Impairment Assessment for
San Diego Creek, Upper Newport Bay, Lower Newport Bay, and Rhine Channel
Total DDT, Chlordane, Dieldrin, Toxaphene, Total PCBs

Introduction

Section 303(d)(1) of the Clean Water Act (CWA) requires states to identify waters that do not meet applicable water quality standards following implementation of technology-based controls, and to prioritize such waters for development of Total Maximum Daily Loads (TMDLs) (40 CFR 130.7(b)). Water quality limited segments are defined as "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(b) or 306…" (40 CFR 130.2(j)). States are required to assemble and evaluate all existing and readily available water quality-related data and information (40 CFR 130.7(b)(5)). The State's Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List (the Policy) (2004) requires a weight-of-evidence approach in evaluating these data to assess impairment.

Water Quality Standards

The CWA definition of water quality standards includes both the beneficial uses of specific water bodies and the levels of quality that must be met and maintained to protect those uses. Water quality objectives may be narrative or numeric. The water quality objectives identified in the Santa Ana Regional Water Quality Control Board (SARWQCB) Basin Plan that are relevant to this impairment assessment are narrative objectives for toxic substances:

> *Toxic substances shall not be discharged at levels that will bioaccumulate in aquatic resources to levels which are harmful to human health.*
>
> *The concentrations of toxic pollutants in the water column, sediments or biota shall not adversely affect beneficial uses.*

Data Evaluated in Impairment Assessment

Concentrations of organochorine pesticides and PCBs have been declining in fish/shellfish tissue and sediments in the Newport Bay watershed over time. Therefore, to reflect environmentally relevant conditions, this assessment evaluates data obtained from 1995 forward. The one exception is that Bay Protection and Toxic Cleanup Program (BPTCP) sediment chemistry data from late 1994 were used in the evaluation because these data were coupled with toxicity and benthic community assessments. At the request of USEPA, data reported are separated into the following groups: 1995-2001, 2001-2004; and 1995-2004. The USEPA's impairment assessment documented in the TMDLs for Toxic Pollutants San Diego Creek and Newport Bay, California (2002) evaluated data obtained between 1995 and June 2001. Therefore, the 1995-2001 grouping should correspond to the same data evaluated by USEPA. The State Water Resources Control Board also conducted an impairment assessment in support of its recommendations for the 2006 303(d) listings, and they used data that generally were collected

between 1995-2002 (with some exceptions). This document provides the ability to compare results of this assessment with those performed by USEPA (2002) and the SWRCB (2005).

In some studies/programs, method detection limits (MDLs) for some constituents were higher than the applicable screening values with which pollutant concentrations were evaluated. In these cases, any detectable concentrations exceeded screening values, but non-detects could not be accurately interpreted (maybe concentrations in fish tissue or sediment exceeded applicable screening values, and maybe they did not). For purposes of this impairment assessment, where MDLs exceeded screening values, data that showed detectable concentrations were included in the assessment, but data showing nondetectable concentrations were considered to be invalid and were not included.

Methodology

The Policy was followed in conducting this impairment assessment. A weight of evidence approach to evaluating impairment is required under the Policy. According to the Final Functional Equivalent Document (FED) (2004),

> The expression "weight of evidence" describes whether the evidence in favor or against some hypothesis is more or less strong (Good, 1985). In general, components of the weight-of-evidence consist of the strength or persuasiveness of each measurement endpoint and concurrence among various endpoints. Confidence in the measurement endpoints can vary depending on the type or quality of the data and information available or the manner in which the data and information is used to determine impairment.
>
> Scientists have used a variety of definitions for "weight of evidence." A scientific conclusion based on the weight of evidence is often assembled from multiple sets of data and information or lines of evidence. Lines of evidence can be chemical measurements, biological measurements (bioassessment), and concentrations of chemicals in aquatic life tissue.

In describing how the SWRCB and RWQCBs are to implement a weight-of-evidence approach, the FED states:

> The weight of evidence approach would be a narrative process where individual lines of evidence are evaluated separately and combined using the professional judgment of the RWQCBs and SWRCB. The lines of evidence would be combined to make a stronger inference about water quality standards attainment….Using this approach the SWRCB and RWQCBs would use their judgment to weigh the lines of evidence to determine the attainment of standards based on the available data…Using this approach, a single line of evidence, under certain circumstances, could be *sufficient by itself* to demonstrate water quality standards attainment.

According to the Policy, water segments will be deemed impaired if any of the conditions specified in Sections 3.1-3.11 of the Policy are met.

Pollutant Concentrations in Water (Section 3.1 of the Policy).

According to the Policy, a finding of impairment is made for any water body pollutant combinations for which if there is a sufficient number of samples showing exceedances of pollutant concentrations in the water column, compared to the California Toxics Rule (CTR) (Table 1). There were very little water column data available; existing data largely showed nondetectable pollutant concentrations in the water column due to detection limitations of analytical techniques and due to the fact that these pollutants have low water solubility.

Table 1. Water Quality Criteria used in Impairment Assessment

	Ambient Water Quality (CTR)					
	Freshwater		Saltwater		Human Health (10^{-6} risk for carcinogens) For consumption of:	
Pollutant	Criterion Maximum Concentration (CMC)	Criterion Continuous Concentration (CCC)	Criterion Maximum Concentration (CMC)	Criterion Continuous Concentration (CCC)	Water & Organisms	Organisms Only
	µg/L					
p,p-DDD					0.00083	0.00084
p,p-DDE					0.00059	0.00059
p,p-DDT	1.1	0.001	0.13	0.001	0.00059	0.00059
Dieldrin	0.24	0.056	0.71	0.0019	0.00014	0.00014
Chlordane	2.4	0.0043	0.09	0.004	0.00057	0.00059
Total PCBs[1]		0.014		0.03	0.00017	0.00017
Toxaphene	0.73	0.0002	0.21	0.0002	0.00073	0.00075

[1] PCBs value based on sum of seven Aroclors: 1242, 1254, 1221, 1232, 1248, 1268, 1016

Pollutant Concentrations in Fish/Shellfish Tissue (Section 3.5 of the Policy).

A finding of impairment is made for any pollutant-water body combination in which tissue pollutant concentrations exceed an appropriate evaluation guideline and where the minimum number of exceedances is met using a binomial distribution. In this assessment, pollutant concentrations in fish fillet samples were compared to OEHHA human health risk screening values, and whole fish concentrations were compared to NAS guidelines for protection of aquatic life (Table 2). Shellfish tissue concentrations were compared to either NAS or FDA guidelines for freshwater samples; the lack of applicable guidelines for most marine samples precluded using marine shellfish data in the impairment assessment. OEHHA guidelines were not used for evaluation of shellfish tissue concentration data, because those guidelines were developed using only sportfish tissue concentrations. Furthermore, NAS guidelines for marine organisms only apply to finfish, not shellfish.

Table 2. Fish Tissue Screening Values (SVs) Used in Impairment Assessment

Pollutant	Fish Tissue				
	Human Protection		Aquatic Life/Wildlife Protection		
	OEHHA[1]	FDA[1]	NAS[2]		Environment[1] Canada
			Freshwater	Marine[4]	
	µg/kg wet wt		*µg/kg wet wt*		
p,p-DDD					
p,p-DDE					
p,p-DDT					
Total DDT	**100**		**1,000**	**50**	14 µg/kg diet wet wt
Dieldrin	**2**	**300**	**100**	**5**[3]	
Total Chlordane	**30**		**100**	**50**	
Total PCBs	**20**	**2000**	**500**	**500**	*Mammalian*: 0.78 ng TEQ/kg diet ww *Avian*: 2.4 ng TEQ/kg diet ww
Toxaphene	**30**		**100**	**50**	6.3 µg/kg diet wet wt

[1]Applies for freshwater or marine water organisms; OEHHA values do not apply to shellfish
[2] Water Quality Criteria 1972. A report of the Committee on Water Quality Criteria, Environmental Studies Board, National Academy of Sciences, National Academy of Engineering. Washington, D.C., 1972. At the request and funded by the Environmental Protection Agency.
[3]Sum of concentrations of aldrin, dieldrin, endrin, and heptachlor epoxide in a sample consisting of a homogenate of 25 or more whole fish. Applies to pollutants, individually or in combination.
[4]Applies to marine fish but not marine shellfish

Water/Sediment Toxicity (Section 3.6 of the Policy).

The Policy provides for placement of a water body on the CWA 303(d) list based on toxicity alone; however, if a specific pollutant causing toxicity has been identified, then the listing should include that pollutant. Use of sediment quality guidelines (SQGs) is recommended to show the association between toxicity and a given pollutant.

Pollutant Concentrations in Sediment.

Pollutant concentrations in marine and freshwater sediments were compared to the sediment quality guidelines (SQGs) identified on pages 122-123 of the Final Functional Equivalent Document (FED; 2004) and other additional applicable SQGs as well (see Table 3). The FED, however, contains no recommended SQGs for DDT in marine sediments, or for toxaphene in either freshwater or marine sediments.

The FED states:

"SQGs should be used with caution because they are not perfect predictors of toxicity and are most useful when accompanied by data from in situ biological analyses, other toxicologic assays, and other interpretive tools….The predictability of toxicity, using the sediment values reported, is reasonably good and is most useful if accompanied by data from biological analyses, toxicological analyses, and other interpretive tools. These measures are most predictive of toxicity if several values are exceeded. Since these values often are not good predictors of toxicity alone, SQGs that predict toxicity in 50 percent or more samples, should be used in making decisions to place a water body on the section 303(d) list."

