CALIFORNIA CHAMBER of COMMERCE

November 30, 2007

VIA ELECTRONIC MAIL (commentletters@waterboards.ca.gov) AND U.S. MAIL

RECEIVED
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SWRCB EXECUTIVE

Jeanine Townsend, Acting Clerk to the Board
Executive Office
State Water Resources Control Board
P.O. Box 100
Sacramento, CA 95812-0100

Re: Public Comment on the State Board's Proposed Water Quality Control Plan for Enclosed Bays and Estuaries of California, Sediment Quality Objectives

Dear Ms. Townsend:

The California Chamber of Commerce and its members, General Electric Company and Montrose Chemical Corporation of California, hereby submit to the State Water Resources Control Board ("State Board") the enclosed comments and expert reports on the State Board's September 27, 2007 Draft Staff Report, Water Quality Control Plan for Enclosed Bays and Estuaries and associated documents. We are also submitting under separate cover an appendix of expert reports and supporting materials in support of these comments.

We appreciate the opportunity to provide the State Board with our comments on this important matter. Protecting bay and estuary sediments from adverse effects caused by toxic compounds is an important objective that we share with the State Board. The draft SQOs, however, would appear to result in a major expansion of the bay and estuary sediments previously considered contaminated under Chapter 5.6 of the Water Code. We are concerned that this expansion is not justified by any degradation of sediment quality since the State Board designated contaminated sediments in 1999. In fact, many of the toxic pollutants upon which the proposed SQOs focus (e.g., DDT, PCBs and chlordane) are legacy compounds, for which the concentrations have been declining for many years, representing improved conditions since the State Board designated contaminated sediment "hot spots" in 1999. The apparent expansion of the program under the proposed SQOs appears related to technical problems with the draft SQOs, including statistical chemistry thresholds that are not predictive of toxicity and are exceedingly low values.

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We are available to discuss our comments with the agency at your convenience, and look forward to continued constructive participation with this issue.

Best regards,

Valerie Nera, Policy Advocate
Agriculture, Resources & Privacy
California Chamber of Commerce

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COMMENTS ON STATE WATER RESOURCES CONTROL BOARD'S WATER QUALITY CONTROL PLAN FOR ENCLOSED BAYS AND ESTUARIES, SEDIMENT QUALITY OBJECTIVES

SEPTEMBER 27, 2007 STAFF REPORT

Submitted by:

Date: November 30, 2007

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On behalf of the California Chamber of Commerce ("CalChamber"), General Electric Company and Montrose Chemical Corporation of California, we appreciate the opportunity to submit public comments to the State Water Resources Control Board ("State Board"), in response to the State Board's issuance on September 27, 2007 of a proposed Water Quality Control Plan for Enclosed Bays and Estuaries and proposed sediment quality objectives (the "proposed SQOs") for California's bays and estuaries, and request for public comment on these proposed agency actions.[1] Protecting bay and estuary sediments from adverse effects caused by toxic compounds is an important objective that we share with the State Board. We have a particular interest in this matter, as we believe the Proposed Regulation and SQOs do not reasonably differentiate between sediments contaminated by toxic compounds and those that are not, resulting in a major expansion of the bay and estuary sediments previously considered contaminated under Chapter 5.6 of the Water Code; do not strike a reasonable balance among competing objectives including the need to avoid significant economic impact and other adverse consequences that are not warranted by any realistic assessment of potential benefits; suffer from a number of technical and legal defects; and lack the requisite implementation measures needed to make the proposal transparent and defensible.

I. <u>Executive Summary</u>

CalChamber has served as a member of the Sediment Quality Objectives Advisory Committee ("Advisory Committee") for several years. As such, CalChamber recognizes and appreciates the amount of effort that went into the development of the proposed SQOs. We believe that the State Board has done a good job of recognizing the weaknesses that would result from relying on any of the individual single line of evidence alone for purposes of assessing sediment condition. We further recognize that the State Board is under a court-imposed order to complete development of the SQOs (assuming that defensible SQOs can be established) under a specified timetable.

Despite these practical limitations, the State Board should not forge ahead at this time. The SQOs present an important and unprecedented regulatory effort. There are no SQOs in California, and few across the country. The SQOs will be a milestone in the regulation of sediment quality in California and potentially will be a model for other coastal states across the nation. The stakes are high, both in terms of the SQOs' potential effects on the environment and water quality, and the resources that may be required to be directed toward meeting these SQOs.

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1 These comments are based on the Draft Staff Report entitled, "Water Quality Control Plan for Enclosed Bays and Estuaries, Part 1, Sediment Quality Objectives," (hereinafter "Staff Report"), and attachments thereto. We respectfully request that these public comments, and related expert reports, appendices, and attachments submitted concurrently be given appropriate consideration and be placed in the administrative record for these proceedings.

We also incorporate by reference the comments submitted under separate cover by Dr. James L. Byard. We also request that the State Board incorporate the administrative record developed during the development and implementation of the toxic hot spot program into the administrative record for these proceedings, as the subject matter of both programs substantially overlaps.

Given the potentially huge stakes of the SQOs, and the fact that they may be used in California's Toxic Hot Spots Cleanup Plan, as well as in various TMDLs, it is critical that the State Board apply sound scientific methods to identifying sediments as contaminated, and develop SQOs that are consistent with Chapter 5.6's principal goal of identifying and addressing discrete areas of contaminated sediments that are unreasonably affecting the beneficial uses of California's bays and estuaries. The current proposal does not satisfy these objectives and accordingly must be revised.

If adopted as proposed, the SQOs would classify 80% of all sediments in California's bays, and more than 90% of sediments in San Francisco Bay, as contaminated. Under the State Board's current classification, finalized in 1999 after years of work, a relatively small percentage of bay and estuary sediment is considered contaminated, corresponding to discrete "hot spots." The SQO and "hot spot" classifications both are intended to demarcate those sediments containing toxic pollutants that are unreasonably affecting beneficial uses. The State Board carries a significant burden to explain the dramatic expansion of the 1999 classification portended by the proposed SQOs. Our analysis indicates that the proposed expansion is not warranted, and should be addressed through revisions of the proposed rule.

Principal concerns with the proposed SQOs include, without limitation, the following:

- <u>The Proposed Chemistry Thresholds Are Not Scientific</u>. Chapter 5.6 requires the SQOs to be based on science; the proposed chemistry thresholds are not based on science. They are based on statistical calculations of data without regard to underlying information as to what may be causing biological effects observed in toxicity tests. By ignoring information on toxicology, such as causation studies and dose-response knowledge, and chemical bioavailability, the chemistry thresholds are set without regard to toxicological and scientific principles.

- <u>The Proposed Chemistry Thresholds Are Based on Incoherent Data</u>. The heavy reliance on statistics to set the chemistry thresholds is undermined by the absence of any apparent statistical relationship between chemical concentrations in the sediment, on the one hand, and observed biological responses in toxicity tests, on the other. In fact, the data sets relied on to derive the chemistry thresholds lack meaningful coherency between these two measures – chemical concentrations and observed biological effects. Plots of these variables against each other look like scatterplots, completely random assemblages of data. The State Board's own analysis concluded that 90 percent of the time, there is no relationship between these two measures. Yet, the SQOs include threshold values picked from these poor associations.

- <u>The Proposed Chemistry Thresholds Lack Any Correspondence to Levels of Toxic Pollutants Known to Cause Toxicity, which Generally Are Hundreds of Time Higher</u>. The SQOs cannot justify the chemistry thresholds on a margin of safety basis when the levels are so far below those levels that pose actual risk. Without scientific rationale, the statistics used to set the thresholds seem to produce values much closer to zero than to any value with toxicological significance. While a zero, or close-to-zero value may be protective, it is not reasonable or scientific to choose such values when much higher values, set based on science, are just as protective.

- The SQOs Lack a Logical Scheme by which to Label Sediments Contaminated. The SQOs would establish a scheme by which sediment unimpacted by toxic pollutants is nonetheless classified as impacted. For example, under the SQOs, sediment may be classified as impacted even if no toxic pollutants are detected at the site. Similarly, a site that has a robust benthic community that does not show any signs of being impacted by toxic pollutants can be classified as impacted. Even when both toxicity and exposure are low, the SQOs can designate sediments as contaminated.

