by itself to assess sediment quality impacts due to toxic pollutants. The tools described below are based upon relationships established from regional or statewide data. Within a given site, the exposure LOE may underestimate or overestimate the risk to benthic communities or toxicity and does not demonstrate causality. When the exposure and effects tools are integrated, the approach can quantify protection through effects measures and also provide predictive capability through the exposure assessment.

C. Water Bodies

1. The tools described in the following sections are applicable to Euhaline Bays and Coastal Lagoons south of Point Conception and Polyhaline San Francisco Bay defined in general by waters south and west of the San Rafael Bridge and north of the Dumbarton Bridge.
2. For all other bays and estuaries where benthic tools are unavailable only the chemistry and toxicity LOE will be applied. Section J. describes how a station assessment will be determined.

D. Field Procedures

1. All samples shall be collected using a grab sampler.
2. Benthic samples shall be screened through:

    a. A 0.5-millimeter (mm) screen in San Francisco Bay;
    b. A 1.0 mm screen in all other locations.

3. Bulk sediment chemical analysis will include at a minimum the pollutants identified in Appendix A. (Inserted in this document at the end of Section 3)

E. Laboratory Testing

All samples will be tested in accordance with U.S. EPA or ASTM methodologies where applicable. Analytical tests shall be conducted by laboratories certified by the California Department of Health Services in accordance with Water Code Section 13176.

F. Assessment of Sediment Toxicity

1. Short Term Survival -A minimum of one short-term survival test shall be performed on sediment collected from each station. Acceptable acute test organisms and methods are summarized in Table 3.2.

Table 3.2 Acceptable Short Term Survival Sediment Toxicity Test Methods

TEST ORGANISM	EXPOSURE TYPE	DURATION	ENDPOINT
Eohaustorius estuarius	**Whole Sediment**	**10 days**	**Survival**
Leptocheirus plumulosus	**Whole Sediment**	**10 days**	**Survival**
Rhepoxynius abronius	**Whole Sediment**	**10 days**	**Survival**

2. Sublethal Tests -A minimum of one sublethal test shall be performed on sediment collected from each station. Acceptable test organisms and methods are summarized in Table 3.3:

Table 3.3 Acceptable Sublethal Sediment Toxicity Test Methods

TEST ORGANISM	EXPOSURE TYPE	DURATION	ENDPOINT
Neanthes arenaceodentata	**Whole Sediment**	**28 days**	**Growth/Survival**
Mytilus galloprovincialis	**Sediment-water Interface**	**48 hour**	**Embryo Development**

3. Assessment of Sediment Toxicity -Sediment toxicity shall be categorized according to response described in Table 3.4. The response categories are:

Nontoxic: Response not substantially different from that expected in sediments that are uncontaminated and have optimum characteristics for the test species (e.g., control sediments).

Low toxicity: A response that is of relatively low magnitude; the response may not be greater than test variability.

Moderate toxicity: High confidence that a statistically significant toxic effect is present.

High toxicity: High confidence that a toxic effect is present and the magnitude of response includes the strongest effects observed for the test.

Table 3.4 Sediment Toxicity Categorical Responses

TEST ORGANISM/METHODS	LOW EFFECT (PERCENT)	MODERATE EFFECTS (PERCENT RELATIVE TO CONTROL)	HIGH EFFECTS (PERCENT RELATIVE TO CONTROL)
Eohaustorius Survival	90%	82%	63%
Leptocheirus Survival	90%	78%	60%
Rhepoxynius Survival	90%	81%	63%
Neanthes Growth	90%	68%	59%
Mytilus Normal	80%	77%	38%

4. Integration of Sediment Toxicity Data:
The average value of all test responses shall be used to determine the final toxicity category.

G. Assessment of Benthic Community Condition

1. General Requirements:

   a. All benthic invertebrates shall be identified to the lowest possible taxon.
   b. Taxonomic nomenclature shall follow the conventions described in XXXXXX (Master Species Lists).

2. Benthic Tools:

   The benthic data shall be assessed using four of the following methods:

   a. BRI, which was originally developed for the southern California mainland shelf and extended into California's bays and estuaries. The BRI is the abundance-weighted average pollution tolerance score of organisms occurring in a sample.

   b. Index of Benthic Integrity (IBI), which was developed for freshwater streams and adapted for California's bays and estuaries. The IBI identifies community measures that have values outside a reference range.

   c. Relative Benthic Index (RBI), which was originally developed for estuarine applications in California's Bay Protection and Cleanup Program. The RBI is the weighted sum of: (a) several community parameters (total number of species, number of crustacean species, number of crustacean individuals, and number of mollusc species), and abundances of (b) three positive, and (c) two negative indicator organisms.

   d. River Invertebrate Prediction and Classification System (RIVPACS), which was originally developed for British freshwater streams and adapted for California's bays and estuaries. The approach compares the assemblage at a site with an expected species composition determined by a multivariate predictive model that is based on species relationships to habitat gradients.

3. Calculation of Benthic Condition.

4. Benthic Community Assessment -
   Benthic community data shall be categorized according to response. The response categories are:

Reference: A community composition equivalent to a "least affected" or "unaffected" site.