In the Policy, SQGs are used to show association between toxic or other biological effects and a given pollutant and do not infer causality, in and of themselves. They are only to be used in situations where other biological effects data (e.g., toxicity or benthic community degradation) also exist. Therefore, in the absence of toxicity or other biological effects data, pollutant concentrations in sediments were not used as a line of evidence in this assessment.

Limitations of Impairment Assessment

The Policy outlines methodology to evaluate impairment through direct effects of a given pollutant in a particular water body. These effects can be related to human health risk from consumption of contaminated fish, or to wildlife risk resulting in direct effects on aquatic organisms wildlife that eat those organisms. The organochlorine pollutants evaluated in this assessment are generally not considered to cause acute toxicity to aquatic organisms at the levels at which they presently exist in the environment. Instead, chronic adverse effects to biota may be caused through bioaccumulation and biomagnification in the food web of sensitive species (e.g., biomagnification of DDE within the food web of brown pelican leading to eggshell thinning and reproductive failure). An ecological risk assessment (ERA) may be required to evaluate the impacts or threatened impacts to beneficial uses resulting from elevated concentrations of bioaccumulative compounds. However, methodology for conducting site specific risk assessments is not provided in the Policy.

Results

The following pages summarize data collected between 1995-Present for organochlorine pollutants (DDTs, PCBs, Chlordane, Dieldrin, Toxaphene) for San Diego Creek, Peters Canyon Wash, Santa Ana

Delhi Channel, Upper Newport Bay, Lower Newport Bay, and Rhine Channel (35 water body-pollutant combinations), and quantifies exceedances of applicable screening guidelines. Table 4 summarizes those results and provides a comparison among assessments performed by SARWQCB staff, USEPA and SWRCB.

Table 3. Applicable Sediment Quality Guidelines. Values in bold are those recommended for use in the Policy (note that there are no recommended guidelines for DDT in marine sediments).

	Freshwater Sediment				Marine and Estuarine Sediment					
Pollutant	**TEL[1]**	**PEL[1]**	**TEC[2]**	**PEC[2]**	**TEL[3]**	**PEL[3]**	**ERL**	**ERM**	**Other SQG**	**SoCalERM[6]**
	µg/kg dry wt				**µg/kg dry wt**					
p,p-DDD	3.54	8.51			1.22	7.81	2[5]	20[5]		2.5
p,p-DDE	1.42	6.75			2.07	374	2.2[4]	27[4]		12.2
p,p-DDT					1.19	4.77	1[5]	7[5]		1.9
o,p-DDE										
o,p-DDT										
Sum DDD			4.88	**28.0**						
Sum DDE			3.16	**31.3**						
Sum DDT			4.16	**62.9**						
Total DDT	6.98	4450	5.28	**572**	3.89	51.7	1.58[4]	46.1[4]		
Dieldrin	2.85	6.67	1.90	**61.8**	0.72	4.3	0.02[5]	**8[5]**		1.08
Chlordane	4.5	8.9	3.24	**17.6**	2.26	4.79	0.5[5]	**6[5]**		
Total PCBs	34.1	277	59.8	**676**	21.6	189	22.7[4]	180[4]	**400[8]**	77.2
Toxaphene	0.1[7]									

[1] Buchman, M.F. 1999. NOAA Screening Quick Reference Tables, NOAA HAZMAT Report 99-1, Seattle WA, Coastal Protection and Restoration Division, National Oceanic and Atmospheric Administration, 12 pages.

[2] MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. Arch. Environ. Contam. Toxicol. 39: 20-31.

[3] MacDonald, D.D., R.S. Carr, F.D. Calder, E.R. Long, and C.G. Ingersoll. 1996. Development and Evaluation of Sediment Quality Guidelines for Florida Coastal Waters. Ecotoxicology 5: 253-278.

[4] Long, E.R., D.D. MacDonald, S.L. Smith, F.D. Calder. 1995. Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. Environ. Manage. 19: 81-97.

[5] Long, E.R. and L.G. Morgan. 1990. The Potential for Biological Effects of Sediment-sorbed Contaminants Tested in the National Status and Trends Program, Seattle, WA: National Oceanic and Atmospheric Administration.

[6]Vidal, D.E. and S.M. Bay. 2005. Comparative Sediment Quality Guideline Performance for Predicting Sediment Toxicity in Southern California, USA. Environ. Toxicol. Chem. 24: 3173-3182.
ERM values correspond to the 50th percentile of the distribution of sediment concentrations in the toxic dataset (amphipod survival normalized to the control).

[7] from New York Department of Environmental Conservation

[8] MacDonald,D.D., L.M. Dipinto, J. Fields, C.G. Ingersoll, E.R. Long, and R.C. Swartz. 2000. Development and evaluation of consensus-based sediment effect concentrations for polychlorinated biphenyls. Environ. Toxicol. Chem. 19(5):1403-1413.

I. SAN DIEGO CREEK REACH 1

A. TOTAL DDT

1. Fish/Shellfish Tissue Concentrations
   (a) State Mussel Watch Program (SMWP)– No data since 1995
   (b) Toxic Substances Monitoring Program (TSMP) – Eighteen samples (n=18) with collection dates ranging from 1995-2002, at two sampling locations at Michelson Drive and Barranca Parkway. Whole fish composite samples of red shiner, with numbers of individuals making up composites ranging from 23-104. 0/18 exceedances compared to NAS guideline (1000 ppb ww).
   (c) In-Channel Basin 2 (June 2003) – Samples obtained by SARWQCB staff and analyzed by SCCWRP – a single catfish fillet (n=1); 1/1 sample exceeded OEHHA SV (100 ppb ww). Six shellfish composite samples (Clam - *Corbicula fluminea*); and eight samples whole fish composites (bluegill, black crappie, fathead minnow, common carp, red shiner) (n=14); 0/14 exceedances compared to NAS guideline (1000 ppb ww).
   (d) In-Channel Basin 2 (November 2004) – Two single whole fish (carp and sunfish) and a single shellfish (n=3), collected and analyzed by IRWD; 0/3 exceedance compared to NAS screening value (1000 ppb ww). One single shellfish sample.

San Diego Creek R1-Total DDT	**1995 – 2001**	**2002-2004**	**1995-2004**
Total Number of Samples			
Human Health Risk (fish fillet sample)	0	1	1
Wildlife Risk (whole fish)	16	19	35
Total Number of Exceedances (Human Health; OEHHA)	0	1	1
Total Number of Exceedances (Wildlife; NAS)	0	0	0

2. Sediment Chemistry
   (a) Orange County NPDES monitoring results (1995-Present) 66 samples total (n=66); 0/66 sample above PEC for total DDT (572 μg/kg dw); 1/66 sample > PEC for sum DDE (31.3 μg/kg dw); 1/66 sample > PEC for sum DDD (28.0 μg/kg dw); 0/66 sample > PEC for sum DDT (62.9 μg/kg dw). No measure of sediment toxicity or benthic community degradation accompanied sediment chemistry measurements; therefore, sediment chemistry data were not included in impairment assessment.
   (b) In-Channel Basin 2 (June 2003) – Samples obtained by SARWQCB staff and analyzed by SCCWRP – Eight samples (n=8); 0/6 samples > PEC. No measure of sediment toxicity or benthic community degradation accompanied sediment chemistry measurements; therefore, sediment chemistry data were not included in impairment assessment.
   (c) In-Channel Basin 2 (November 2004) – Samples from six stations were divided into sand and silt+clay fractions. Bulk sediment was not analyzed; therefore, samples will not be used in impairment assessment.

3. Water Column Concentrations – No data exist for water column.

B. CHLORDANE

1. Fish/Shellfish Tissue Concentrations
   (a) State Mussel Watch Program (SMWP)– No data since 1995
   (b) Toxic Substances Monitoring Program (TSMP) – Eighteen samples (n=18) with collection dates ranging from 1995-2002, at two sampling locations at Michelson Drive and Barranca Parkway. Whole fish composite samples of red shiner, with numbers of individuals making up composites ranging from 23-104. 0/13 exceedances compared to NAS guideline (100 ppb ww).
   (c) In-Channel Basin 2 (June 2003) – Samples obtained by SARWQCB staff and analyzed by SCCWRP – a single catfish fillet (n=1); 0/1 sample exceeded OEHHA SV (30 ppb ww). Six shellfish composite samples (Clam - *Corbicula fluminea*); and eight samples whole fish composites (bluegill, black crappie, fathead minnow, common carp, red shiner) (n=14); 0/14 exceedances compared to NAS guideline (100 ppb ww).
   (d) In-Channel Basin 2 (November 2004) – Two single whole fish (carp and sunfish) and a single shellfish (n=3), collected and analyzed by IRWD; 0/3 exceedance compared to NAS screening value (100 ppb ww).

San Diego Creek R1-Chlordane	1995 – 2001	2002-2004	1995-2004
Total Number of Samples			
Human Health Risk	0	1	1
Wildlife Risk	16	19	35
Total Number of Exceedances (Human Health; OEHHA)	0	0	0
Total Number of Exceedances (Wildlife; NAS)	0	0	0

2. Sediment Chemistry
   (a) Orange County NPDES monitoring results (2000-Present) 14 samples total; 5 samples had MDL > PEC, so 9 samples were valid (n=9). 1/9 sample had a measurable concentration above PEC (17.6 μg/kg dw). No measure of sediment toxicity or benthic community degradation accompanied sediment chemistry measurements; therefore, sediment chemistry data were not included in impairment assessment.
   (b) In-Channel Basin 2 (June 2003) – Samples obtained by SARWQCB staff and analyzed by SCCWRP – Eight samples (n=8); all samples had non-detectable concentrations of chlordane.
   (c) In-Channel Basin 2 (November 2004) – Samples from six stations were divided into sand and silt+clay fractions. Bulk sediment was not analyzed; therefore, samples will not be used in impairment assessment.