- The SQOs Will Make Contaminated Sediments the Rule, Dramatically Expanding Chapter 5.6 Jurisdiction without Scientific Basis, and Contrary to Intent. The flawed chemistry thresholds, and other problems, result in the SQOs incorrectly classifying the vast majority of bay and estuary sediment as contaminated, in sharp contrast to the 1999 classification under the same basic principle. The SQOs neither acknowledge nor explain this dramatic departure from the State Board's earlier findings, and are arbitrary and capricious in that regard. Our analysis indicates that no such expansion is warranted on the merits. The grossly overbroad proposal frustrates the intent of Chapter 5.6 and the California Legislature, which call for a focused program to address discrete sediment "hot spots."

- The Proposed SQOs Are Not Reasonably Achievable and Lack Implementation Detail. There can be no doubt that restoring bay and estuary sediment to compliance with the grossly overbroad SQOs would be a monumental and unprecedented undertaking. Yet, perhaps in recognition of how ambitious such a program would look on paper, the draft SQOs provide no useful discussion of how the regulated community reasonably can achieve the SQOs, which entities are to take what steps to remedy the picture of widespread and chronic non-compliance painted by the draft SQOs. These are failings under the basin planning provisions of the Water Code and CEQA.

- The Proposed SQOs Did Not Consider Economics, or Properly Disclose the Potential Costs of the SQOs. The State Board previously estimated the cost to address sediment "hot spots" at up to $1 billion. Since the SQOs would multiply the amount of sediment considered contaminated, it is reasonable that the SQOs program would cost many billions of dollars. The costs presented, however, are far below such numbers, and do not consider the costs of implementation measures needed to achieve the SQOs, casting doubt on their validity and utility, and raising arbitrary and capricious inconsistencies with the "hot spots" program. Further, there is no discussion of the economics associated with the expected environmental benefits of achieving the SQOs.

- The Proposed SQOs Do Not Comply With CEQA. CEQA requires that the environmental document fairly disclose all the potentially significant environmental impacts associated with project. The proposed SQOs, however, do not provide a sufficient description of the project's baseline against which project impacts can be assessed, and did not assess the environmental impacts associated with implementation measures that will be required to achieve compliance with the SQOs. Given the low thresholds under which sediment is brought into the program, significant questions arise as to the many environmental impacts that will occur to achieve compliance with the SQOs, none of which are addressed in the proposed SQOs.

For the above reasons, and others discussed below, we respectfully request that the State Board revise the SQOs to conform with sound science, good policy, and the law.

II. <u>The Proposed Regulation Includes Technical Problems That Render It Scientifically Unsound</u>

The State Board is required to strike a reasonable balance among competing objectives when adopting SQOs, and must establish a technically sound basis in order to inform SQO implementation measures. As more particularly described below, the proposed SQOs do not meet these basic requirements.

A. <u>The SQOs Must Be Based on Good Science.</u>

The California Legislature mandated that "<u>[t]he sediment quality objectives shall be based on scientific information</u>, including, but not limited to, chemical monitoring, bioassays, or established modeling procedures, and shall provide adequate protection for the most sensitive aquatic organisms." <u>Id.</u> § 13393(b) (emphasis added). The State Board's own counsel recognized that the agency should not adopt SQOs until it can demonstrate that they are scientifically based, as required by statute. <u>See</u> Meeting Notes, Sediment Quality Objectives Advisory Committee, 3rd Meeting (April 26, 2004) at 3 ("Sheila Vassey, from the Counsel's Office, addressed Committee members' questions about the adequacy of this approach. She stated that, as with the development of all water quality objectives, the goal of the State Board is to do the best possible job given real-world constraints. While the Act states that SQO shall be developed for all bays and estuaries, it also says that these should be scientifically based, implying that if the necessary data are not available, then the SQO cannot be developed now, but would be developed in the future"), available at <u>http://www.swrcb.ca.gov/bptcp/docs/sqoac/2004/april/sqo_meetsumm.doc</u>.

B. <u>The Chemistry Prong Is Based on Non-Scientific Evidence</u>

The proposed SQOs rely on empirical sediment quality guidelines, such as the California Logistic Regression Models ("Cal-LRM") and Chemical Score Indicator ("CSI"), for purposes of establishing threshold concentrations to be used in the chemistry line of evidence. <u>See</u> Staff Report, at 74-80. The statistical methods proposed in the SQOs to predict potential impairment of sediments from concentrations of individual chemicals in sediments are without merit and should not be used in the SQOs. The statistical associations derived from these methods do not inform as to whether there is a causal relationship between chemical concentration in sediments and biological effects that has a high predictability and spatial generality in its application.

Instead, the proposed SQOs contain low thresholds and rely on a statistical association between the chemicals and the sediments to support its threshold values. The types of statistical approaches contained in the proposed SQOs do not have a valid scientific basis, do not help in establishing causal relationships between chemical concentration and biological effects, and should not be used to develop the SQOs.

The Staff Report acknowledged that the "use of SQGs [sediment quality guidelines] 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." Staff Report, at 75. The proposed SQOs further recognized that "there are many factors that make their use a complex and challenging task." Id., at 74. Yet, the proposed SQOs attempt to justify reliance on these methods by stating that "sediment chemistry would be proposed as a surrogate measure of exposure and used only with other LOEs." Id., at 75. As set forth in Section II.C.1, infra, there are many possible scenarios where a station would fail the SQO (by falling within the "Possibly Impacted" category), even under reference and minimal chemistry exposure. The impact of the proposed SQOs' reliance on unsound statistical methods is significant and real.

ENTRIX evaluated the proposed SQOs' methods to determine whether they were scientifically sound using established scientific benchmarks, and to determine whether they could be used reliably and predictably to identify a specific cause of observed toxicity (versus merely relying on an association between the chemicals and the sediments) to support threshold values in the Staff Report. ENTRIX further evaluated whether the methods could be used to find ecologically and statistically significant relationships between individual biological effects and contaminant concentrations. After extensive graphical and statistical analyses, no such relationships were found to exist.

In order to be scientifically valid, the proposed SQOs should (1) establish a cause-and-effect relationship between chemical concentration in sediments and biological effects; (2) have a high predictability and spatial generality in their application; (3) have a high degree of reliability (or degree of confidence); and (4) apply to complex mixtures to predict the potential toxicity of individual chemicals. The proposed SQOs do not meet any of these fundamental requirements and suffer from numerous limitations. It therefore is scientifically unsound for the proposed SQOs to rely on the statistical methods to predict potential impairment of sediments. The proposed SQOs propose exceedingly low thresholds and are relying on an association between the chemicals and the sediments to support threshold values. The statistical approaches contained in the proposed SQO do not have a valid scientific basis and should not be used for a number of reasons, including the following:

- *Statistical associations do not explain or establish causation.* The methods assume associations between chemical concentrations and biological effects rather than supporting development of cause-and-effect relationships. Any number of variables such as unmeasured chemicals, ammonia, hydrogen sulfide, and dissolved oxygen content in sediments could affect sediment toxicity and species responses.

- *The proposed methods do not account for factors affecting chemical bioavailability.* Chemicals only represent a potential harm to benthic and other wildlife if they are bioavailable. The methods may not account for factors affecting chemical bioavailability such as grain size and acid volatile sulfide (AVS) content of sediment-sorbed materials (e.g., Nebeker et al. 1989; DiToro et al. 1990).

- *The proposed methods do not account for effects due to mixtures of chemicals, only a single chemical.* When multiple chemicals exist, as is common in bay sediments, the methods preclude the ability to separate which chemical is causing an observed effect. (Adams et al. 1992; Chapman 1989).

- *The scientific community recognizes the defects in the proposed methods should preclude their use in establishing sediment criteria or cleanup levels.* Almost from the beginning of the development of these types of statistical methods, it was recognized by the scientific community that the assumptions needed to allow the approaches to be used as a tool for regulating sediment quality were almost never met. ENTRIX confirmed conclusions previously reached by other investigators which include that the proposed methods (1) generate statistical associations that do not help establish causal relationships between chemical concentration and biological effects; (2) cannot account for factors important in determining bioavailability of chemicals; and (3) cannot account for biological effects due to unmeasured concentrations of other chemicals or chemical mixtures.