Low disturbance: A community that shows some indication of stress, but could be within measurement error of unaffected condition.

Moderate disturbance: Confident that the community shows evidence of physical, chemical, natural, or anthropogenic stress.

High disturbance: The magnitude of stress is high.

5. Integration of benthic community data.
   The median of all benthic index response categories shall be used to determine the benthic community response category.

H. Assessing Exposure to Toxic Pollutants in Sediment

1. All samples shall be tested for the analytes identified in Appendix A. This list represents the minimum analytes required to assess exposure. In water bodies where other toxic pollutants are believed to pose risk to benthic communities, those toxic pollutants should be included in the analysis. Inclusion of additional analytes cannot be used in the exposure assessment described below. However, the data can provide greater value in the overall sediment quality assessment.

2. Assessment of Chemical Concentration in Sediment
   Concentrations shall be categorized according to response. The response categories are:

   Minimal exposure: Sediment-associated contamination may be present, but exposure is unlikely to result in effects.
   Low exposure: Small increase in contaminant exposure that may be associated with increased effects, but magnitude or frequency of occurrence of biological impacts is low.
   Moderate exposure: Clear evidence of sediment contaminant exposure that is likely to result in biological effects; an intermediate category.
   High exposure: Contaminant exposure highly likely to result in possibly severe biological effects; generally present in a small percentage of the samples.

3. To categorize the risk of exposure to toxic pollutants, two methods shall be employed:

   a. The regionally derived north and south Chemical Category Score (nCCS, sCCS) developed from chemistry and community response data, and
   b. The California Pmax derived by logistic regression that relates the probability of toxicity to the concentration of chemical mixtures.

4. The CCS approach is based on the association between chemicals and the magnitude of benthic community disturbance. Two types of data are combined to calculate the mean weighted CCS: a set of predicted benthic community effects categories based on the individual chemical concentrations and a set of weighting factors for each of the chemicals. The predicted benthic effect category for each chemical is determined by comparing the chemical concentration to a series of three thresholds that define four effects categories. Each constituent's predicted effect level is then multiplied by its respective weighting factor

to produce a benthic impact score. These scores are then summed across all constituents in the sample and divided by the sum of weighting factors, producing the mean weighted benthic category score (CCS).

Equation 1. Mean weighted CCS = $\Sigma(w \times cat)/\Sigma w$

Where cat = predicted chemical impact category, and w is the weighting factor for that constituent.

Effect values and weighting factors are identified in Table 3.5.

Table 3.5. Effect values and weighting factors for the north and south variations of the CCS.

		North CCS				South CCS			
Chemical	units	Weight	T1	T2	T3	Weight	T1	T2	T3
Cadmium	Mg/kg	40	0.14	0.22	0.75	38	0.09	0.22	1.66
Copper	Mg/kg	68	32.5	44.7	62.9	100	52.8	96.5	406
Lead	Mg/kg	37	21.7	25.5	70.6	88	26.4	60.8	154
Mercury	Mg/kg	100	0.20	0.26	0.41	30	0.09	0.45	2.18
Zinc	Mg/kg	67	94.8	123	164	98	112	200	629
PAHs, total high MW	Ug/kg	53	770	943	2085	16	312	1325	9320
PAHs, total low MW	Ug/kg	41	160	191	764	5	85.4	312	2471
Chlordane, alpha-	Ug/kg	42	0.12	0.19	3.08	55	0.50	1.23	11.1
Chlordane, gamma-	Ug/kg	72	0.13	0.17	0.30	58	0.54	1.45	14.5
DDDs, total	Ug/kg	30	1.13	8.13	15.4	46	0.38	2.69	117
DDEs, total	Ug/kg	43	0.07	0.79	5.19	31	0.11	4.15	153
DDTs, total	Ug/kg	36	0.02	0.10	3.68	16	0.42	1.52	89.3
PCBs, total	Ug/kg	39	8.22	18.9	31.2	55	11.9	24.7	288

5. Categorization of CCS

The mean weighted CCS shall be categorized based on the following values:

Minimal exposure:	$\leq$ 1.68
Low exposure:	1.69 - 2.33
Moderate Exposure:	2.34 - 2.99
High Exposure:	$\geq$ 2.99

6. The California Pmax approach is based on logistic regression analysis of matching chemistry and toxicity data. Chemistry and toxicity data from national and California databases were used for this approach. A logistic regression model describes the relationship between the concentration of each contaminant and the probability of observed toxicity.

The logistic model is described by the following equation:

Equation 2. $p = e^{B0+B1\,(x)} / (1 + e^{B0+B1\,(x)})$

Where: p= probability of observing a toxic effect;
B0= intercept parameter;
B1= slope parameter; and

x= concentration the chemical.

The probability of toxicity is calculated for each chemical using chemical-specific regression parameters (Table 3.6). The maximum probability (Pmax) obtained from the individual chemical results is used to represent the chemical mixture present in a sample.

Table 3.6. Logistic regression parameters for the California Pmax approach.