3. Water Column Chemistry – No water column data

C. DIELDRIN

1. Fish/Shellfish Tissue Concentrations
   (a) State Mussel Watch Program (SMWP)– No data since 1995
   (b) Toxic Substances Monitoring Program (TSMP) – Eighteen samples (n=18) with collection dates ranging from 1995-2002, at two sampling locations at Michelson Drive and Barranca Parkway. Whole fish composite samples of red shiner, with numbers of individuals making up composites ranging from 23-104. 0/13 exceedances compared to NAS guideline (100 ppb ww).
   (c) In-Channel Basin 2 (June 2003) – Samples obtained by SARWQCB staff and analyzed by SCCWRP – a single catfish fillet (n=1); 0/1 sample exceeded OEHHA SV (2 ppb ww). Six shellfish composite samples (Clam - *Corbicula fluminea*); and eight samples whole fish composites (bluegill, black crappie, fathead minnow, common carp, red shiner) (n=14); 0/14 exceedances compared to NAS guideline (100 ppb ww).
   (d) In-Channel Basin 2 (November 2004) – Two single whole fish (carp and sunfish) and a single shellfish (n=3), collected and analyzed by IRWD; 0/3 exceedance compared to NAS screening value (100 ppb ww).

San Diego Creek R1-Dieldrin	1995 – 2001	2002-2004	1995-2004
Total Number of Samples			

Human Health Risk Wildlife Risk	0 16	1 19	1 35
Total Number of Exceedances (Human Health; OEHHA)	0	0	0
Total Number of Exceedances (Wildlife; NAS)	0	0	0

2. Sediment Chemistry
   (a) In-Channel Basin 2 (June 2003) – Samples obtained by SARWQCB staff and analyzed by SCCWRP – Eight samples (n=8); all samples had non-detectable concentrations of dieldrin.
3. Water Column Concentrations – No data were found

D. TOXAPHENE

1. Fish/Shellfish Tissue Concentrations
   (a) State Mussel Watch Program – No data since 1995
   (b) Toxic Substances Monitoring Program (TSMP) – Eighteen samples (n=18) with collection dates ranging from 1995-2002, and two sampling locations at Michelson Drive and Barranca Parkway. Whole fish composite samples of red shiner, with numbers of individuals making up composites ranging from 23-104. 4/18 exceedances compared to NAS screening values (100 ppb ww).
   (c) In-Channel Basin 2 (June 2003) – Samples obtained by SARWQCB staff and analyzed by SCCWRP – a single catfish fillet (n=1); 0/1 sample exceeded OEHHA SV (30 ppb ww). Six shellfish composite samples (Clam - *Corbicula fluminea*); and eight samples whole fish composites (bluegill, black crappie, fathead minnow, common carp, red shiner) (n=14); 0/14 exceedances compared to NAS guideline (100 ppb ww).
   (d) In-Channel Basin 2 (November 2004) – Two single whole fish (carp and sunfish) and a single shellfish (n=3), collected and analyzed by IRWD; 0/3 exceedance compared to NAS screening value (100 ppb ww).

San Diego Creek R1-Toxaphene	**1995 – 2001**	**2002-2004**	**1995-2004**
Total Number of Samples Human Health Risk Wildlife Risk	 0 16	 1 19	 1 35
Total Number of Exceedances (Human Health; OEHHA)	0	0	0
Total Number of Exceedances (Wildlife; NAS)	4	0	4

2. Sediment Chemistry
   (a) In-Channel Basin 2 (June 2003) – Samples obtained by SARWQCB staff and analyzed by SCCWRP – Eight samples (n=8); all samples had non-detectable concentrations of toxaphene.
3. Water Column Concentrations – No data

E. TOTAL PCBs

1. Fish/Shellfish Tissue Concentrations
   (a) State Mussel Watch Program – No data since 1995
   (b) Toxic Substances Monitoring Program (TSMP) – Eighteen samples (n=18) with collection dates ranging from 1995-2002, and two sampling locations at Michelson Drive and Barranca Parkway. Whole fish composite samples of red shiner, with numbers of individuals making up composites ranging from 23-104. 0/18 exceedances compared to NAS screening values (500 ppb ww).

San Diego Creek R1-Total PCBs	1995 – 2001	2002-2004	1995-2004
Total Number of Samples			
Human Health Risk	0	0	0
Wildlife Risk	16	2	18
Total Number of Exceedances (Human Health; OEHHA)	0	0	0
Total Number of Exceedances (Wildlife; NAS)	0	0	0

2. Sediment Concentrations
   (a) Orange County NPDES monitoring results (1995-Present) 48 samples total (n=48); 0/48 sample above SQG (400 μg/kg dw).
3. Water Column Concentrations – No data

F. TOXICITY AND BENTHIC COMMUNITY DEGRADATION – SAN DIEGO CREEK REACH 1

1. Bay Protection and Toxic Cleanup Program (1994-1997) – Two sample locations within San Diego Creek Reach 1 (86001, 86002), analyzed 8/20/97. No samples showed sediment toxicity to amphipods.

II. SAN DIEGO CREEK REACH 2

A. TOTAL DDT

1. Fish/Shellfish Tissue Concentrations – No Data
2. Sediment Chemistry
   (a) Orange County NPDES monitoring results (1995-Present) 24 samples total (n=24); 0/24 sample above PEC for Total DDT (572 μg/kg dw); 3/24 samples > PEC for Sum DDE (31.3 μg/kg dw); 2/24 samples > PEC for Sum DDD (28.0 μg/kg dw); 1/24 sample > PEC for Sum DDT (62.9 μg/kg dw); 8/24 samples > TEL (6.98 μg/kg dw). No measure of sediment toxicity or benthic community degradation accompanied sediment chemistry measurements; therefore, sediment chemistry data were not included in impairment assessment.
3. Water Column Chemistry – No Data

B. CHLORDANE

1. Fish/Shellfish Tissue Concentrations – No Data

2. Sediment Chemistry
   (a) Orange County NPDES monitoring results (2000-Present) 7 samples total; 5/7 samples had MDLs above SQG for total valid samples (n-5); 1/5 sample above PEC for chlordane (17.6 μg/kg dw. No measure of sediment toxicity or benthic community degradation accompanied sediment chemistry measurements; therefore, sediment chemistry data were not included in impairment assessment.
3. Water Column Chemistry – No Data

C. DIELDRIN

1. Fish/Shellfish Tissue Concentrations – No Data
2. Sediment Chemistry – No Data
3. Water Column Chemistry – No Data

D. TOXAPHENE

1. Fish/Shellfish Tissue Concentrations – No Data
2. Sediment Chemistry – No Data
3. Water Column Chemistry – No Data

E. TOTAL PCBs

1. Fish/Shellfish Tissue Concentrations – No Data
2. Sediment Chemistry
   (a) Orange County NPDES monitoring results (1995-Present) 19 samples total (n=19), all below detection limits.
3. Water Column Chemistry – No Data

F. **TOXICITY AND BENTHIC COMMUNITY DEGRADATION –** No data were available for toxicity or benthic community degradation.

III. PETERS CANYON WASH

A. TOTAL DDT

1. Fish/Shellfish Tissue Concentrations
   (a) State Mussel Watch Program – No data since 1995
   (b) Toxic Substances Monitoring Program (TSMP) – Eleven samples (n=11) with collection dates ranging from 1995-2002, and one sampling location. Whole fish composite samples of red shiner, with numbers of individuals making up composites ranging from 28-42. 1/11 exceedance compared to NAS screening values (1000 ppb ww).

Peters Cyn Channel-Total DDT	**1995 – 2001**	**2002-2004**	**1995-2004**
Total Number of Samples			
Human Health Risk	0	0	0
Wildlife Risk	9	2	11
Total Number of Exceedances (Human Health; OEHHA)	0	0	0
Total Number of Exceedances (Wildlife; NAS)	1	0	1

2. Sediment Chemistry
   (a) Orange County NPDES monitoring results (1995-Present) 36 samples total (n=36); 0/36 sample above PEC for Total DDT (572 µg/kg dw); 4/36 samples > PEC for Sum DDE (31.3 µg/kg dw); 0/36 samples > PEC for Sum DDD (28.0 µg/kg dw); 1/36 sample > PEC for Sum DDT (62.9 µg/kg dw). No measure of sediment toxicity or benthic community degradation accompanied sediment chemistry measurements; therefore, sediment chemistry data were not included in impairment assessment.
3. Water Column Chemistry – No Data

B. CHLORDANE

1. Fish/Shellfish Tissue Concentrations

(a) State Mussel Watch Program – No data since 1995

(b) Toxic Substances Monitoring Program (TSMP) – Eleven samples (n=11) with collection dates ranging from 1995-2002, and one sampling location. Whole fish composite samples of red shiner, with numbers of individuals making up composites ranging from 28-42. 0/11 exceedances compared to NAS screening values (100 ppb ww).