- *No ability to reliably identify a specific cause of observed toxicity in sediments.* To be reliable, a proposed method must be able to adequately estimate or predict adverse effects or toxicity at a given location, and have a high probability of estimating effects in a consistent manner. The proposed method also must have a high degree of predictability, which refers to the ability to apply the reliable method spatially among various geographical locations (e.g., will the method predict the same toxicity or effects in San Francisco Bay as in Los Angeles Harbor). The State Board's test methods are neither dependable in estimating toxicity (i.e., reliable), nor capable of being applied to various geographical locations to get consistent responses or comparable estimates of toxicity (i.e., predictable).

- *No ability to predict potential sediment impairment.* Since the key assumptions that are necessary to make the methods scientifically sound are rarely met, it is essentially not possible to develop a predictive relationship for individual chemicals from synoptic measures of exposure to complex mixtures and responses, either in bioassays or in field measurements of benthic invertebrate populations and communities. State Board staff illustrated this problem when they examined the proposed methods, reporting very small coefficients of determination (a measure or relatedness between concentrations of individual chemicals and outcomes). In many cases, the correlation between the magnitude of exposure to a chemical (concentration in sediments) and the adverse effects were much less than 10%. In other words, <u>90% of the time there was no relationship between concentration of the chemical in the sediment and biological response</u>.

- *Inability to achieve intended biological response.* For Selected California Harbor sediments, use of either Cal-LRM and CSI methods-based toxicity threshold concentrations of Total DDT or Total PCB for setting injury or sediment clean-up levels would not be justified since these thresholds failed to distinguish between toxic and non-toxic effects for any of the toxicity endpoints considered. Cal-LRM and CSI-based thresholds derived for establishing sediment quality using selected field observations lead to values that have no toxicological or statistical meaning.

- *Inconsistent results cast doubt on proposed methods' validity.* There were instances in which statistically significant differences were found in the magnitude of an endpoint response among areas or among data sources within an area, yet no significant differences were found with respect to the co-occurring concentration of a contaminant. Such inconsistencies immediately call into question the validity of assuming a direct relationship between the magnitude of contamination and the magnitude of adverse biological effects using field observations.

For all of these reasons, as more particularly set forth in ENTRIX's comments, the SQOs' proposed statistical methods have severe limitations. Such statistical methods can be used to explore whether associations between levels of contamination and biological effects exist (here they do not). Such methods might be appropriate as screening tools to identify sediments in areas that may require more detailed evaluation. It is not scientifically sound, however, to use such methods to support the identification of SQOs or site-specific sediment cleanup goals. The proposed SQOs' statistical approaches do not have a scientific basis and should not be included in the development of SQOs or classification of the degree of potential impairment of sediments.

C. The Proposed Multiple Lines of Evidence Approach Is Grossly Overbroad and Fails to Discriminate Between Impacted and Unimpacted Sites

The State Board correctly has recognized that evaluation of sediment quality is unique. Unlike water quality which "is routinely assessed based on a single line of evidence," sediment "is a more complex matrix that makes establishment of an objective" based on a single line of evidence alone "problematic." Staff Report, at 60. There are significant weaknesses and confounding factors that make the individual lines of evidence poor diagnostic tools when used in isolation, and lead to the principle that impacts due to contaminants should not be inferred unless the weight of the evidence clearly supports such inference.

Reliance on chemical concentration alone is problematic because it does not account for factors that affect bioavailability of contaminants in sediment. Toxicity tests can lead to spurious results because of the presence of confounding factors such as ammonia, hydrogen sulfide or physical abrasion, and may not be ecologically significant because they are based on species introduced in a laboratory, not necessarily those occurring naturally at the test site. Examination of the benthic community condition is problematic because the benthos are affected by a large number of factors other than chemical concentration, making it difficult to distinguish whether a degraded community resulted from chemical exposure or physical disturbance. Staff Report, at 60-1. Because of these weaknesses in the individual lines of evidence, and assuming the multiple lines of evidence approach is consistent with the statutory definition of an SQO, there is potential value in using this approach in evaluating sediment quality so as to minimize the burden and waste of chasing non-problems. There are significant defects, however, in the proposed application of the multiple lines of evidence framework which render it overbroad, and technically unsound, because it fails to discriminate between impacted and unimpacted sites.

Specifically, the State Board proposes to interpret the lines of evidence in such a fashion that most, if not all, of the enclosed bays and estuaries in California likely will fail the SQOs. For example, five of seven regions in San Francisco Bay examined by the Southern California Coastal Water Research Project ("SCCWRP") failed to meet the SQOs. According to SCCWRP, 83% of California's marine embayments fail the SQO:

> "Of the approximately 1294 km^2 of marine embayments in California, approximately 20% was Clearly Impacted or Likely Impacted; 63% of the area was Possibly Impacted and 17% was Unimpacted or Likely Unimpacted. Only 0.3% of California's marine embayment areas was classified as Inconclusive. The statewide analysis results were dominated by the conditions present in San Francisco Bay, which represented nearly 80% of the embayment areas."

See Sediment Quality in California Bays and Estuaries, Draft Final Report, A. Barnett, *et al.*, SCCWRP (September 2007) at ii; see also id. at iii, 13, Table 4 and Figure 5 (96.3% of San Francisco Bay failed SQOs).

Application of the proposed multiple lines of evidence framework led to similarly overbroad results in Newport Bay waterbodies that failed the SQOs. Both regions of Newport Bay failed to meet the SQOs, as well as three of the other four Bays evaluated in Region 8 (Anaheim Bay, Huntington Harbor, Bolsa Bay, and Rhine Channel). See SCCWRP (September 2007) at 16 ("Sites having Likely Impacted and Possibly Impacted sediment quality were most prevalent in Newport Bay and San Francisco Bay (Figure 6), where each of these water bodies had over 80% of sites in these [degraded] assessment categories."). Similarly, the majority of the regions of San Diego Bay failed to meet the SQOs.

The State Board's interpretation of the lines of evidence suffers from at least three other problems, as discussed below.

1. Assessment Is Biased Toward Designating Stations as Impacted

The proposed approach is biased toward designating a station as impacted. The approach is flawed in that two lines of evidence indicating a low likelihood of impact are dismissed in favor of the single line of evidence indicating an adverse impact. For example, a station is designated as impacted (i.e., the station assessment is Possibly Impacted, Likely Impacted or Clearly Impacted) if benthos community condition and chemistry exposure indicate little or no impact, but toxicity is high. This is not appropriate given that toxicity is the weakest line of evidence because (1) factors other than toxic chemicals can cause toxicity; (2) the laboratory conditions often differ from in-situ conditions; and (3) the specified test organisms may not occur naturally at the site.[2] As a result of the State Board's disproportionate reliance on toxicity in interpreting the multiple lines of evidence, many waterbodies will fail the SQOs under high toxicity conditions regardless of the findings for benthos community condition or chemistry exposure. Indeed, a waterbody fails to meet the SQO or is inconclusive under "high" toxicity in all cases regardless of sediment chemistry exposure or benthic community condition levels. Staff Report, Appendix A, Attachment B. A site also will be designated as impacted if toxicity and chemistry exposure indicate little or no impact, but the benthic community is moderately or highly disturbed.

Designating sites based on these findings is not consistent with the multiple lines of evidence approach. Indeed, such designations are not consistent with principles set out in the State Board's own proposal. Namely, that (1) results for a single line of evidence shall not be used as the basis for an assessment; and (2) evidence of both elevated chemical exposure and biological effects must be present to indicate pollutant-associated impacts. Staff Report, Appendix A, p. 17.

There also are many possible scenarios where a station would fail the SQO (by falling within the "Possibly Impacted" category), even under reference and minimal chemistry exposure or toxicity. For a more detailed discussion of this issue, see the QEA Technical Memorandum at 5-6 which combines the results of Staff Report Tables 9-11.[3]

An additional factor that renders the proposed SQOs overbroad and not able to discriminate between impacted and non-impacted sites is the instruction to "round up" when evaluating the lines of evidence. As specified in Appendix A, parties are instructed to "round up" evaluations that fall between categories. See Appendix A at 11-12, 15. This rounding-up rule is another conservatism heaped on the various conservatisms that render the SQOs overbroad as a whole. The rounding-up rule contributes to the inability of the proposed multiple lines of evidence procedure to distinguish between impacted and non-impacted sites. Similarly, the fact that it takes as few as two impacted stations to trigger an exceedance of a receiving water limit makes the SQOs overbroad. The full data set used to conduct the SQO assessment can contain as few as two stations. Given the variability inherent in the nature and chemistry of sediments and the large areas over which SQO assessments are likely to take place, it is not appropriate to evaluate compliance with the receiving water limit on so few data points. This approach introduces yet another conservative bias. Although only two samples are required to

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2 The State Board's approach is biased toward toxicity despite the fact that the agency itself recognizes the weaknesses in this line of evidence (Staff Report at 61).