Chemical	Units	B0	B1
Cadmium	mg/kg	0.2894	3.1764
Copper	mg/kg	-5.5931	2.5885
Lead	mg/kg	-4.7228	2.8404
Mercury	mg/kg	-0.0618	2.6837
Zinc	mg/kg	-5.1337	2.4205
HMW PAH	ug/kg	-8.1922	1.9995
LMW PAH	ug/kg	-6.8071	1.8827
Chlordane, alpha	ug/kg	-3.4080	4.4570
Dieldrin	ug/kg	-1.8344	2.5890
Trans nonachlor	ug/kg	-4.2590	5.3135
Total PCBs	ug/kg	-4.4144	1.4837
p,p' DDT	ug/kg	-3.5531	3.2621

Categorization of California Pmax
The California Pmax shall be categorized based on the following values:

Minimal exposure: $\leq$ 0.32
Low exposure: 0.33 – 0.49
Moderate Exposure: 0.50 – 0.66
High Exposure: $\geq$ 0.67

Integration of sediment chemistry data:
The average value of both approaches shall be used to determine the final chemical exposure category.

I. Integration of MLOE

1. Severity of effects
Severity of effects (the toxicity and benthic effects categorization) shall be integrated using the decision matrix presented in Table 3.7.

Table 3.7 Severity of Effects Matrix

		TOXICITY RESPONSE CATEGORY			
		Nontoxic	Low Toxicity	Moderate Toxicity	High Toxicity
BENTHIC RESPONSE CATEGORY	Reference	Unaffected	Unaffected	Unaffected	Low Effect
	Low Disturbance	Unaffected	Low Effect	Low Effect	Low Effect
	Moderate Disturbance	Moderate Effect	Moderate Effect	Moderate Effect	Moderate Effect
	High Disturbance	Moderate Effect	High Effect	High Effect	High Effect

2. Potential for Chemically-Mediated Effects

The potential for effects to be chemically-mediated shall be assessed using the decision matrix presented in Table 3.8.

Table 3.8 Analysis of the Potential for Chemical Mediated Effects

		TOXICITY RESPONSE CATEGORY			
		Nontoxic	Low Toxicity	Moderate Toxicity	High Toxicity
POLLUTANT CATEGORY	Minimal Exposure	Minimal Potential	Minimal Potential	Low Potential	Moderate Potential
	Low Exposure	Minimal Potential	Low Potential	Moderate Potential	Moderate Potential
	Moderate Exposure	Low Potential	Moderate Potential	Moderate Potential	Moderate Potential
	High Exposure	Moderate Potential	Moderate Potential	High Potential	High Potential

3. Station Level Assessment

The station level assessment shall be determined using the decision matrix presented in Table 3.9. This assessment combines the intermediate classifications for severity of effect and potential for chemically-mediated effect to result in six categories of impact at the station level:

Unimpacted. Confident that any sediment contamination present at the site is not causing significant adverse direct impacts to aquatic life. The sediment conditions support a benthic community composition that is similar to that attained in reference areas representing the best available conditions in the region. High agreement among the LOE is present.

Likely unimpacted. Sediment contamination present at the site is not expected to cause significant adverse direct impacts to aquatic life. Some disagreement among the LOE is present, which indicates uncertainty in the classification.

Possibly impacted. Sediment contamination present at the site may be causing significant adverse direct impacts to aquatic life, but these impacts may be moderate or variable in nature. The LOE may agree in indicating a minor level of effect, or there may be substantial disagreement among the LOE.

Likely impacted. Confidence that sediment contamination present at the site is causing significant adverse direct impacts to aquatic life. There may be disagreement among the LOE, but the evidence for a contaminant-related impact is persuasive.

Clearly impacted. Confidence that sediment contamination present at the site is causing severe adverse direct impacts to aquatic life.

Inconclusive. Unable to classify, as a result of extreme disagreement among the LOE indicating that either the data are suspect or that additional information is needed before a classification can be made. This designation is only applied when high toxicity is present without corroborating evidence of chemical exposure and benthic disturbance.

Table 3.9 Station Assessment Matrix.

		SEVERITY OF EFFECT			
		Unaffected	Low Effect	Moderate Effect	High Effect
POTENTIAL FOR CHEMICALLY-MEDIATED EFFECTS	Minimal Potential	Unimpacted	Likely Unimpacted	Likely Unimpacted	Likely Unimpacted
	Low Potential	Unimpacted	Likely Unimpacted	Possibly Impacted	Possibly Impacted
	Moderate Potential	Likely Unimpacted	Possibly Impacted or Inconclusive[1]	Likely Impacted	Likely Impacted
	High Potential	Likely Unimpacted	Likely Impacted	Clearly Impacted	Clearly Impacted

[1] Inconclusive category when chemistry is classified as minimal exposure, benthic response is classified as reference, and toxicity response is classified as high.

J. Missing Benthic LOE

In waters where one line of evidence is missing, the responses from the two existing lines shall be assessed relative to the parameters described in Section 3.F, and H. The final station assessment will be based upon Table 3.10.

Table 3.10 Multiple lines of evidence designations based on toxicity and chemistry LOE (i.e., benthos LOE is missing).