Peters Cyn Channel - Chlordane	**1995–2001**	**2002-2004**	**1995-2004**
Total Number of Samples			
Human Health Risk	0	0	0
Wildlife Risk	9	2	11
Total Number of Exceedances (Human Health; OEHHA)	0	0	0
Total Number of Exceedances (Wildlife; NAS)	0	0	0

2. Sediment Chemistry

(a) Orange County NPDES monitoring results (1995-Present) 10 samples total; 8 samples had MDLs above PEC (n=8); 8/8 samples were below limits of detection.

3. Water Column Concentrations – No Data

C. DIELDRIN

1. Fish/Shellfish Tissue Concentrations

(a) State Mussel Watch Program – No data since 1995

(b) Toxic Substances Monitoring Program (TSMP) – Eleven samples (n=11) with collection dates ranging from 1995-2002, and one sampling location. Whole fish composite samples of red shiner, with numbers of individuals making up composites ranging from 28-42. 0/11 exceedances compared to NAS screening values (100 ppb ww).

Peters Cyn Channel - Dieldrin	1995 – 2001	2002-2004	1995-2004
Total Number of Samples			
Human Health Risk	0	0	0
Wildlife Risk	9	2	11
Total Number of Exceedances (Human Health; OEHHA)	0	0	0
Total Number of Exceedances (Wildlife; NAS)	0	0	0

2. Sediment Concentrations – No Data
3. Water Column Concentrations – No Data

D. TOXAPHENE

1. Fish/Shellfish Tissue Concentrations
   (a) State Mussel Watch Program – No data since 1995
   (b) Toxic Substances Monitoring Program (TSMP) – Eleven samples (n=11) with collection dates ranging from 1995-2002, and one sampling location. Whole fish composite samples of red shiner, with numbers of individuals making up composites ranging from 28-42. 5/11 exceedances compared to NAS screening values (100 ppb ww), with the highest measured concentration >500 ppb (1995).

Peters Cyn Channel - Toxaphene	1995 – 2001	2002-2004	1995-2004
Total Number of Samples			
Human Health Risk	0	0	0
Wildlife Risk	9	2	11
Total Number of Exceedances (Human Health; OEHHA)	0	0	0
Total Number of Exceedances (Wildlife; NAS)	5	0	5

2. Sediment Concentrations – No Data
3. Water Column Concentrations – No Data

E. TOTAL PCBs

1. Fish/Shellfish Tissue Concentrations
   (a) State Mussel Watch Program – No data since 1995
   (b) Toxic Substances Monitoring Program (TSMP) – Eleven samples (n=11) with collection dates ranging from 1995-2002, and one sampling location. Whole fish composite samples of red shiner, with numbers of individuals making up composites ranging from 28-42. 0/11 exceedances compared to NAS screening value (500 ppb ww).

Peters Cyn Channel–Total PCBs	1995 – 2001	2002-2004	1995-2004
Total Number of Samples			
Human Health Risk	0	0	0
Wildlife Risk	9	2	11
Total Number of Exceedances (Human Health; OEHHA)	0	0	0
Total Number of Exceedances (Wildlife; NAS)	0	0	0

2. Sediment Concentrations
   (a) Orange County NPDES monitoring results (1995-Present) 26 samples total (n=26); 26/26 samples were below detection limits.
3. Water Column Concentrations – No Data

IV. UPPER NEWPORT BAY

A. TOTAL DDT

1. Fish/Shellfish Tissue Concentrations
   (a) Toxic Substances Monitoring Program (TSMP) – Seven samples (n=7) with collection dates ranging from 1997-2002, and two sampling locations: Newport Dunes and the Ecological Reserve. Fillet samples (one individual or composite of three) of diamond turbot, brown smoothhound shark, orangemouth corvina, and California halibut. 3/7 exceedances compared to OEHHA screening value (100 ppb ww).
   (b) Coastal Fish Contamination Program (CFCP) 1999 – Five composite fillet samples (n=5) including diamond turbot, shiner surfperch, spotted turbot and yellowfin croaker. 2/5 exceedances compared to OEHHA screening value (100 ppb ww).
   (c) SCCWRP Fish Bioaccumulation Study (2000-2002) – Fifteen fillet composites, including black perch, California halibut, diamond turbot, shiner perch, spotted sandbass, spotted turbot, and sandbass (n=15); 8/15 exceedances compared to OEHHA SVs (100 ppb ww). Eight whole fish composite samples (n=8) including arrow goby, California killifish, topsmelt and sculpin; 8/8 exceedances compared to NAS guideline (50 ppb ww).

Upper Newport Bay-Total DDT	1995 – 2001	2002-2004	1995-2004
Total Number of Samples			
Human Health Risk	25	2	27
Wildlife Risk	0	8	8
Total Number of Exceedances (Human Health; OEHHA)	11	2	13
Total Number of Exceedances (Wildlife; NAS)	0	8	8

2. Sediment Chemistry
   No appropriate sediment quality guidelines exist for DDT in marine sediments (SWRCB, 2004). Appendix A, however, compares measured marine sediment concentrations of DDT, from a number of different monitoring efforts, to a variety of published SQGs, for informational purposes..
3. Water Column Chemistry
   (a) SCCWRP Sediment Toxicity Study (2004). 1/1 sample taken at Pacific Coast Highway Bridge had total recoverable DDT (dissolved plus particulates) > CTR CCC (1 ng/L).

B. CHLORDANE

1. Fish/Shellfish Tissue Concentrations
   (a) Toxic Substances Monitoring Program (TSMP) – Seven samples (n=7) with collection dates ranging from 1997-2002, and two sampling locations: Newport Dunes and the Ecological Reserve. Fillet samples (one individual or composite of three) of diamond turbot, brown smoothhound shark, orangemouth corvina, and California halibut. 1/7 exceedance compared to OEHHA screening value (30 ppb ww).
   (b) Coastal Fish Contamination Program (CFCP) 1999 – Five composite fillet samples (n=5) including diamond turbot, shiner surfperch, spotted turbot and yellowfin croaker. 0/5 exceedances compared to OEHHA screening value (30 ppb ww).
   (c) SCCWRP Fish Bioaccumulation Study (2000-2002) – Fifteen fillet composites, including black perch, California halibut, diamond turbot, shiner perch, spotted sandbass, spotted turbot, and sandbass (n=15); 0/15 exceedances compared to OEHHA SV (30 ppb ww). Eight whole fish composite samples (n=8) including arrow goby, California killifish, topsmelt and sculpin; 0/8 exceedances compared to NAS guideline (50 ppb ww).

Upper Newport Bay - Chlordane	1995 – 2001	2002-2004	1995-2004
Total Number of Tissue Samples			
Human Health Risk	25	2	27
Wildlife Risk	0	8	8
Total Number of Exceedances (Human Health; OEHHA)	0	1	1
Total Number of Exceedances (Wildlife; NAS)	0	0	0

2. Sediment Chemistry
   (a) Bay Protection & Toxic Cleanup Program (BPTCP) (1994,1996) – 7 samples (n=7). 3/7 samples exceed the ERM for total chlordane (6 ppb dw).
   (b) Masters & Inman (2000) – samples obtained March 1997 (n=10). 10/10 samples > ERM for chlordane (6 μg/kg dw).
   (c) SCCWRP Sediment Toxicity Study (2004); samples obtained May and November 2001, and March 2002 (n=8). 3/8 samples > ERM for chlordane (6 μg/kg dw). Toxicity testing and a TIE accompanied sediment chemistry analyses (see below).
   (d) Orange County NPDES monitoring program (1995-Present) – 26 samples; 15/26 samples were below detection but MDL > SQG, so these samples were not considered to be valid (n_{valid} =11) and all invalid samples were collected between 2002-2004; 11/11 samples were > ERM for chlordane (6 μg/kg dw).

Upper Newport Bay - Chlordane	1995 – 2001	2002-2004	1995-2004
Total Number of Sediment Samples	33	3	36
Total Number of Exceedances (NOAA ERM (6 μg/kg dw)	26	1	27

3. Water Column Chemistry
   (a) SCCWRP Sediment Toxicity Study (2004). 1/1 sample taken at Pacific Coast Highway Bridge had nondetectable concentration of chlordane.

C. DIELDRIN

1. Fish/Shellfish Tissue Concentrations
   (a) Toxic Substances Monitoring Program (TSMP) – Seven samples (n=7) with collection dates ranging from 1997-2002, and two sampling locations: Newport Dunes and the Ecological Reserve. Fillet samples (one individual or composite of three) of diamond turbot, brown smoothhound shark, orangemouth corvina, and California halibut. 1/7 exceedance compared to OEHHA screening value (2 ppb ww).
   (b) Coastal Fish Contamination Program (CFCP) 1999 – Five composite fillet samples (n=5) including diamond turbot, shiner surfperch, spotted turbot and yellowfin croaker. 0/5 exceedances compared to OEHHA screening value (2 ppb ww); all samples were nd.

(c) SCCWRP Fish Bioaccumulation Study (2000-2002) – Fifteen fillet composites, including black perch, California halibut, diamond turbot, shiner perch, spotted sandbass, spotted turbot, and sandbass (n=15); 0/15 exceedances compared to OEHHA SV (2 ppb ww). Eight whole fish composite samples (n=8) including arrow goby, California killifish, topsmelt and sculpin; 0/8 exceedances compared to NAS guideline (5 ppb ww).