3 All of following are "possibly impacted," for example: (1) **minimal** chemistry exposure, high toxicity, **reference** benthos; (2) **minimal** chemistry exposure, high toxicity, **low disturbance** of benthos; (3) **minimal** chemistry exposure, **moderate** toxicity, **moderate** disturbance of benthos; (4) **minimal** chemistry exposure, **moderate** toxicity, high disturbance of benthos; (5) **reference** benthos, high toxicity, **minimal** chemistry exposure; (6) **reference** benthos, high toxicity, **low** chemistry exposure; (7) **low** toxicity, **low** chemistry exposure, moderate benthos; (8) **nontoxic**, moderate chemistry exposure, moderate benthos. Id. at 5-6.

declare that a water body is impaired and must be included on the State's Section 303(d) list, 28 or more samples are required to remove waters from the State's 303(d) list.

2. The Proposed Chemistry Thresholds Do Not Bear a Reasonable Relationship to Concentrations that Might Actually Cause Toxicity

The proposed chemistry thresholds are alarmingly low. Statistics based on paired biological and chemical data, which are the basis for the chemical thresholds, are useful for the limited purpose of defining levels below which no effects are expected and levels above which effects are always expected. These statistical approaches, however, provide little additional insight because of the co-variation among chemicals and other factors such as sediment grain size and organic content. Specifically, it is not possible to demonstrate that a specific chemical is the cause of any observed adverse environmental effects using statistics. For example, a toxic sediment high in metal concentrations and low in PCB concentration can result in impairment for PCBs – without consideration of the possible causal effect of the metal and the lack of evidence of a causal effect of PCB. The numbers proposed by the State Board do not correspond to the level of a constituent that provides for the reasonable protection of beneficial uses or the prevention of nuisance even taking into account an adequate margin of safety.

Of particular concern is that statistical thresholds conflict with and are often lower than thresholds based on an understanding of toxicology (such as the equilibrium partitioning (EqP) approach) which reflect process and mechanistic understanding as to how toxic compounds cause toxicity, and account for site-specific factors that affect contaminant bioavailability. In addition, statistical thresholds often fall within the range of naturally occurring levels of contaminants (i.e. metals such as zinc and lead). Statistical thresholds such as those used in the SQOs infer toxicity at non-toxic concentrations. In contrast, thresholds based on toxic mechanisms in many instances are orders of magnitude higher than those based on raw statistics. The proposed statistical thresholds for PCBs, for example, are orders of magnitude lower than those estimated from EqP methods.[4]

3. The Percentage of Sites Needed to Classify a Site as Impacted Is Too Low and Is Based on a Precedent That Is Not Relevant

The State Board is proposing to utilize the approach described in the current Section 303(d) listing policy for the purpose of integrating the results of many single station assessments into a single watershed-based or water body assessment. Staff Report, at 98-99 (Section 5.7.3). The proposed Section 303(d) approach, however, is not an appropriate precedent for assessing sediment impairment, as it would significantly overstate the number of impaired waterbodies. Under the State Board's proposed approach, a waterbody would be identified as impaired if more than 3% of the stations exceeded the SQOs. If a waterbody had 100 stations, exceedances only would need to be demonstrated in over 3 of them, and the SQOs would classify 97 stations as not impacted. This number is so low given all of the variability in the matrices being examined that one could exceed this level by pure chance, particularly given the

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4 Indeed, in all three of the comparisons on page 3 of the QEA Technical Memorandum; the EqP thresholds below which no toxicity is expected are all higher than the high exposure thresholds in the Staff Report.

inherent likelihood for false positives (i.e., declaring a station as being impacted when it is not). Indeed, it is likely that some fraction of the sampled sediments, perhaps as high as 20% in some cases, will exhibit toxicity that is unrelated to and not caused by local dischargers. The Section 303(d) listing policy applies the 3% threshold in an entirely different context; namely, to refer to sample results collected over time (i.e., the water quality standard cannot be exceeded more than 3% of the time). This is fundamentally different than setting the appropriate frequency of exceedance in space that would constitute a failure to meet standards. This approach therefore is an inappropriate precedent for assessing the condition of the waterbody.

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To begin to correct the above technical defects, the State Board should take the following measures:

- The "possibly impacted" category "represents the greatest uncertainty and disagreement amongst the LOE," "only suggests the "*possibility* of the station being impacted," and stations "within this category may be either unimpacted or impacted." Staff Report, at 93 (emphasis added). "Possibly impacted" sites therefore should not be included as impaired. The State Board should state that these sites are meeting the protective condition until studies demonstrate otherwise. Perhaps this category could be used as a trigger for expanded monitoring, rather than the full suite of investigations triggered by a declaration of impairment.
- The proposed SQOs should not base any thresholds on purely a statistical association between chemical concentrations and biological endpoints. Chemical thresholds must reflect toxicological factors and account for background levels.
- Minimum sample size for multi-station assessment of a single water body and minimum geographical coverage extent for individual sampling events must be specified.
- The proposal should include reasonable specifications for the minimum number of stations and minimum number of "Impacted" stations. These specifications should be tied to a desired minimum sampling density. For example, it might be appropriate to require a minimum of 10 stations per site and a minimum spatial density of one station per hectare. Further, sites should be defined by the discharge gradient of regulated dischargers. Regional scale evaluations are useful for identifying water body status, but they have little value in managing individual dischargers.

D. <u>The Relationship Between the SQOs and Implementation Measures to Achieve the SQOs Is Not Clear and Lacks Transparency</u>

The SQOs as currently proposed lack transparency regarding many crucial aspects and contain significant ambiguities and uncertainties regarding the State Board's proposed process. The SQOs should examine what implementation will likely be required to achieve the SQOs, what alternative approaches to achieving the SQOs' goals exist, how much sediment will fail to comply with the SQOs, and how much it will cost to return these sediments to compliance. For example, the Staff Report is not clear on when and how a nonattainment of the SQOs will be determined, or how remediation of the site will be accomplished, and lacks a defined implementation plan.

The Staff Report states that a Regional Board may apply SQOs to a discharger's permit if it determines that sediment quality is "potentially at risk" "in the vicinity" or "within [the] discharge gradient" of a discharger. Staff Report, Appendix A, p. 21. Despite the importance of these qualitative expressions of spatial association in dictating whether SQOs can be applied in a permit, they are never defined. The SQO does not identify what data should be used to make the necessary determination and how that data should be used. The proposed methods to identify a discharger or dischargers responsible for an exceedance of the SQOs are vague and subjective in regions of multiple discharges. In such circumstances, the SQOs fail to provide guidance as to how gradient analyses can be applied to determine the alleged source of contamination. In practical terms, how will a discharger prove that the contamination is or is not related to their permitted discharge, especially if the contaminated sediment is located some distance from the discharge?

The need for guidance on these key issues is acute given that the analyses required to determine whether sediments are "potentially at risk" may be involved and costly for both dischargers and regulators. Modeling is typically used to link dischargers and receiving water quality when developing water quality-based effluent limits. Whereas relatively simple models are adequate for most water quality-based permitting, the modeling necessary to link a discharge to sediment toxic pollutant concentrations is complicated by the numerous processes involved in sediment transport, contaminant sorption and speciation and physical and chemical interactions between the sediment and the water column. This is especially true in bays and estuaries because of the complex hydrodynamics, the influence of winds and variations in salinity. It may not be scientifically feasible, practical, or cost effective to routinely determine sediment quality potentially at risk.