		Chemistry			
		Minimal exposure	Low exposure	Moderate exposure	High exposure
Toxicity	Nontoxic	Likely unimpacted	Likely unimpacted	Possibly impacted	Likely impacted
	Low toxicity	Likely unimpacted	Possibly impacted	Likely impacted	Likely impacted
	Moderate toxicity	Possibly impacted	Likely impacted	Likely impacted	Clearly impacted
	High toxicity	Likely impacted	Likely impacted	Likely impacted	Clearly impacted

K. Exceedances and Listings

1. Exceedance of Narrative Objective

2. Water Body Listing

VI. HUMAN HEALTH

Protection of human health will be assessed based upon a human health risk assessment in accordance with the California Environmental Protection Agency's (Cal/EPA) OEHHA policies for fish consumption and risk assessment, Cal/EPA's DTSC Risk Assessment, and U.S. EPA Human Health Risk Assessment policies.

VII. PROGRAM OF IMPLEMENTATION

A. Receiving Water Limits

The SQOs shall be implemented as receiving water limits in NPDES permits where the Regional Water Board believes there is the reasonable potential that the discharge of toxic or priority pollutants may cause or contribute to an exceedance of an applicable SQO or SQOs. The Regional Water Board shall require periodic sediment monitoring at intervals not less than once per permit cycle, prior to the issuance or re-issuance of a permit. However, the Regional Water Board may choose to exempt low volume discharges, determined to have no significant adverse impact on sediment quality, from this monitoring requirement.

B. Sediment Monitoring

1. Objective

   a. Bedded sediments in bays contain an accumulation of contaminants from a wide variety of past and present sources discharged either directly into the bay or indirectly into waters draining into the bay. Embayments also represent highly disturbed or altered habitats as a result of dredging and physical disturbance caused by construction and maintenance of harbor works, boat and ship traffic, and development of adjacent lands. Due to the multitude of stressors and the complexity of the environment, a well-designed monitoring program is necessary to ensure that the data collected adequately characterizes the condition of sediment in these water bodies.

2. Permitted Discharges

   a. Where the State Water Board or Regional Water Boards believe there is the reasonable potential that toxic or priority pollutants discharged by a Permittee may accumulate in sediments at levels that will cause, have the reasonable potential to cause, or contribute to an exceedance of applicable SQOs, sediment quality monitoring shall be required. However, the Regional Water Board may choose to exempt low volume discharges, determined to have no significant adverse impact on sediment quality, from this monitoring requirement.
   b. Monitoring may be performed by individual Permitees to assess compliance with receiving water limits, participate in a regional or water body monitoring coalition as described under VII.A. 3, or both as determined by the Regional Water Board and Permittee.

3. Monitoring Coalitions

   a. To achieve maximum efficiency and economy of resources, the State Water Board encourages the regulated community in coordination with the Regional Water Boards to establish water body-monitoring coalitions. Monitoring coalitions would enable the sharing of technical resources, trained personal, and associated costs and create an integrated sediment-monitoring program within each major water body.

b. Focusing resources on regional issues and developing a broader understanding of pollutants effects in these water bodies will enable the development of more rapid and efficient response strategies and enable better management of sediment quality.

4. Methods

Sediments collected from each station shall be tested or assessed using the methods and metrics described in Section 5.

5. Design

a. Sediment monitoring programs shall be designed to ensure that the aggregate stations are spatially representative of the sediment within the water body.
b. Design of a sediment-monitoring program shall take into consideration existing data and information of appropriate quality.
c. Stratified Random network will provide the most useful information when assessing conditions throughout a water body.
d. Identification of appropriate strata shall consider characteristic of the water body including sediment transport, hydrodynamics, depth, salinity, land uses, inputs (both natural and anthropogenic) and other factors that could affect the physical, chemical, or biological condition of the sediment.
e. Targeted designs shall be applied to those Permitees that are required to meet receiving water limits as described in Section II.B.

5. Index Period

All stations shall be sampled between the months of June through September.

6. Monitoring Schedule and Frequency

a. Permittees shall, at a minimum, monitor sediment quality as described in this Plan at least once prior to the issuance and re-issuance of a permit.
b. Regional sediment quality monitoring will occur at a minimum of once every three years. (?) Who does this?
c. Sediments identified as exceeding the narrative objective will be evaluated more frequently.

C. Focused Studies

If sediments fail to meet the narrative SQOs in accordance with Section V and VI, a sequential approach is necessary to manage the sediment appropriately. The sequential approach consists of the following 3 tasks:

1. Confirmation and characterization of pollutants related impacts
2. Pollutant(s) Identification
3. Source Identification

1. Confirmation and characterization of pollutant related impacts

Exceedance of the direct effects SQO at a site indicates that pollutants in the sediment are the cause but does not identify the specific contaminants responsible. The MLOE assessment establishes linkage to sediment contaminants; however, the lack of confounding factors (e.g., physical disturbance, non-pollutant constituents) should be confirmed. There are two generic stressors that may cause the narrative to be exceeded:

> Physical Alteration: Examples of physical stressors include reduced salinity, impacts from dredging, very fine or course grain size, and prop wash from passing ships. These types of stressors may produce a non-reference condition in the benthic community that is similar to that caused by contaminants. If impacts to a site are purely due to physical disturbance, the LOE characteristics will likely show a degraded benthic community with little or no toxicity and low chemical concentrations.
>
> Other non-toxic pollutant related stressors: These constituents, that include elevated total organic carbon, nutrients and pathogens, may have sources similar to chemical pollutants. Chemical and microbiological analysis will be necessary to determine if these constituents are present. The LOE characteristics for this type of stressor would likely be a degraded benthic community with possibly an indication of toxicity, and low chemical concentrations.