Upper Newport Bay - Dieldrin	**1995 – 2001**	**2002-2004**	**1995-2004**
Total Number of Samples			
Human Health Risk	25	2	27
Wildlife Risk	0	8	8
Total Number of Exceedances (Human Health; OEHHA)	0	1	1
Total Number of Exceedances (Wildlife; NAS)	0	0	0

2. Sediment Chemistry
   (a) Bay Protection & Toxic Cleanup Program (BPTCP) (1994,1996) – 7 samples (n=7). 0/7 samples exceed the ERM for dieldrin (8 ppb dw).
   (b) SCCWRP Sediment Toxicity Study (2004); samples obtained May and November 2001, and March 2002 (n=8). All samples had nondetectable concentrations of dieldrin.

3. Water Column Concentrations
   (a) SCCWRP Sediment Toxicity Study (2004). 1/1 sample taken at Pacific Coast Highway Bridge had nondetectable concentration of dieldrin.

D. TOXAPHENE

1. Fish/Shellfish Tissue Concentrations
   (a) Toxic Substances Monitoring Program (TSMP) – Seven samples (n=7) with collection dates ranging from 1997-2002, and two sampling locations: Newport Dunes and the Ecological Reserve. Fillet samples (one individual or composite of three) of diamond turbot, brown smoothhound shark, orangemouth corvina, and California halibut. 0/7 exceedance compared to OEHHA screening value (30 ppb ww).
   (b) Coastal Fish Contamination Program (CFCP) 1999 – Five composite fillet samples (n=5) including diamond turbot, shiner surfperch, spotted turbot and yellowfin croaker. 0/5 exceedances compared to OEHHA screening value (30 ppb ww); all samples were nd (DL for two samples was above screening value).

Upper Newport Bay - Toxaphene	**1995–2001**	**2002-2004**	**1995-2004**
Total Number of Samples			
Human Health Risk	10	2	12
Wildlife Risk	0	0	0
Total Number of Exceedances			

(Human Health; OEHHA)	0	0	0
Total Number of Exceedances (Wildlife; NAS)	0	0	0

2. Sediment Chemistry
   (a) Bay Protection & Toxic Cleanup Program (BPTCP) (1994,1996) – 7 samples (n=7). All samples had nondetectable concentrations of toxaphene.
3. Water Column Concentrations – No data

E. TOTAL PCBs

1. Fish/Shellfish Tissue Concentrations
   (a) Toxic Substances Monitoring Program (TSMP) – Seven samples (n=7) with collection dates ranging from 1997-2002, and two sampling locations: Newport Dunes and the Ecological Reserve. Fillet samples (one individual or composite of three) of diamond turbot, brown smoothhound shark, orangemouth corvina, and California halibut. 3/7 exceedances compared to OEHHA screening value (20 ppb ww).
   (b) Coastal Fish Contamination Program (CFCP) 1999 – Five composite fillet samples (n=5) including diamond turbot, shiner surfperch, spotted turbot and yellowfin croaker. 3/5 exceedances compared to OEHHA screening value (20 ppb ww).
   (c) SCCWRP Fish Bioaccumulation Study (2000-2002) – Fifteen fillet composites, including black perch, California halibut, diamond turbot, shiner perch, spotted sandbass, spotted turbot, and sandbass (n=15); 0/15 exceedances compared to OEHHA SV (20 ppb ww). Eight whole fish composite samples (n=8) including arrow goby, California killifish, topsmelt and sculpin; 0/8 exceedances compared to NAS guideline (500 ppb ww).

Upper Newport Bay–Total PCBs	**1995–2001**	**2002-2004**	**1995-2004**
Total Number of Samples			
Human Health Risk	25	2	27
Wildlife Risk	0	8	8
Total Number of Exceedances (Human Health; OEHHA)	4	2	6
Total Number of Exceedances (Wildlife; NAS)	0	0	0

2. Sediment Chemistry
   (a) Bay Protection & Toxic Cleanup Program (BPTCP) (1994,1996) – 7 samples (n=7). 0/7 samples exceeded the ERM for total PCBs (180 ppb dw).
   (b) SCCWRP Sediment Toxicity Study (2004); samples obtained September 2000, May and November 2001, and March 2002 (n=14). No samples exceeded the State's recommended SQG (400 μg/kg dw; MacDonald et al., 2000). 12/14 samples were nondetects.

(c) Orange County NPDES monitoring program (1995-Present) – 51 samples; all samples had concentrations that were below method detection limits.

3. Water Column Concentrations
   (a) SCCWRP Sediment Toxicity Study (2004). 1/1 sample taken at Pacific Coast Highway Bridge had concentration of total PCB < CTR CCC (30 ng/L).

F. **TOXICITY AND BENTHIC COMMUNITY DEGRADATION – UPPER NEWPORT BAY**

1. Bay Protection and Toxic Cleanup Program (BPTCP) (1994-1997). Six sites sampled in Upper Newport Bay (total of 8 samples; n=8). 2/8 sediment samples were toxic to amphipods (*Rhepoxynius*). 6/6 sites sampled showed porewater (100%) toxicity to purple urchin larval development. Spearman Rank Correlation testing showed significant correlation between amphipod toxicity and urchin development toxicity, and chemistry, for total chlordane, total PCB, and DDTs. 3/8 sites showed transitional benthic communities (benthic index of 0.31-0.6), intermediate between degraded and undegraded communities. The benthic indices for Upper Newport Bay were significantly correlated with DDE.
2. SCCWRP Sediment Toxicity Study (2004) - In September 2000, reduced amphipod survival was measured in sediments at 3 out of 5 of the sites sampled. One site had 99% mortality. Sediment-water interface was not toxic to sea urchin fertilization, and was toxic to sea urchin development at 1 site. In May 2001, 3 out of 5 sites showed sediment toxicity to amphipods, and the sediment-water interface was toxic to sea urchin fertilization at 2 sites. The TIE concluded that the primary toxicant was likely nonpolar organic pollutants. While concentrations of DDTs, chlordane and PCBs were not likely to be high enough to independently result in toxicity, there is no evidence to conclude that these pollutants did not contribute to the toxicity that was observed. There was a statistically significant relationship between concentration of total DDT and amphipod survival.

V. SANTA ANA DELHI CHANNEL

A. TOTAL DDT

1. Fish/Shellfish Tissue Concentrations
   (a) State Mussel Watch Program (SMWP) – No SMW samples taken from Delhi Channel
   (b) Toxic Substances Monitoring Program (TSMP) – Seven samples (n=7) with collection dates ranging from 1997-2001. Whole fish, composite samples with numbers of individuals making up composites ranging from 11-63. Species were red shiner, striped mullet, mosquitofish, and tilapia. 0/7 exceedances compared to NAS guideline (1000 ppb ww).

Delhi Channel – Total DDT	1995–2001	2002-2004	1995-2004
Total Number of Samples			
Human Health Risk	0	0	0
Wildlife Risk	7	0	7
Total Number of Exceedances (Human Health; OEHHA)	0	0	0
Total Number of Exceedances (Wildlife; NAS)	0	0	0

2. Sediment Concentrations – No Data
3. Water Column Concentrations – No Data

B. CHLORDANE

1. Fish/Shellfish Tissue Concentrations
   (a) State Mussel Watch Program (SMWP) – No SMW samples taken from Delhi Channel
   (b) Toxic Substances Monitoring Program (TSMP) – Seven samples (n=7) with collection dates ranging from 1997-2001. Whole fish, composite samples with numbers of individuals making up composites ranging from 11-63. Species were red shiner, striped mullet, mosquitofish, and tilapia. 0/7 exceedances compared to NAS guideline (100 ppb ww).

Delhi Channel – Chlordane	1995–2001	2002-2004	1995-2004
Total Number of Samples			
Human Health Risk	0	0	0
Wildlife Risk	6	0	6
Total Number of Exceedances (Human Health; OEHHA)	0	0	0
Total Number of Exceedances (Wildlife; NAS)	0	0	0

2. Sediment Concentrations – No Data
3. Water Column Concentrations – No Data

C. DIELDRIN

1. Fish/Shellfish Tissue Concentrations
   (a) State Mussel Watch Program (SMWP)– No SMW samples taken from Delhi Channel
   (b) Toxic Substances Monitoring Program (TSMP) – Seven samples (n=7) with collection dates ranging from 1997-2001. Whole fish, composite samples with numbers of individuals making up composites ranging from 11-63. Species were red shiner, striped mullet, mosquitofish, and tilapia. 0/6 exceedance compared to NAS guideline (100 ppb ww).
   (c)

Delhi Channel – Dieldrin	1995–2001	2002-2004	1995-2004
Total Number of Samples			

Human Health Risk	0	0	0
Wildlife Risk	7	0	7
Total Number of Exceedances (Human Health; OEHHA)	0	0	0
Total Number of Exceedances (Wildlife; NAS)	0	0	0

2. Sediment Concentrations – No Data
3. Water Column Concentrations – No Data

D. TOXAPHENE

1. Fish/Shellfish Tissue Concentrations
   (a) State Mussel Watch Program (SMWP) – No SMW samples taken from Delhi Channel
   (b) Toxic Substances Monitoring Program (TSMP) – Seven samples (n=7) with collection dates ranging from 1997-2001. Whole fish, composite samples with numbers of individuals making up composites ranging from 11-63. Species were red shiner, striped mullet, mosquitofish, and tilapia. 2/7 exceedances compared to NAS guideline (100 ppb ww).