The proposed SQOs also state that a discharger shall be in violation of its permit if it is demonstrated that the discharge is causing or contributing to the SQO exceedance. Staff Report, at 99 ("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."). The Staff Report, however, does not outline how the causal relationship between the discharges and sediment quality will be established and whose burden it is to make such a determination. The approach outlined in the Staff Report sets up a situation in which multiple dischargers are affected by a regional evaluation without determining causality. The burden improperly is shifted to dischargers within an area subject to regional evaluation to prove to the agency that their discharge is not the cause of any observed impairment, at potentially significant costs. All dischargers within the vicinity under evaluation will be presumed responsible for any observed toxicity, even if there is no evidence that the particular discharge caused or contributed to the problem.

Compounding the problem, no means are provided to determine the extent of pollution abatement to be required by the discharger, or the regulatory process that will guide pollution abatement. On the contrary, the proposed SQOs have a number of ambiguities and uncertainties on crucial questions, including the following:

- The proposed SQOs do not provide an effective means to assess responsibility of SQO exceedances. The conceptual model provided in the Staff Report provides only a hypothesis regarding the relationship of a discharge to the SQO exceedance and sediment quality at a sampling station, which by itself cannot discriminate among multiple sources. No guidance is provided to relate a pollutant-caused SQO exceedance to the extent of discharge reduction necessary to bring the water body into compliance.

- The proposed SQOs indicate that an exceedance would not be considered as a violation of the permit until it is demonstrated that the discharge is causing or contributing to the SQO exceedance (Appendix A, VII(C)). This safeguard may be of little consequence in practice because the exceedance of multiple stations within the water body may force an exceedance of water quality standards, which, according to the Staff Report, would put the water body on the State's 303(d) list and force the development of a TMDL for the water body even though it is not clear that there is a violation of the water quality standard based on the multiple lines of evidence used in the sediment quality evaluation.

- The proposed SQOs clearly state that "[t]he sediment chemistry guidelines shall not be translated into or applied as effluent limits." Appendix A, p. 21. The Staff Report fails to provide sufficient guidance for determining how to establish effluent limits. The proposed SQOs merely state that "[e]ffluent limits established to protect or restore sediment quality shall be developed only after" three conditions are met.[5] Regional Boards are then directed to Appendix A, Sections VII(F) and VII(G) for stressor identification and site-specific management guidelines, but these sections are unclear as to who has the responsibility to develop and implement the work plans and the definition and extent of "appropriate loading studies."

- The proposed SQOs do not address how a discharger would potentially be controlled using the findings of the SQO evaluation set forth in Appendix A. It is assumed that this control would occur through the NPDES permitting process, but no clear steps are identified to indicate exactly how a discharge permit may be evaluated and changed when an SQO is exceeded.

- The ultimate "goal" for the sediment quality is not clearly defined. Is the target to make all "impacted" systems "unimpacted"? Such a goal would be unrealistic and costly (in addition to being legally invalid as discussed below). The proposed

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5 Namely, the three conditions are that "(a) A clear relationship has been established linking the discharge to the degradation, (b) The pollutants causing or contributing to the degradation have been identified, and (c) Appropriate loading studies have been completed to estimate the reductions in pollutant loading that will restore sediment quality." Appendix A, p. 21.

SQOs should contain guidance on how to set realistic goals once a failure to achieve an SQO is determined. The proposed SQOs should specify how to determine what level of reduction in permitted discharges (if any) would be necessary to accomplish the program's goals, and how dischargers are expected to evaluate the effect of reductions in water-based concentrations on the sediment quality.

These issues will impact regulators and dischargers through the cost and management of detailed monitoring plans, stressor identification studies, and operational modifications loosely prescribed by the SQO process and driven through the NPDES permitting process. The current SQO document is relatively silent on these key issues and consequently, raises many questions for stakeholders that may be impacted if an SQO exceedance is determined.

In order to address these problems, the SQOs should include a framework that clearly lays out how to evaluate the steps necessary to determine causality and effect. The SQOs should not require stations within the discharge mixing zones to be considered when evaluating existing sediment conditions, and future sampling for the purpose of establishing exceedances of SQOs should be done outside mixing zones. Discharge permittees are required to identify a mixing zone, in which water quality standards do not apply, for water quality applications. Because it is not consistent to require that SQOs be met in a region in which water column concentrations can exceed water quality standards, the same approach should be applied in the proposed SQOs. QEA Technical Memorandum at 8-9.

In addition, the SQOs should contain guidance on determining the link between sediment quality and discharge effluents along with a framework for when violations of the SQOs force the water body into the TMDL process. Appropriate loading studies should be defined and explicitly indicate that the fate and transport processes that govern the relationship between a discharge and sediment quality (e.g., dilution, sediment transport, speciation) must be taken into account. The SQOs should identify what studies are to be performed and indicate how the results of the studies will relate sediment quality to effluent loadings.

E. <u>The SQOs Fail To Evaluate Whether the Available Data Make Sense and Are Consistent</u>

An important and missing step in the proposed SQOs' approach is evaluating whether the available data lead to consistent, scientifically sound conclusions. For example, there are instances when indicators of benthic health are contradictory and the balance between chemical toxicity and community disturbance is unclear. For example, the investigation of sites in San Francisco Bay by Hunt *et al.* (2001) reported conflicting chemical and biological lines of evidence. This detailed study indicates that characterization of a site requires thorough analyses and even then may yield gross inconsistencies among the lines of evidence, which suggests the potential for data quality issues or the dominant impact of factors other than the considered chemicals. The Staff Report fails to delineate at what point and under what guidelines the process will account for such inconclusive lines of evidence.

In addition, the SQOs apply a Logistic Regression Modeling ("LRM") approach where the data provide a poor fit for evaluating PCB-contaminated sediments. The SQOs rely on data from Field *et al.* (1999), or propose to adopt an approach similar to that by Field.[6] The Field study, however, concluded that "PCBs tended to fit poorly with the model." As a result, the applicability of the LRM approach to evaluate PCB-contaminated sediments is questionable. The proposed SQOs should provide further discussion and analyses supporting the use of this model for PCBs in the SQO evaluation. The State Board should explain to what extent its analysis differs from Field's, and how the proposed SQOs have overcome (if they did) the poor fit in the data that precludes its use in evaluating PCB-contaminated sediments.

These examples and others set forth in QEA's Technical Memorandum demonstrate that at some point in the evaluation process, there must be a step to evaluate whether the overall data are consistent and supportable prior to applying the prescribed methods. For example, a survey of all data used in a site assessment for applicability, relevance, quality assurance, and quality control is a critical component of the process and should be required in Appendix A. Where the data provide conflicting evidence, particularly along a gradient of chemistry, the results should be declared to be inconclusive. Guidance should be provided regarding the follow-up to such a designation. If a site is rated as inconclusive in two rounds of monitoring, it should be declared to be likely unimpacted.

F. Application of the SQOs Leads to Results that Are at Odds with the Underlying Data

The proposed SQOs' lead to the conclusion that sediments are impaired when such a conclusion is at odds with the underlying data. For example, when the multiple lines of evidence are integrated and a site is found to be "possibly impacted," that is supposed to indicate that sediment contamination at the site may be causing adverse impacts to aquatic life, but these impacts are small or uncertain because of disagreement among lines of evidence. Staff Report, at 87. This category is supposed to reflect a "degraded condition" (id., at 92-93), even though this category "only suggests the possibility of the station being impacted," it "represents the greatest uncertainty and disagreement amongst the LOE," and "[s]tations within this category may be either unimpacted or impacted." Id., at 93.

Based upon the State Board's proposed framework, a site can be characterized as "possibly impacted" and therefore "degraded" even though sediment contamination at the site is considered low from both a toxicity and exposure standpoint. Staff Report, Appendix A, Attachment B, LOE Category Combination 26 and 30. There are multiple examples where a site is characterized as "possibly impacted" at reference benthic and minimal chemistry exposure categories.

Similarly, a site is categorized as "likely impacted" when there is high toxicity and high disturbance, but minimal exposure. Id., LOE Category Combination 16. The designation is supposed to indicate that there is persuasive evidence for a contaminant-related impact to aquatic life at the site, even if there is some disagreement among lines of evidence, yet it applies even if no pollutants are detected in the sediment. Id., LOE Category Combination 16. It also is

6 See Staff Report at 77 ("The Logistic Regression Modeling (LRM) approach was based on the statistical analysis of paired chemistry and amphipod toxicity data from studies throughout the U.S. (Field et al., 1999, 2002).").

illogical to conclude, as the process does, that sediment is "likely impacted" by toxic pollutants when the benthos is at the reference condition. Id., LOE Category Combination 52.