To further assess a site with this indication, there are several lines of investigation that should be pursued.

a. Evaluate the spatial extent of the Area of Concern. This information can be used to evaluate the potential risk associated with the sediment, distinguish areas of known physical disturbance or pollution and evaluate the proximity to sources such as outfalls, storm drains, and industrial and agricultural activities.

b. Body burden data should be examined from animals exposed to the site's sediment to indicate if contaminants are being accumulated and to what degree.

c. Chemical specific mechanistic benchmarks applied to interpret sediment chemistry concentrations.

d. Chemistry and biology data from the site should be examined to determine if there is a correlation between the two LOE.

e. Alternate biological effects data may be pursued, such as bioaccumulation experiments and pore water toxicity or chemical analysis.

2. Pollutant Identification

Methods to help determine cause may be statistical, biological, chemical or a combination. Pollutant identification studies should be based upon the following:

a. Statistical methods: Correlations between individual chemicals and biological endpoints (toxicity and benthic community).

b. Gradient analysis. Comparisons are made between different samples taken at various distances from a chemical hotspot to examine patterns in chemical concentrations and biological responses. The concentrations of causative agents should decrease as biological effects decrease.

c. Toxicity Identification Evaluation: A toxicological method for determining the cause of impairments is the use of toxicity identification evaluations (TIE). Sediment samples are manipulated chemically or physically to remove classes of chemicals or render them biologically unavailable. Following the manipulations, animal exposures are performed to determine if toxicity has been removed.

d. Bioavailability: Chemical contaminants may be present in the sediment but not biologically available to cause toxicity or degradation of the benthic community. There are several measures of bioavailability that can be made. Chemical and toxicological measurements can be made on pore water to determine the availability of sediment contaminants. Metal compounds may be naturally bound up in the sediment and rendered unavailable by the presence of sulfides. Measurement of acid volatile sulfides and simultaneously extracted metals analysis can be conducted to determine if sufficient sulfides are present to bind the observed metals. Similarly, organic compounds can be tightly bound to sediments. Solid phase microextraction (SPME) can be used to identify what organics are available to animals in the sediment. Other methods using animal digestive fluids or weak chemical extractions also exist to predict bioavailability.

e. Verification: After specific chemicals are identified as likely causes of impairment, analysis should be performed to verify the results. Body burden analysis can be measured on animals exposed to the sediment. The concentrations in the animals may then be compared to established toxicity thresholds. Sediments can be spiked with the suspected chemicals to verify that they are indeed toxic at the concentrations observed in the field. Alternately, animals can be transplanted to suspected sites for *in situ* toxicity and bioaccumulation testing.

3. There will be situations where the results of stressor identification are inconclusive.

4. Sources Identification and Management Actions

a. If a single discharger is found to be responsible for discharging the stressor pollutant, the Regional Water Board shall require the discharger to take all necessary and appropriate steps to address exceedance of the SQO, including but not limited to reducing the pollutant loading into the sediment.

b. When multiple sources are present in the water body, the Regional Water Board shall require the sources to take all necessary and appropriate steps to address exceedance of the SQO. If appropriate, the Regional Water Board may adopt a TMDL to ensure attainment of the sediment standard. .

D. Existing Management Actions

If a Regional Water Board has developed a TMDL and adopted a basin plan amendment that addresses specific pollutants in sediment and sources identified under Section VII B, 1-3, no further action is required except for the collection of load and trend data to access load reduction and restoration of the beneficial use.

Appendix A. List of chemical analytes needed to characterize sediment contamination exposure and effect.