Delhi Channel – Toxaphene	**1995–2001**	**2002-2004**	**1995-2004**
Total Number of Samples			
Human Health Risk	0	0	0
Wildlife Risk	7	0	7
Total Number of Exceedances (Human Health; OEHHA)	0	0	0
Total Number of Exceedances (Wildlife; NAS)	2	0	2

2. Sediment Concentrations – No Data
3. Water Column Concentrations – No Data

E. TOTAL PCBs

1. Fish/Shellfish Tissue Concentrations
   (a) State Mussel Watch Program (SMWP)– No SMW samples taken from Delhi Channel
   (b) Toxic Substances Monitoring Program (TSMP) – Seven samples (n=7) with collection dates ranging from 1997-2001. Whole fish, composite samples with numbers of individuals making up composites ranging from 11-63. Species were red shiner, striped mullet, mosquitofish, and tilapia. 0/7 exceedances compared to NAS guideline (500 ppb ww).

Delhi Channel – Total PCBs	**1995–2001**	**2002-2004**	**1995-2004**
Total Number of Samples			
Human Health Risk	0	0	0
Wildlife Risk	7	0	7
Total Number of Exceedances (Human Health; OEHHA)	0	0	0

Total Number of Exceedances (Wildlife; NAS)	0	0	0

2. Sediment Concentrations – No Data
3. Water Column Concentrations – No Data

F. TOXICITY AND BENTHIC COMMUNITY DEGRADATION – SANTA ANA DELHI CHANNEL

1. Bay Protection and Toxic Cleanup Program (1994-1997) – Two sample locations within Santa Ana Delhi Channel (86003, 86004), analyzed 8/20/97. No samples showed sediment toxicity to amphipods (*Eohaustorius*).

VI. LOWER NEWPORT BAY

A. TOTAL DDT

1. Fish/Shellfish Tissue Concentrations
   (a) Toxic Substances Monitoring Program (TSMP) – One sample (n=1) collected in 1995. Fillet sample (composite of two individuals) of black croaker. 0/1 exceedance compared to OEHHA screening value (100 ppb ww).
   (b) SCCWRP Fish Bioaccumulation Study (2000-2002) – Thirty-five fillet composites, including barred sand bass, black perch, California halibut, sole, diamond turbot, fantail sole, spotted sand bass, spotted turbot, yellowfin croaker, California corbina, kelp bass, spotfin croaker (n=35); 8/35 exceedances compared to OEHHA SV (100 ppb ww). Sixteen whole fish samples (n=16) including arrow goby, California killifish, sculpin, topsmelt, California halibut, diamond turbot, checkerspot goby, black perch, and diamond perch; 16/16 exceedances compared to NAS guideline (50 ppb ww).

Lower Newport Bay –Total DDT	1995–2001	2002-2004	1995-2004
Total Number of Samples			
Human Health Risk	36	0	36
Wildlife Risk	0	16	16
Total Number of Exceedances (Human Health; OEHHA)	8	0	8
Total Number of Exceedances (Wildlife; NAS)	0	16	16

2. Sediment Chemistry
   (a) There are no appropriate sediment quality guidelines for DDT in marine sediment (SWRCB 2004).

3. Water Column Concentrations
   (a) SCCWRP Sediment Toxicity Study (2004) – 1/1 sample taken at the Lower Bay Turning Basin had total recoverable DDT concentration > CTR CCC.

B. CHLORDANE

1. Fish/Shellfish Tissue Concentrations
   (a) Toxic Substances Monitoring Program (TSMP) – One sample (n=1) with collection 1995. Fillet sample (composite of two individuals) of black croaker. 0/1 exceedance compared to OEHHA screening value (30 ppb ww).
   (b) SCCWRP Fish Bioaccumulation Study (2000-2002) – Thirty-five fillet composites, including barred sand bass, black perch, California halibut, sole, diamond turbot, fantail sole, spotted sand bass, spotted turbot, yellowfin croaker, California corbina, kelp bass, spotfin croaker (n=35); 0/35 exceedances compared to OEHHA SV (30 ppb ww). Sixteen whole fish samples (n=16) including arrow goby, California killifish, sculpin, topsmelt, California halibut, diamond turbot, checkerspot goby, black perch, and diamond perch; 0/16 exceedances compared to NAS guideline (50 ppb ww).

Lower Newport Bay –Chlordane	1995–2001	2002-2004	1995-2004
Total Number of Samples			
Human Health Risk	36	0	36
Wildlife Risk	0	16	16
Total Number of Exceedances (Human Health; OEHHA)	0	0	0
Total Number of Exceedances (Wildlife; NAS)	0	0	0

2. Sediment Chemistry

(a) Bay Protection & Toxic Cleanup Program (BPTCP) (1994) – 11 samples (n=11). 8/11 samples exceeded the ERM for total chlordane (6 ppb dw).
(b) BIGHT '98 – 11 samples (n=11); 2/11 samples exceeded the ERM for total chlordane (6 ppb dw).
(c) SCCWRP Sediment Toxicity Study (2004); samples obtained May 2001 (n=5). All samples had nondetectable concentrations of chlordane.
(d) Orange County NPDES monitoring program (2000 -Present) – 13 samples; 10/13 samples were below detection but MDL > SQG, so these samples were not considered to be valid (n_{valid} =3). 3/3 samples > ERM for chlordane (6 μg/kg dw)

Lower Newport Bay - Chlordane	**1995 – 2001**	**2002-2004**	**1995-2004**
Total Number of Sediment Samples	30	0	30
Total Number of Exceedances (NOAA ERM (6 μg/kg dw)	13	0	13

3. Water Column Concentrations
   (a) SCCWRP Sediment Toxicity Study (2004) – 1/1 sample taken at the Lower Bay Turning Basin had nondetectable concentration of chlordane.

C. DIELDRIN

1. Fish/Shellfish Tissue Concentrations
   (a) Toxic Substances Monitoring Program (TSMP) – One sample (n=1) with collection 1995. Fillet sample (composite of two individuals) of black croaker. 0/1 exceedance compared to OEHHA screening value (2 ppb ww).
   (b) SCCWRP Fish Bioaccumulation Study (2000-2002) – Thirty-five fillet composites, including barred sand bass, black perch, California halibut, sole, diamond turbot, fantail sole, spotted sand bass, spotted turbot, yellowfin croaker, California corbina, kelp bass, spotfin croaker (n=35); 0/35 exceedances compared to OEHHA SV (2 ppb ww). Sixteen whole fish samples (n=16) including arrow goby, California killifish, sculpin, topsmelt, California halibut, diamond turbot, checkerspot goby, black perch, and diamond perch; 0/16 exceedances compared to NAS guideline (50 ppb ww).

Lower Newport Bay –Dieldrin	**1995–2001**	**2002-2004**	**1995-2004**
Total Number of Samples			
Human Health Risk	36	0	36
Wildlife Risk	0	16	16
Total Number of Exceedances (Human Health; OEHHA)	0	0	0
Total Number of Exceedances (Wildlife; NAS)	0	0	0

2. Sediment Chemistry

(a) Bay Protection & Toxic Cleanup Program (BPTCP) (1994) – 11 samples (n=11). 0/11 samples exceeded the ERM for dieldrin (8 ppb dw).

(b) SCCWRP Sediment Toxicity Study (2004); samples obtained May 2001 (n=5). All samples had nondetectable concentrations of dieldrin.

3. Water Column Chemistry

(a) SCCWRP Sediment Toxicity Study (2004) – 1/1 sample taken at the Lower Bay Turning Basin had nondetectable concentration of dieldrin.

D. TOXAPHENE

1. Fish/Shellfish Tissue Concentrations

(a) Toxic Substances Monitoring Program (TSMP) – One sample (n=1) with collection 1995. Fillet sample (composite of two individuals) of black croaker. 0/1 exceedance compared to OEHHA screening value (30 ppb ww).

Lower Newport Bay –Toxaphene	1995–2001	2002-2004	1995-2004
Total Number of Samples			
Human Health Risk	1	0	1
Wildlife Risk	0	0	0
Total Number of Exceedances (Human Health; OEHHA)	0	0	0
Total Number of Exceedances (Wildlife; NAS)	0	0	0

2. Sediment Chemistry

(a) Bay Protection & Toxic Cleanup Program (BPTCP) (1994) – 11 samples (n=11). All samples had nondetectable concentrations of toxaphene.

3. Water Column Concentrations

E. TOTAL PCBs

1. Fish/Shellfish Tissue Concentrations

(a) Toxic Substances Monitoring Program (TSMP) – One sample (n=1) with collection 1995. Fillet sample (composite of two individuals) of black croaker. 0/1 exceedance compared to OEHHA screening value (20 ppb ww).

(b) SCCWRP Fish Bioaccumulation Study (2000-2002) – Thirty-five fillet composites, including barred sand bass, black perch, California halibut, sole, diamond turbot, fantail sole, spotted sand bass, spotted turbot, yellowfin croaker, California corbina, kelp bass, spotfin croaker (n=35); 3/35 exceedances compared to OEHHA SV (20 ppb ww). Sixteen whole fish samples (n=16) including arrow goby, California killifish, sculpin, topsmelt, California halibut, diamond turbot, checkerspot goby, black perch, and diamond perch; 0/16 exceedances compared to NAS guideline (500 ppb ww).

Lower Newport Bay–Total PCBs	1995–2001	2002-2004	1995-2004

Total Number of Samples Human Health Risk Wildlife Risk	 36 0	 0 16	 36 16
Total Number of Exceedances (Human Health; OEHHA)	3	0	3
Total Number of Exceedances (Wildlife; NAS)	0	0	0

2. Sediment Chemistry
   (a) Bay Protection & Toxic Cleanup Program (BPTCP) (1994) – 11 samples (n=11). 0/11 samples exceed the ERM for total PCBs (180 ppb dw).
   (b) BIGHT '98 – 11 samples (n=11); 0/11 exceeded the ERM for total PCBs (180 ppb dw).
   (c) SCCWRP Sediment Toxicity Study (2004); samples obtained September 2000 and May 2001 (n=8). 7 of 8 samples had nondetectable concentrations of total PCBs; no samples were above the SQG (400 µg/kg dw).