III. The Proposed SQOs Do Not Conform With Applicable Legal Requirements

The proposed SQOs must meet various legal requirements of the Porter-Cologne Water Quality Control Act ("Porter-Cologne"), the California Environmental Quality Act ("CEQA"), the California Administrative Procedures Act, as well as due process requirements of the federal and state constitutions. As set forth below, the proposed SQOs do not satisfy legal requirements.

A. The Proposed SQOs Would Dramatically Expand Jurisdiction Under Porter Cologne Chapter 5.6 Over Contaminated Sediment Without Sufficient Explanation

The State Board has previously identified sediments that may adversely impact beneficial uses when it identified toxic hot spots in the 1990s. The proposed SQOs are also intended to identify sediments that may adversely affect beneficial uses. *Compare* Cal. Water Code § 13391.5(e) ("'Toxic hot spots' means locations in enclosed bays . . . where hazardous substances have accumulated in the water or sediment to levels which . . . may adversely affect the beneficial uses of the bay . . . .") *with* Cal. Water Code § 13391.5(d) ("Sediment quality objective' means that level of a constituent in sediment which is established with an adequate margin of safety, for the reasonable protection of beneficial uses of water . . . .") (emphasis added). The SQOs would dramatically expand the quantity of sediment that the State Board would consider to adversely affect beneficial uses, as compared to the quantity of sediment already identified as adversely affecting beneficial uses when it implemented the toxic hot spot program. For example, as of the late 1990s, the State Board designated just a few portions of the Newport Bay as a toxic hot spot. See SWRCB, Draft Amended Functional Equivalent Document, Consolidated Toxic Hot Spot Cleanup Plan, Aug, 29, 2003, at 37, 140-141 (only a portion of the Rhine Channel, Newport Island, and the Narrows were identified as hot spots). Under the SQOs, the State Board has identified that almost the entire Upper and Lower Newport Bay is identified as possibly, likely or clearly impacted. See SCCWRP, Sediment Quality in California Bays and Estuaries, Draft Final Report, Sept. 2007, at C-4. The comparison is the same in San Francisco Bay, where the hot spot program identified just 10 priority hot spots, but the SQOs would classify 90% of the Bay as failing the SQOs. Compare Regional Water Quality Control Board, San Francisco Bay Region, Final Regional Toxic Hot Spot Cleanup Plan, March 1999, at 30, 58–60, and 146–151 with Sediment Quality in California Bays and Estuaries, Draft Final Report, A. Barnett, et al., SCCWRP (September 2007) at iii, 13, Table 4 and Figure 5 (96.3% of San Francisco Bay failed SQOs).

If an agency interprets its statutory mandate differently from how it has previously interpreted its mandate, without adequately accounting for the difference, a court is more likely to find that an agency abused its discretion. This proposition is well established in administrative law. See Greater Boston Television Corp. v. FCC, 444 F.2d 841, 852 (D.C. Cir. 1971) ("Greater Boston") ("[A]n agency changing its course must supply a reasoned analysis indicating that prior policies and standards are being deliberately changed, not casually ignored, and if an agency glosses over or swerves from prior precedents without discussion it may cross the line from the tolerably terse to the intolerably mute.") (internal citations omitted). The California Supreme

Court has cited Greater Boston favorably. See California Hotel & Motel Ass'n v. Industrial Welfare Commission, 25 Cal. 3d 200, 210 and 219 (1979).

The proposed SQOs do not provide an explanation for why the SQOs apparently will dramatically expand the State Board's sediment program beyond the toxic hot spot program. Instead, the proposed SQOs erroneously contend that the SQOs will not likely expand the program at all. See, e.g., Staff Report, at 122 ("[B]ecause Regional Water Boards already assessed sediment quality under the BPTCP based on a two-step process that uses three lines of evidence, it is unlikely that new or additional hot spots would be identified under the Plan that were not already identified under the BPTCP."); see also Science Applications International Corporation, Economic Considerations of Proposed Sediment Quality Plan for Enclosed Bays in California, Sept. 18, 2007 ("SAIC Report") at 7-2 ("[T]he impairment status of most sites is not expected to change under the proposed Plan, ..."). Because the proposed SQOs did not acknowledge that the SQOs will result in an expansion of the designation of sediments as contaminated, and did not explain the designations will be expanded, the proposed SQOs are not supportable.

B. The Proposed Regulation Is Defective as a Matter of Law Because It Does Not Further the Purpose of the Bay Protection and Toxic Cleanup Program of Identifying Actual Toxic "Hot Spots"

The Bay Protection and Toxic Cleanup Program ("Program") is designed to focus on toxic "hot spots." To effectuate the purpose of the statute, the Proposed Regulation should establish a mechanism that can be utilized to distinguish properly between impacted and non-impacted areas and identify those that actually constitute specific and discrete toxic "hot spots" in need of remedial action. Application of the proposed SQOs instead suggests that vast portions of California's waterbodies exceed the proposed SQOs (see Section II.C, supra), eviscerating the ability to use the proposed SQOs as an effective, specific and discrete toxic "hot spot" identification and management tool.

The California Legislature's intent to focus on specific and discrete sediment "hot spots" is evident from the face of the statute, as well as the legislative history created during the adoption of the Program. In creating the Program, the California Legislature intended that a plan be prepared for remedial action at toxic "hot spots" (Cal. Water Code Section 13390), and required the development of cleanup plans that are distinct from Water Quality Control Plans. Chapter 5.6 requires the formulation of a water quality control plan for enclosed bays and estuaries (Section 13391) and toxic hot spot cleanup plans (Section 13394). The Water Code further states that the State Board and Regional Boards shall "(1) identify and characterize toxic hot spots . . ., (2) plan for the cleanup or other appropriate remedial or mitigating actions at the sites, and (3) amend water quality control plans and policies to incorporate strategies to prevent the creation of new toxic hot spots and the further pollution of existing hot spots." Cal. Water Code § 13392.

The section of the Water Code requiring the development of a workplan for adoption of SQOs likewise underscores the Legislature's emphasis on addressing discrete and specific toxic "hot spots." See Water Code § 13392.6 (requiring the State Board to "adopt and submit to the Legislature a workplan for the adoption of sediment quality objectives for toxic pollutants that have been identified in known or suspected toxic hot spots and for toxic pollutants that have been identified by the state board or a regional board as a pollutant of concern. The workplan shall include priorities and a schedule for development and adoption of sediment quality objectives, identification of additional resource needs, and identification of staff or funding needs.") (emphasis added).

Similarly, the legislative history supports the conclusion that the Program was designed to identify and eventually clean up discrete and specific toxic "hot spots." See Kerollis v. Department of Motor Vehicles, 75 Cal. App. 4th 1299, 1305 (1999) ("Both the legislative history of the statute and the wider historical circumstances of its enactment may be considered in ascertaining the legislative intent."). For example, the intent of Assembly Bill 3947 was described as follows by the Assembly Committee on Environmental, Safety and Toxic Materials:

> This bill is intended to concentrate the resources of the state water board and the appropriate regional boards on the particular water quality problem of an accumulation of hazardous substances in the sediments of California's bays and estuaries. These so-called "toxic hot spots" are comprised of toxic chemicals and heavy metals which have reached levels of accumulation which pose a threat to aquatic life and/or human health.
>
> The author contends that regional boards do not presently have standardized, comprehensive and accurate data upon which to base a concerted program to clean up individual toxic hot spots. This bill, by establishing a program of identification, characterization and site mitigation . . . is intended to achieve the eventual cleanup of these toxic hot spots.