Chemical Name	Chemical Group	Chemical Name	Chemical Group
Total Organic Carbon	General	Alpha Chlordane	Pesticide
Percent Fines	General	Gamma Chlordane	Pesticide
		Trans Nonachlor	Pesticide
Cadmium	Metal	Dieldrin	Pesticide
Copper	Metal	o,p'-DDE	Pesticide
Lead	Metal	o,p'-DDD	Pesticide
Mercury	Metal	o,p'-DDT	Pesticide
Zinc	Metal	p,p'-DDD	Pesticide
		p,p'-DDE	Pesticide
		p,p'-DDT	Pesticide
Acenaphthene	PAH	2,4'-Dichlorobiphenyl	PCB congener
Anthracene	PAH	2,2',5-Trichlorobiphenyl	PCB congener
Biphenyl	PAH	2,4,4'-Trichlorobiphenyl	PCB congener
Naphthalene	PAH	2,2',3,5'-Tetrachlorobiphenyl	PCB congener
2,6-dimethylnaphthalene	PAH	2,2',5,5'-Tetrachlorobiphenyl	PCB congener
Fuorene	PAH	2,3',4,4'-Tetrachlorobiphenyl	PCB congener
1-methylnaphthalene	PAH	2,2',4,5,5'-Pentachlorobiphenyl	PCB congener
2-methylnaphthalene	PAH	2,3,3',4,4'-Pentachlorobiphenyl	PCB congener
1-methylphenanthrene	PAH	2,3',4,4',5-Pentachlorobiphenyl	PCB congener
Phenanthrene	PAH	2,2',3,3',4,4'-Hexachlorobiphenyl	PCB congener
Benzo(a)anthracene	PAH	2,2',3,4,4',5'-Hexachlorobiphenyl	PCB congener
Benzo(a)pyrene	PAH	2,2',4,4',5,5'-Hexachlorobiphenyl	PCB congener
Benzo(e)pyrene	PAH	2,2',3,3',4,4',5-Heptachlorobiphenyl	PCB congener
Chrysene	PAH	2,2',3,4,4',5,5'-Heptachlorobiphenyl	PCB congener
Dibenz(a,h)anthracene	PAH	2,2',3,4',5,5',6-Heptachlorobiphenyl	PCB congener
Fluoranthene	PAH	2,2',3,3',4,4',5,6-Octachlorobiphenyl	PCB congener
Perylene	PAH	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	PCB congener
Pyrene	PAH	Decachlorobiphenyl	PCB congener

4.0 GLOSSARY

ACUTE TOXICITY: Short-term lethal response of an organism to a pollutant.

ALTERNATE HYPOTHESIS: Statement or claim that a statistical test is set up to establish.

BEST MANAGEMENT PRACTICES (BMPs): Methods, measures, or practices designed and selected to reduce or eliminate the discharge of pollutants to surface waters from point and nonpoint source discharges including storm water. BMPs include structural and non-structural controls, and operation and maintenance procedures, which can be applied before, during, and/or after pollution producing activities.

BENTHIC: Living on or in bottom of the ocean, bays, and estuaries, or in the streambed.

BETA: Statistical error of failing to reject a null hypothesis that is not true. This type of error is also called Type II error.

BINOMDIST: ,An Excel® function that can be used to calculate the cumulative binomial distribution.

BINOMIAL DISTRIBUTION: Mathematical distribution that describes the probabilities associated with the possible number of times particular outcomes will occur in series of observations (i.e., samples). Each observation may have only one of two possible results (e.g., standard exceeded or standard not exceeded).

BIOACCUMULATION: A process in which an organism's body burden of a contaminant exceeds that in its surrounding environment as a result of chemical uptake through all routes of chemical exposure; dietary and dermal absorption and transport across the respiratory surface.

BIOACCUMULATION FACTOR (BAF): The ratio of contaminant concentration in biota to contaminant concentration in some other matrix. In this report, unless specified otherwise, the term "bioaccumulation factor" refers to wet weight concentration in fish or invertebrate tissue divided by dry weight concentration in sediment.

BIOAVAILABILITY: Fraction of pollutant an organism is exposed to that is available for uptake through biological membranes (gut, gills).

BIOTA-SEDIMENT ACCUMULATION FACTOR (BSAF): This is the bioaccumulation factor for tissue vs. sediment, normalized for lipid and organic carbon. BSAF = (tissue contaminant concentration in wet wt. * sediment % organic carbon) / (sediment contaminant concentration in dry wt. * tissue % lipid).

BIOASSESSMENT: Assessment of biological community information along with measures of the physical/habitat quality to determine, in the case of water quality, the integrity of a water body of interest.

BTAG: Biological Technical Assistance Group, a multi-agency group of State and federal ecological and human health risk assessors supported by U.S. EPA responsible for providing technical assistance for Site remediation and mitigation.

CHEMICALS OF CONCERN (COCS): Pollutants that occur in environmental media at levels that pose a risk to ecological receptors or human health.

CONTAMINATION: An impairment of the quality of the waters of the State by waste to a degree that creates a hazard to the public health through poisoning or through the spread of disease. "Contamination" includes any equivalent effect resulting from the disposal of waste whether or not waters of the State are affected (CWC section 13050(k)).

CHRONIC TOXICITY: Sublethal response of an organism to repeated, long-term exposure to a chemical substance. Typical observed endpoints include growth expressed as length and weight.

CALIFORNIA TOXICS RULE (CTR): Numerical water quality criteria established by U.S. EPA for priority toxic pollutants for California's inland surface waters, enclosed bays, and estuaries.

DEMERSAL: Organisms that prefer to spend the majority of their time on or near the bottom of a water body.

DIEL: Measurements pertain to measurements taken over a 24-hour period of time.

DREDGED MATERIAL: Any material excavated or dredged from the navigable waters of the United States, including material otherwise referred to as "spoil."