3. Water Column Concentrations
   (a) SCCWRP Sediment Toxicity Study (2004) – 1/1 sample taken at the Lower Bay Turning Basin had concentration of total PCB < CTR CCC (30 ng/L).

F. TOXICITY AND BENTHIC COMMUNITY DEGRADATION – LOWER NEWPORT BAY

1. Bay Protection and Toxic Cleanup Program (BPTCP) (1994-1997). Eleven sites sampled in Lower Newport Bay. 5/11 sediment samples were toxic to amphipods (*Rhepoxynius*). 10/11 samples showed porewater (100%) toxicity to purple urchin larval development. Spearman Rank Correlation testing showed significant correlation between amphipod toxicity and urchin development toxicity, and chemistry, for total chlordane, total PCB, and DDTs. 4/11 sites showed degraded benthic communities (benthic index of 0-0.3); 4/11 sites were transitional (benthic index = 0.31-0.6); and 3/11 sites were undegraded (benthic index = 0.61-1). The benthic indices for Newport Bay were significantly correlated with DDE.
2. BIGHT '98 – Toxicity to amphipods was measured at 11 stations: 5 were highly toxic, 4 were moderately toxic, 2 were nontoxic. During BIGHT '98, the highest number of highly toxic samples came from Newport Bay.
3. BIGHT '03 – Toxicity to amphipods was measured at 8 stations: 5 were highly toxic, 2 were moderately toxic, and 1 was nontoxic to amphipod survival.
4. SCCWRP Sediment Toxicity Study (2004) – In September 2000, 3 out of 4 stations showed sediment toxicity to amphipod survival; 1 of 3 stations had water column toxicity to sea urchin fertilization and development; no stations showed sediment-water interface toxicity. In May 2001, 3 of 4 stations had sediment toxicity to amphipods. No TIE was performed on Lower Bay sediments.

VII. RHINE CHANNEL

A. TOTAL DDT

1. Fish/Shellfish Tissue Concentrations
   (a) Toxic Substances Monitoring Program (TSMP) – Two samples (n=2) with collection dates 1997 and 1999. Fillet samples (composite of 22 and 9 individuals) of chub mackerel and yellowfin croaker, respectively. 1/2 exceedance compared to OEHHA screening value (100 ppb ww).

Rhine Channel – Total DDT	**1995–2001**	**2002-2004**	**1995-2004**
Total Number of Samples			
Human Health Risk	2	0	2
Wildlife Risk	0	0	0
Total Number of Exceedances (Human Health; OEHHA)	1	0	1
Total Number of Exceedances (Wildlife; NAS)	0	0	0

2. Sediment Chemistry
   There are no appropriate sediment quality guidelines for DDT in marine sediment (SWRCB 2004).
3. Water Column Concentrations – No data

B. CHLORDANE

1. Fish/Shellfish Tissue Concentrations
   (a) Toxic Substances Monitoring Program (TSMP) – Two samples (n=2) with collection dates 1997 and 1999. Fillet samples (composite of 22 and 9 individuals) of chub mackerel and yellowfin croaker, respecitively. 0/2 exceedance compared to OEHHA screening value (30 ppb ww).

Rhine Channel – Chlordane	**1995–2001**	**2002-2004**	**1995-2004**
Total Number of Samples			
Human Health Risk	2	0	2
Wildlife Risk	0	0	0
Total Number of Exceedances (Human Health; OEHHA)	0	0	0
Total Number of Exceedances (Wildlife; NAS)	0	0	0

2. Sediment Chemistry
   (a) Bay Protection & Toxic Cleanup Program (BPTCP) (1994,1996) – 2 samples (n=2). 1/2 samples exceeded the ERM for total chlordane (6 ppb dw).
   (b) Orange County NPDES monitoring results (2000-2004); Total of 7 samples. Method detection limits were greater than the SQG, so only samples with detectable concentrations were considered to be valid (n=1). 1/1 sample > ERM (6 ppb dw).

(c) SCCWRP Chemistry and Toxicity in Rhine Channel Sediments (2003) – 15 stations sampled (n=15). All samples had nondectable concentrations of chlordane.

(d) SCCWRP Sediment Toxicity Study (2004). Rhine Channel sampled May 2001, March 2002 (n=2). All samples had nondetectable concentrations of chlordane.

Rhine Channel - Chlordane	**1995 – 2001**	**2002-2004**	**1995-2004**
Total Number of Sediment Samples	4	16	20
Total Number of Exceedances of ERM (6 μg/kg dw)	2	0	2

3. Water Column Concentrations – No Data

C. DIELDRIN

1. Fish/Shellfish Tissue Concentrations

(a) Toxic Substances Monitoring Program (TSMP) – Two samples (n=2) with collection dates 1997 and 1999. Fillet samples (composite of 22 and 9 individuals) of chub mackerel and yellowfin croaker, respecitively. 0/2 exceedance compared to OEHHA screening value (2 ppb ww).

Rhine Channel – Dieldrin	**1995–2001**	**2002-2004**	**1995-2004**
Total Number of Samples			
Human Health Risk	2	0	2
Wildlife Risk	0	0	0
Total Number of Exceedances (Human Health; OEHHA)	0	0	0
Total Number of Exceedances (Wildlife; NAS)	0	0	0

2. Sediment Chemistry

(a) Bay Protection & Toxic Cleanup Program (BPTCP) (1994,1996) – 2 samples (n=2). 0/2 samples exceeded the ERM for dieldrin (8 ppb dw).

(b) SCCWRP Chemistry and Toxicity in Rhine Channel Sediments (2003) – 15 stations sampled (n=15). All samples had nondectable concentrations of dieldrin.

(c) SCCWRP Sediment Toxicity Study (2004). Rhine Channel sampled May 2001, March 2002 (n=2). All samples had nondetectable concentrations of dieldrin.

Rhine Channel - Dieldrin	**1995 – 2001**	**2002-2004**	**1995-2004**
Total Number of Sediment Samples	3	16	19
Total Number of Exceedances of ERM (8 μg/kg dw)	0	0	0

3. Water Column Concentrations – No Data

D. TOXAPHENE

1. Fish/Shellfish Tissue Concentrations
   (a) Toxic Substances Monitoring Program (TSMP) – Two samples (n=2) with collection dates 1997 and 1999. Fillet samples (composite of 22 and 9 individuals) of chub mackerel and yellowfin croaker, respecitively. 0/2 exceedance compared to OEHHA screening value (30 ppb ww).

Rhine Channel – Toxaphene	1995–2001	2002-2004	1995-2004
Total Number of Samples			
Human Health Risk	2	0	2
Wildlife Risk	0	0	0
Total Number of Exceedances (Human Health; OEHHA)	0	0	0
Total Number of Exceedances (Wildlife; NAS)	0	0	0

2. Sediment Chemistry – Note there is no state-recommended SQG for toxaphene

   (a) Bay Protection & Toxic Cleanup Program (BPTCP) (1994,1996) – 2 samples (n=2). Both samples had nondetectable concentrations of toxaphene.
   (b) SCCWRP Chemistry and Toxicity in Rhine Channel Sediments (2003) – 15 stations sampled (n=15). All samples had nondectable concentrations of toxaphene.
   (c) SCCWRP Sediment Toxicity Study (2004). Rhine Channel sampled May 2001, March 2002 (n=2). All samples had nondetectable concentrations of toxaphene.

3. Water Column Concentrations – No data

E. TOTAL PCBs

1. Fish/Shellfish Tissue Concentrations
   (a) Toxic Substances Monitoring Program (TSMP) – Two samples (n=2) with collection dates 1997 and 1999. Fillet samples (composite of 22 and 9 individuals) of chub mackerel and yellowfin croaker, respectively. 2/2 exceedances compared to OEHHA screening value (20 ppb ww).

Rhine Channel – Total PCBs	1995–2001	2002-2004	1995-2004
Total Number of Samples			
Human Health Risk	2	0	2
Wildlife Risk	0	0	0
Total Number of Exceedances (Human Health; OEHHA)	2	0	2
Total Number of Exceedances (Wildlife; NAS)	0	0	0

2. Sediment Chemistry
   (a) Bay Protection & Toxic Cleanup Program (BPTCP) (1994,1996) – 2 samples (n=2). 2/2 samples exceeded the SQG for total PCBs (based on sum of Aroclors) (400 ppb dw).
   (b) Orange County NPDES monitoring results (1996-2004); Total of 16 samples (n=16). 1/16 samples > state-recommended SQG (400 μg/kg dw).

(c) SCCWRP Chemistry and Toxicity in Rhine Channel Sediments (2003) – 15 stations sampled (n=15). 0/15 samples > state-recommended SQG (400 μg/kg dw).

(d) SCCWRP Sediment Toxicity Study (2004). Rhine Channel sampled September 2000, May and November 2001, March 2002 (n=6). 0/6 samples > state-recommended SQG (400 μg/kg dw).