Assembly Bill 3947 Analysis, Assembly Committee on Environmental, Safety and Toxic Materials (April 5, 1988) at 2 (emphasis added).[7] See also Senate Bill 1084 Bill Analysis, Assembly Environmental Safety & Toxics Materials Committee (July 13, 1993) at 2 ("According to the state board staff, there are several reasons [it has been unable to meet several of the deadlines established in the original legislation to implement the program]…. [T]he toxic hot spots program is breaking new ground in the environmental area. A program to define what an underwater hot spot is, how they may be identified and what should be done about them has not been tried before."). Thus, it is clear that the legislative intent of the statute was (1) to define what exactly constitutes specific and discrete toxic "hot spots" that actually "pose a threat to

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7 Assembly Bill 3947 of 1988 was the vetoed predecessor to Senate Bill 475, Chapter 269, Statutes of 1989 which added Chapter 5.6 (adopting the Program) and Water Code Section 13391.5 (defining SQOs). Assembly Bill 3947 was vetoed by the governor because funding for the bill was dependent upon passage of the Hazardous Substance Cleanup Bond Act of 1988. The governor explained that "since the Legislature did not place the bond on the ballot, signing of this bill would serve no purpose." Senate Bill 475, Enrolled Bill Report, Environmental Affairs Agency (July 26, 1989) at 1. Assembly Bill 3947 proposed to add Chapter 5.6, but proposed the use of the term "sediment quality threshold" (rather than "sediment quality objective").

aquatic life and/or human health"; (2) to identify such specific and discrete toxic "hot spots" by distinguishing them from other waterbodies that are not as impaired; and (3) to clean up those identified specific and discrete "hot spots" by focusing resources on those waterbodies.

The SQOs should positively identify specific and discrete toxic "hot spots" – i.e., sites where scientifically defensible evidence demonstrates the presence of significant adverse impacts to aquatic life or human health, and sound evidence establishes that specific pollutants in the sediment are the cause of the observed adverse effects on benthic organisms. As currently drafted, the SQOs fail to accomplish these objectives. Rather than focusing on sites that are known to have the highest magnitude of identifiable, concrete impacts and making sediment management decisions targeted at those sites, the proposed SQOs would establish a scheme where sediment impairment is the norm.[8]

The proposed SQOs create the appearance of being able to make finely-tuned determinations and distinctions that will trigger management actions (e.g., by distinguishing between "possibly impacted" and "likely unimpacted" locations), when such a detailed analysis and methodology is not scientifically supportable. The SQOs should instead adopt an approach that identifies specific and discrete toxic "hot spots" and consider the pathways by which risks exist, receptors for those risks (sediment-dwelling organisms, wildlife or humans), the spatial extent of the contamination, the regulatory goals of the Program, and costs of different sediment management decisions. Utilizing such an approach will better allow the State Board to provide a meaningful interpretation of ecological significance and to make sound management decisions designed to provide the appropriate degree of ecological and human health protection consistent with the regulatory context.

The SQOs as proposed do not further the fundamental goal of Chapter 5.6.[9] The proposed SQOs should draw from the state's experience with the TMDL program, where impairment has become the rule in the water column, and implementation plans are required for

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8 See Section II.C, supra.

9 See, e.g., Bearden v. U.S. Borax, Inc., 138 Cal. App. 4th 429, 487 (2006) (Industrial Welfare Commission exceeded its authority as the regulation was not (1) within the scope of authority conferred and (2) reasonably necessary to effectuate the purpose of the statute); Agric. Labor Relations Bd., 16 Cal. 3d 392, 411 (1976) (same); Home Depot, U.S.A., Inc., v. Contractors' State License Bd., 41 Cal App. 4th 1592, 1605 (1996) (state licensing regulation was struck down as it was not necessary to reasonably effectuate the legislative purpose, which was to protect the public from unscrupulous or incompetent contractors); Friends of Mammoth v. Bd. of Supervisors, 8 Cal. 3d 247, 259 (1972) (same); Ocean Park Assoc. v. Santa Monica Rent Control Bd., 114 Cal App. 4th 1050 (2004) (Santa Monica Rent Control Board regulation struck down as it did not rationally advance the purposes of the governing ordinance); San Bernardino Valley Audubon Soc'y v. City of Moreno Valley, 44 Cal. App. 4th 593 (1996) (same); San Francisco Fire Fighters Local 798 v. City and County of San Francisco, 38 Cal. 4th 653, 668 (2006) (When a regulation "is challenged as inconsistent with the terms or intent of the authorizing statute, the standard of review is different, because the courts are the ultimate arbiters of the construction of the statute.").

virtually every water body near human activity. The SQOs need not, and should not, be tantamount to a TMDL program for all sediments statewide. As currently proposed, there is a risk that the SQOs needlessly will result in a vastly expanded program of sediment cleanups that are unjustified on the science, fail to effectively reduce risk, and cause more harm than good. Such a program is unwarranted by any reasonable assessment of potential impacts to the benthic community, human health or wildlife. The State Board instead should focus on specific and discrete toxic "hot spots" where scientifically defensible evidence (1) demonstrates the presence of significant adverse aquatic or human health impacts, and (2) identifies the specific pollutants in the sediment that are the cause of the observed adverse effects. Without this necessary linkage, the proposed SQO is flawed, and does not comport with the statutory mandate to reasonably protect the beneficial uses of California bays and estuaries, and does not advance the legislative purpose of the Program.

C. The Proposed SQOs Appear To Be Inconsistent With the Statutory Definition of a "Sediment Quality Objective"

The State Board has exceeded its statutory mandate by proposing a complex mechanism that does not appear to meet the definition of a "sediment quality objective" under the Porter-Cologne Act. State agencies have only those powers directly conferred on them by the Legislature. Bearden v. U.S. Borax, Inc., 138 Cal. App. 4th 429, 435 (2006) ("The authority of an administrative agency to adopt regulations is limited by the enabling legislation."). The Legislature has emphasized that, "[e]ach regulation adopted, to be effective, shall be within the scope of the authority conferred" and "no regulation adopted is valid or effective unless consistent and not in conflict with the statute." Cal. Gov't Code §§ 11342.1 and 11342.2. "[I]t is well established that the rulemaking power of an administrative agency does not permit the agency to exceed the scope of authority conferred on the agency by the Legislature." Agnew v. California State Board of Equalization, 21 Cal. 4th 310, 321 (1999).

The SQOs must correspond to "that level of a constituent in sediment which is established with an adequate margin of safety, for the reasonable protection of the beneficial uses of water or the prevention of nuisances." Cal. Water Code § 13391.5 (emphasis added). The State Board's proposed multiple lines of evidence framework does not constitute a "level of a constituent" within the meaning of the Legislature's mandate. Instead, the State Board has developed a triad approach for evaluating sediment quality, in which each of the individual lines of evidence has significant limitations and the integration across the lines of evidence lacks transparency and does not result in clear, coherent delineations between sediments that are actually impacted and in need of remediation and those that are not.

Whatever the merits of the triad approach as a general scientific concept over a single line of evidence approach, the novel, complex framework proposed appears inconsistent with the meaning of Section 13391.5. The State Board's complex approach for managing sediment quality, involving (1) the selection of indicators and thresholds from the individual lines of evidence, (2) the joining of multiple lines of evidence to make a station assessment, and (3) the joining of multiple stations to make a waterbody assessment by combining the "severity of effect and potential for chemically mediated effects" (Staff Report, at 85-87), could not reasonably have been contemplated by the Legislature when defining "sediment quality objectives" as set forth in Section 13391.5.

The Legislature envisioned that the State Board would identify a specific "level of a constituent" in sediment that would be used to identify environmentally impaired sediments in need of cleanup. See, e.g., Enrolled Bill Report, Environmental Affairs Agency, SB 475 (July 26, 1989) at 2 ("SB 475 would also require the State Board, by July 1, 1991 to submit to the Legislature a workplan for the development of 'sediment quality thresholds', which would be numerical indicators of the maximum allowable concentrations of pollutants in sediments. The database and the sediment quality thresholds would become the foundation for both the cleanup and the regulatory program.") (emphasis added); Enrolled Bill Report, Environmental Affairs Agency, AB 3947 (September 16, 1988) at 2 (to the same effect).[10] In light of this legislative history and the clear language of the statute, the public had no notice that the State Board would expand the explicit, narrowly tailored definition of a "sediment quality objective" to a complex multiple lines of evidence approach that lacks clarity and transparency, and results in classifying vast bodies of waters as impaired.

Thus, the State Board's Proposed Regulation as applied to California waterbodies is both (a) void under Gov't Code § 11342.1 as beyond the State Board's authority under § 13391.5; and (b) void under Gov't Code § 11342.2 as inconsistent with the Legislature's direction in Water Code § 13391.5 that the State Board adopt "sediment quality objectives" in the form of specific "levels of a constituent in sediment."