EFFECTS RANGE-MEDIAN (ERM)/EFFECTS RANGE-LOW (ERL): Sediment quality guidelines based on a biological effects empirical approach. These values represent chemical concentration ranges that are rarely (i.e., below the ERL), sometimes (i.e., between ERL and ERM), and usually (i.e., above the ERM) associated with toxicity for marine and estuarine sediments. Ranges are defined by the tenth percentile and fiftieth percentile of the distribution of contaminant concentrations associated with adverse biological effects.

EFFECT SIZE: Maximum magnitude of exceedance frequency that is tolerated.

ENCLOSED BAYS: Indentations along the coast that enclose an area of oceanic water within distinct headlands or harbor works. Enclosed bays include all bays where the narrowest distance between headlands or outermost harbor works is less than 75 percent of the greatest dimension of the enclosed portion of the bay. This definition includes, but is not limited to: Humboldt Bay, Bodega Harbor, Tomales Bay, Drakes Estero, San Francisco Bay, Morro Bay, Los Angeles Harbor, Upper and Lower Newport Bay, Mission Bay, and San Diego Bay.

ENDPOINT: A measured response of a receptor to a stressor. An endpoint can be measured in a toxicity test or in a field survey.

EPIFAUNA: Organisms that live on the substrate.

EQUILIBRIUM PARTITIONING APPROACH: Approach used to relate the dry-weight sediment concentration of a particular chemical that causes an adverse biological effect to the equivalent free chemical concentration in pore water and to that concentration sorbed to sediment organic carbon or bound to sulfide. Based on the theory that the partitioning of a nonionic organic chemical between organic carbon and pore water and the partitioning of a divalent metal between the solid and solution phases are at equilibrium.

EQUILIBRIUM PARTITIONING SEDIMENT GUIDELINES: Sediment quality guidelines derived using the EqP approach. When used in conjunction with appropriately protective water only exposure concentration, a resulting guideline represents the sediment contaminant concentration that protects benthic organisms from the effects of that contaminant.

ESTUARIES AND COASTAL LAGOONS: Waters at the mouths of streams that serve as mixing zones for fresh and ocean waters during a major portion of the year. Mouths of streams that are temporarily separated from the ocean by sandbars shall be considered as estuaries. Estuarine waters will generally be considered to extend from a bay or the open ocean to the upstream limit of tidal action but may be considered to extend seaward if significant mixing of fresh and salt water occurs in the open coastal waters. The waters described by this definition include, but are not limited to, the Sacramento-San Joaquin Delta as defined by Section 12220 of the California Water Code, Suisun Bay, Carquinez Strait downstream to Carquinez Bridge, and appropriate areas of the Smith, Klamath, Mad, Eel, Noyo, and Russian Rivers.

EUHALINE: Waters ranging in salinity from 25–32 practical salinity units (psu).

INDIRECT EFFECTS: Adverse effects to humans and wildlife as a result of consuming prey items exposed to polluted sediments.

INFAUNA: Organisms that live within sediment or substrate.

INLAND SURFACE WATERS: All surface waters of the State that do not include the ocean, enclosed bays, or estuaries.

LOAD ALLOCATION (LA): The portion of a receiving water's total maximum daily load that is allocated to one of its nonpoint sources of pollution or to natural background sources.

MIXING ZONE: Limited zone within a receiving water that is allocated for mixing with a wastewater discharge where water quality criteria can be exceeded without causing adverse effects to the overall water body.

MAXIMUM CONTAMINANT LEVEL (MCL): The maximum permissible level of a contaminant in water delivered to any user of a public water system.

MAXIMUM TISSUE RESIDUE LEVEL (MTRL): Tissue values developed from human health water quality objectives in the 1997 California Ocean Plan and from the California Toxic Rule as established in the Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California. MTRLs are used as alert levels or guidelines indicating water bodies with potential human health concerns and are an assessment tool and not compliance or enforcement criteria. The MTRLs are calculated by multiplying human health water quality objectives by the bioconcentration factor for each substance.

MESOHALINE: Waters ranging in salinity from 5 to 18 psu.

NATIONAL ACADEMY OF SCIENCE TISSUE GUIDELINES: Guidelines established for the protection of predators. Values are suggested for residues in whole fish (wet weight) for DDT (including DDD and DDE), aldrin, dieldrin, endrin, heptachlor (including heptachlor epoxide), chlordane, lindane, benzene hexachloride, toxaphene, and endosulfan either singularly or in combination.

NATIONAL TOXICS RULE: Numerical water quality criteria established by U.S. EPA for priority toxic pollutants for 12 states and two Territories who failed to comply with the section 303(c)(2)(B) of the Clean Water Act.

NEW DISCHARGER?: Any building, structure, facility, or installation from which there is, or may be, a discharge of pollutants, the construction of which commenced after the effective date of this Policy.

NONPOINT SOURCE POLLUTION: Sources are diffused and do not have a single point of origin or are not introduced into a receiving stream from a specific outlet. The commonly used categories for nonpoint sources are agriculture, forestry, mining, construction, land disposal, and salt intrusion.

NULL HYPOTHESIS: Statement used in statistical testing that has been put forward either because it is believed to be true or because it is to be used as a basis for argument, but has not been proved.