Rhine Channel – Total PCBs	**1995 – 2001**	**2002-2004**	**1995-2004**
Total Number of Sediment Samples	17	22	39
Total Number of Exceedances (SQG = 400 μg/kg dw)	3	0	3

3. Water Column Concentrations – No Data

F. TOXICITY AND BENTHIC COMMUNITY DEGRADATION – RHINE CHANNEL

1. Bay Protection and Toxic Cleanup Program (BPTCP) (1994-1997). One site sampled in Rhine Channel. This site showed sediment toxicity to amphipods (*Rhepoxynius* and *Eohaustorius*); porewater (100%) toxicity to purple urchin larval development; and a transitional benthic community status. Spearman Rank Correlation testing showed significant correlation between amphipod toxicity and urchin development toxicity, and chemistry, for total chlordane, total PCB, and DDTs. The benthic indices for Newport Bay were significantly correlated with DDE.
2. SCCWRP Sediment Toxicity Study (2004) – Sediment toxicity (amphipod survival) was observed in September 2000 and May 2001, Sediment-water interface toxicity to sea urchin development or fertilization was also observed. TIEs were not successful in accurately identifying the toxicants, and multiple toxicants are likely present.
3. SCCWRP Chemistry and Toxicity in Rhine Channel Sediments (2003) – Sediments at 11/15 sites were toxic to amphipods. Most toxic sediments were near the entrance to the channel and off the Lido Shipyard. 10/15 sites showed sediment-water interface toxicity. An association between sediment contamination and toxicity could not be established.

Table 4. Impairment Summary for all Water Body-Pollutant Combinations & Comparison with Impairment Assessments Performed by USEPA and SWRCB. Yes = Impaired, Requires TMDL; No = Not Impaired or Insufficient Data to Make Determination

Author	Water Body	Total DDT	Total PCBs	Chlordane	Dieldrin	Toxaphene
USEPA	San Diego Creek*	Yes	Yes	Yes	Yes	Yes
	Upper Newport Bay	Yes	Yes	Yes	No	No
	Lower Newport Bay	Yes	Yes	Yes	Yes	No
	Rhine Channel	Yes	Yes	Yes	Yes	No
SWRCB	San Diego Creek R1	No	No	No	No	No
	Peters Cyn Wash	Yes	No	No	No	Yes
	San Diego Creek R2	No	No	No	No	No
	Santa Ana Delhi Ch	No	No	No	No	Yes
	Upper Newport Bay	Yes	Yes	No	No	No
	Lower Newport Bay	Yes	Yes	No	No	No
	Rhine Channel	No	Yes	No	No	No
SARWQCB	San Diego Creek R1	No	No	No	No	Yes
	Peters Cyn Wash	No	No	No	No	Yes
	San Diego Creek R2	No	No	No	No	No
	Santa Ana Delhi Ch	No	No	No	No	Yes
	Upper Newport Bay	Yes	Yes	Yes	No	No
	Lower Newport Bay	Yes	Yes	Yes	No	No
	Rhine Channel	No	Yes	Yes	No	No

*USEPA's Impairment Assessment did not distinguish between San Diego Creek and its tributaries.

Discussion

San Diego Creek and Tributaries

The weight of evidence approach specified in the State's Listing Policy requires that multiple lines of evidence be assessed in making a finding of impairment (see Background) and the Policy also identifies appropriate guidelines with which to evaluate data. There were no water column data available for these water bodies. There were also very limited fish tissue data available with which to evaluate risk to human health, since sport fish fillet samples were not obtained for this time period and shellfish tissue data are not appropriately compared to OEHHA SVs.

USEPA's impairment assessment (USEPA, 2002) showed that TMDLs were required for all five of the OC pollutants, but their methodology evaluated the data using different screening values than are recommended in the state Policy (they compared concentrations in whole fish tissue composites of red shiner to the OEHHA SVs; and in Regional Board staff's evaluation those data were compared to NAS guidelines to assess risk to wildlife). Note that USEPA did not distinguish between San Diego Creek and its tributaries when evaluating impairment; they also did not separately evaluate Santa Ana Delhi Channel in their assessment.

Staff's results for San Diego Creek and its tributaries differed from those of the SWRCB in two respects: (1) SARWQCB staff found insufficient evidence for impairment due to elevated DDT in Peter's Canyon Wash. The SWRCB evaluated TSMP data obtained as far back as 1992 for Peters Canyon Wash (SWRCB, 2004), while staff evaluated data obtained between 1995 and present. High concentrations of DDT were observed in fish tissue in the early 1990s, yielding the results obtained by the SWRCB. More recent data show that concentrations in fish have dramatically declined and few exceedances of NAS guidelines are currently observed; and (2) SARWQCB staff identified impairment in San Diego Creek Reach 1 due to exceedances of toxaphene concentrations in fish tissue.

Upper and Lower Newport Bay, and Rhine Channel

SARWQCB staff's assessment differed from that previously conducted by USEPA in several respects:

(1) Sediment chemistry data, in the absence of toxicity or other biologic assessment effects data, were not used in staff's impairment assessment, and exceedances of SQGs for DDT in marine/estuarine sediments were generally weighted low in the assessment, since there is a poor correlation with published SQGs for DDT and toxicity. USEPA, on the other hand, defined methodology whereby exceedances of SQGs, alone or in combination with other lines of evidence, were evaluated in their assessment.
(2) Staff compared pollutant concentrations in fish fillet samples to OEHHA SVs, since the fillet is typically the portion of the fish consumed by humans. On the other hand, whole fish concentrations were compared to NAS guidelines for the protection of aquatic life. No appropriate guidelines currently exist with which to evaluate marine shellfish tissue concentrations, so staff did not use shellfish tissue residues in assessing impairment. USEPA compared all measured fish and shellfish concentrations to OEHHA SVs.

Staff's impairment assessment was generally in agreement with that of SWRCB, except for chlordane in Upper and Lower Newport Bay and Rhine Channel. Staff had access to data that were not part of the SWRCB record, namely, sediment data obtained through Orange County's long-term NPDES storm water monitoring efforts. While virtually all fish tissue samples had nondetectable concentrations of chlordane, there were a

substantial number of sediment SQG exceedances that were accompanied by toxicity and benthic community data that implicated chlordane. Therefore, staff disagrees with SWRCB's "Do Not List" recommendations for chlordane for Upper and Lower Newport Bay.

Literature Cited

Allen, M.J., D.W. Diehl, and E.Y. Zeng. 2004. Bioaccumulation of Contaminants in Recreational and Forage Fish in Newport Bay, California in 2000-2002. Southern California Coastal Water Research Project Technical Report 436.

Bay, Steven and J.Brown. 2003. Chemistry and Toxicity in Rhine Channel Sediments. Southern California Coastal Water Research Project 391.

Bay, Steven, D. Greenstein, and J. Brown. 2004. Newport Bay Sediment Toxicity Studies. Southern California Coastal Water Research Project Technical Report 433.

Bay, Steven M., T. Mikel, K. Schiff, S. Mathison, B. Hester, D. Young, and D. Greenstein. Southern California Bight 2003 Regional Monitoring Program: I. Sediment Toxicity. May 19, 2005.

Bay, Steven M., D. Lapota, J. Anderson, J. Armstrong, T. Mikel, A.W. Jirik, and S. Asato. 2000. Southern California Bight 1998 Regional Monitoring Program: IV. Sediment Toxicity.

Buchman, M.F. 1999. NOAA Screening Quick Reference Tables, NOAA HAZMAT Report 99-1, Seattle WA, Coastal Protection and Restoration Division, National Oceanic and Atmospheric Administration, 12 pages.

Long, E.R., D.D. MacDonald, S.L. Smith, F.D. Calder. 1995. Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. Environ. Manage. 19: 81-97.

Long, E.R. and L.G. Morgan. 1990. The Potential for Biological Effects of Sediment-sorbed Contaminants Tested in the National Status and Trends Program, Seattle, WA: National Oceanic and Atmospheric Administration.

MacDonald, D.D., R.S. Carr, F.D. Calder, E.R. Long, and C.G. Ingersoll. 1996. Development and Evaluation of Sediment Quality Guidelines for Florida Coastal Waters. Ecotoxicology 5: 253-278.

MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. Arch. Environ. Contam. Toxicol. 39: 20-31.

Masters, P.M. and D.L. Inman. 2000. Transport and fate of organochlorines discharged to the salt marsh at Upper Newport Bay, California, USA. Environ. Toxicol. Chem. 19(8): 2076-2084.

National Academy of Sciences. 1972. Water Quality Criteria. A report of the Committee on Water Quality Criteria, Environmental Studies Board, National Academy of Sciences, National Academy of Engineering. Washington, D.C., 1972. At the request and funded by the Environmental Protection Agency.

USEPA Region 9. Total Maximum Daily Loads for Toxic Pollutants – San Diego Creek and Newport Bay, California. June 14, 2002.

Vidal, D.E. and S.M. Bay. 2005. Comparative Sediment Quality Guideline Performance for Predicting Sediment Toxicity in Southern California, USA. Environ. Toxicol. Chem. 24: 3173-3182.

MacDonald,D.D., L.M. Dipinto, J. Fields, C.G. Ingersoll, E.R. Long, and R.C. Swartz. 2000. Development and evaluation of consensus-based sediment effect concentrations for polychlorinated biphenyls. Environ. Toxicol. Chem. 19(5):1403-1413.

SWRCBa. Revision of the Clean Water Act Section 303(d) List of Water Quality Limited Segments. Staff Report Volume I, and Fact Sheets Supporting Revision of the Section 303(d) List. September 2005.

SWRCBb. Final Functional Equivalent Document. Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List. September 2004.

SWRCBc. Water Quality Control Policy for Developing California's Clean Water Act Section 303(d) List. September 2004.