OBJECTIONABLE BOTTOM DEPOSITS: An accumulation of materials or substances on or near the bottom of a water body which creates conditions that adversely impact aquatic life, human health, beneficial uses, or aesthetics. These conditions include, but are not limited to, the accumulation of pollutants in the sediments and other conditions that result in harm to benthic organisms, production of food chain organisms, or fish egg development. The presence of such deposits shall be determined by Regional Water Board(s) on a case-by-case basis.

OCEAN WATERS: Territorial marine waters of the State as defined by California law to the extent these waters are outside of enclosed bays, estuaries, and coastal lagoons. Discharges to ocean waters are regulated in accordance with the State Water Board's California Ocean Plan.

PELAGIC: Organisms living in the water column.

PERSISTENT POLLUTANTS: Substances for which degradation or decomposition in the environment is nonexistent or very slow.

POLLUTANT: Defined in section 502(6) of the CWA as "dredged spoil, solid waste, incinerator residue, filter backwash, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water."

POLLUTANT MINIMIZATION: Waste minimization and pollution prevention actions that include, but are not limited to, product substitution, waste stream recycling, alternative waste management methods, and education of the public and businesses.

POLLUTION: Defined in section 502(19) of the CWA as the "the man-made or man-induced alteration of the chemical, physical, biological, and radiological integrity of water." *Pollution* is also defined in CWC section 13050(1) as an alternation of the quality of the waters of the State by waste to a degree that unreasonably affects either the waters for beneficial uses or the facilities that serve these beneficial uses.

POLLUTION PREVENTION: Any action that causes a net reduction in the use or generation of a hazardous substance or other pollutant that is discharged into water and includes, but is not limited to, input change, operational improvement, production process change, and product reformulation (as defined in Water Code Section 13263.3). Pollution prevention does not include actions that merely shift a pollutant in wastewater from one environmental medium to another environmental medium, unless clear environmental benefits of such an approach are identified to the satisfaction of the State Water Board or the Regional Water Boards.

POLYHALINE: Waters ranging in salinity from 18–25 psu.

PROBABLE EFFECT CONCENTRATION (PEC): Empirically derived freshwater sediment quality guidelines (SQG) that rely on the correlation between the chemical concentration in field collected sediments and observed biological effects. PECs are based on geometric means of various SQG approaches (with matching chemical and toxicity field data) to predict toxicity for freshwater sediment on a regional and national basis.

PROBABLE EFFECTS LEVEL (PELS)/THRESHOLD EFFECTS LEVELS (TEL): Empirically derived sediment quality guidelines based on a biological effects empirical approach similar to ERMs/ERLs. A generalized approach used to develop effects-based guidelines for the state of Florida and others. The lower of the two guidelines for each chemical (i.e., the TEL) is assumed to represent the concentration below which toxic effects rarely occur. In the range of concentrations between the two guidelines, effects occasionally occur. Toxic effects usually or frequently occurs at concentrations above the upper guideline value (i.e., the PEL). Ranges are defined by specific percentiles of both the distribution of contaminant concentrations associated with adverse biological effects and the "no effects" distribution.

RANK CORRELATION: The association between paired values of two variables that have been replaced by their ranks within their respective samples (e.g., chemical measurements and response in a toxicity test).

REFERENCE CONDITION: The characteristics of water body segments least impaired by human activities. As such, reference conditions can be used to describe attainable biological or habitat conditions for water body segments with common watershed/catchment characteristics within defined geographical regions.

SIMULTANEOUSLY EXTRACTED METALS (SEM): Metal concentrations that are extracted during the same analysis in which the acid-volatile sulfide (AVS) content of the sediment is determined.

STATISTICAL SIGNIFICANCE: When it can be demonstrated that the probability of obtaining a difference by chance only is relatively low.

TOXICITY IDENTIFICATION EVALUATION (TIE): Techniques used to identify the unexplained cause(s) of toxic events. TIE involves selectively removing classes of chemicals through a series of sample manipulations, effectively reducing complex mixtures of chemicals in natural waters to simple components for analysis. Following each manipulation the toxicity of the sample is assessed to see whether the toxicant class removed was responsible for the toxicity.

TOXICITY REDUCTION EVALUATION (TRE): Study conducted in a step-wise process designed to identify the causative agents of effluent or ambient toxicity, isolate the sources of toxicity, evaluate the effectiveness of toxicity control options, and then confirm the reduction in toxicity. The first steps of the TRE consist of the collection of data relevant to the toxicity, including additional toxicity testing, and an evaluation of facility operations and maintenance practices, and best management practices. A Toxicity Identification Evaluation (TIE) may be required as part of the TRE, if appropriate. (A TIE is a set of procedures to identify the specific chemical(s) responsible for toxicity. These procedures are performed in three phases [characterization, identification, and confirmation] using aquatic organism toxicity tests.)

WASTE: As used in this document, waste includes a discharger's total discharge, of whatever origin, i.e., gross, not net, discharge.

WATER QUALITY-LIMITED SEGMENT: Any segment of a water body where it is known that water quality does not meet applicable water quality standards, and/or is not expected to meet applicable water quality standards, even after application of technology-based effluent limitations required by CWA sections 301(d) or 306.

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