D. The Protectiveness of the SQOs is Inconsistent With the "Reasonableness" Policies of Division 7

Water Code Section 13393(b) requires the State Board to provide "adequate" protection for the most sensitive aquatic organisms. "Adequate" protection must be determined in a manner consistent with Water Code Sections 13000 and 13001 of Chapter 1 of Division 7.

Water Code Section 13000 requires that activities and factors that may affect the quality of water be regulated to the highest water quality which is reasonable by considering all demands being made and to be made on the water and the total values involved, beneficial and detrimental, economic and social, tangible and intangible. The enactment of Section 13000 finds its roots in a study by the State Board, commissioned by the Legislature. See Study Panel, California State Water Resources Control Board, Recommended Changes in Water Quality Control: Final Report of the Study Panel to the California State Water Resources Control Board (March 1969) (recommended changes to the legislation contained in the report were adopted) (hereinafter, the "Study Panel Report").

The Study Panel Report stated: "The recommended language (section 13000, paragraph 2) recognizes that efforts made toward accomplishing the ideal of clean water must accelerate but that economic progress and development is essential, not, however, at the sacrifice of the environment." Study Panel Report at 7. Porter-Cologne is premised upon striking a proper balance among competing objectives, as stated in the Study Panel Report:

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10 Senate Bill 475, Chapter 269, Statutes of 1989 added Chapter 5.6. The provisions to add Chapter 5.6 (Water Code Sections 13390-13396) were first added to Senate Bill 475 in the Assembly amendments of July 10, 1989.

> The regional boards must balance environmental characteristics, past, present and future beneficial uses, and economic considerations (both the cost of providing treatment facilities and the economic value of development) in establishing plans to achieve the highest water quality which is reasonable.

Id. at 13.

Water Code Section 13001 states that the State Board must conform to and implement the policies of Chapter One when exercising any power in Division 7. Since SQOs are required under Division 7, the Section 13001 policies apply.

The State Board therefore must address the balancing test under Water Code Section 13000 and explain how it is to be met in connection with the development and adoption of the proposed SQOs. To avoid running afoul of the principles of Porter-Cologne as reflected in Section 13000 and the Study Panel Report, this balancing test should focus on, among other relevant considerations, sediment quality, benthic community protection, socio-economics, and the feasibility of such protection. The costs associated with the SQOs are among the chief factors that the State Board must evaluate. To appropriately analyze this factor, the State Board must weigh all anticipated costs of its proposal against a realistic assessment of expected risk reduction benefits. The State Board must be able to demonstrate that the costs of the program are justified by a significant and beneficial reduction in harm from contaminated sediments. As described in Section III.H, infra, the State Board has not complied adequately with these fundamental obligations.

E. The State Board Must Comply With Water Code Sections 13240 Through 13247

The State Board is required to comply with the statutory requirements of Water Code Sections 13240-13247 in adopting SQOs.[11] See Staff Report, at 53. Water Code Section 13241 recognizes that in exercising judgment to ensure the reasonable protection of beneficial uses, "it may be possible for the quality of water to be changed to some degree without unreasonably affecting beneficial uses." Section 13241 describes factors to be considered in establishing water quality objectives:

> (a) Past, present, and probable future beneficial uses of water.
>
> (b) Environmental characteristics of the hydrographic unit under consideration, including the quality of water available thereto.
>
> (c) Water quality conditions that could reasonably be achieved through the coordinated control of all factors which affect water quality in the area.
>
> (d) Economic considerations.

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11 These provisions, which relate to water quality control plans, are cross-referenced in the SQOs statute. See Cal. Water Code § 13393(b).

(e) The need for developing housing within the region.

(f) The need to develop and use recycled water.

Water Code Section 13242 requires the State Board to specify a program of implementation with respect to water quality objectives. At a minimum, the implementation program shall include (1) a description of the nature of actions that are necessary to achieve the objectives, including recommendations for appropriate action by any entity; (2) a schedule for the actions to be taken; and (3) a description of surveillance to be undertaken to determine compliance with objectives. Cal. Water Code § 13242.

To satisfy Section 13393, the State Board must interpret the statutory factors under Section 13241 with respect to sediment, and the water associated with it, and specify implementation measures for SQOs pursuant to Section 13242. The "program of implementation" is essential to inform the regulated community as to whether the SQOs are reasonably achievable, as required under Section 13241.

Notably, the proposed SQOs indicate that "additional information and implementation guidance should be provided to provide greater understanding and consistency" with respect to the SQOs (as opposed to water quality objectives). Staff Report, at 53. In other words, the proposed SQOs suggest that there is a heightened duty under Water Code Sections 13241 and 13242 when adopting SQOs. The proposed SQOs, however, do not comply with these provisions.

Although the proposed SQOs state that "Section 6 describes the . . . factors contained in Section 13241" (Staff Report at 7), that section of the report does not satisfy the relevant statutory requirements. For example, it appears that the State Board likely will not be able to establish that the SQOs are reasonably achievable, as required by Water Code Section 13241. As discussed above (Section II.C), the State Board's proposed framework appears to lead to the conclusion that the vast majority of sediments are impacted. Given this pre-ordained conclusion, it appears that most major waterbodies will be determined to have underlying sediments that fail to achieve the SQOs. This is inconsistent with a legislative framework that is based on addressing specific and discrete toxic sediment "hot spots," not all sediments.

Similarly, the requirements of Section 13242 are not satisfied. There is no well-defined implementation plan, and the proposed SQOs do not clarify when and how a nonattainment of the SQO will be determined, and how remediation of the site will be accomplished. Because the regulated community can not determine when and under what circumstances sediments pass or fail the SQOs, the proposed SQOs do not provide reasonable notice of the SQOs' scope and sphere of application. The proposed SQOs lack of sufficient information regarding the nature of the SQOs, their breadth, required implementation measures and associated costs causes the SQOs to violate Sections 13241 and 13242.

F. <u>The SQOs Violate California Water Code Section 13267</u>

Water Code Section 13267 requires that the type of sampling and monitoring requirements set forth in the current proposal, including the costs of the proposed program, bear a reasonable relationship to the benefits to be obtained. The State Board's program requires vast sampling and analysis; yet, the State Board has not demonstrated that the costs and the need for this program bear a reasonable relationship to any concrete environmental benefits. The current proposal therefore violates Water Code Section 13267.

G. To the Extent That the SQOs Are Impossible to Meet, They Are Unlawful

As discussed above, the proposed SQOs create a framework where sediment impairment appears to be the norm and the vast majority of California's bays and estuaries would be classified as degraded. Although the proposed framework identifies six categories of station-level impacts, the data and tools available for interpreting the multiple lines of evidence do not appear to support the varying levels of distinction the SQOs proposes to make. Despite the apparent flexibility embodied in the proposed framework, the default endpoint for the analysis is often an illogical determination that sediments are contaminated (albeit to varying degrees). For example, even using the State Board's own analyses, 83% of California's marine embayments fail the SQO (including 96.3% of San Francisco Bay). See Sediment Quality in California Bays and Estuaries, Draft Final Report, A. Barnett, *et al.*, SCCWRP (September 2007) at ii-iii, 13, Table 4 and Figure 5.

The proposed SQOs do not include guidance on how to set realistic, cost-effective and legally defensible goals once it is determined that an SQO is not attained. If the target is to make all "impacted" systems "unimpacted," this is both unrealistic and legally invalid. "The law never requires impossibilities." Cal. Civ. Code § 3531. Because the SQOs are so conservative and the conditions required to meet the SQOs are so extreme, they may well be impossible to attain.

Impossible components of the SQOs violate not only the Civil Code, but also state and federal due process protections. It long has been settled that a governmental directive to perform an impossible task violates due process. See, e.g., Consolidated Gas Co. of New York v. Prendergast, 6 F.2d 243, 277 (S.D.N.Y. 1925) (affirming referee report finding state utility law invalid because, *inter alia*, requiring transmission of natural gas at standard of 650 B.T.U. per cubic foot "is commercially and physically impossible for the company to comply with"; "it can be safely found that the enforcement of the 650 B.T.U. standard would be in effect a confiscation of the coal gas plants of the company, and render it impossible to operate them under such standard"), *modified and affirmed*, 272 U.S. 576 (1926). Similarly, the SQOs are invalid to the extent that compliance with their requirements is impossible.

Even strict liability statutes for regulatory offenses -- which ordinarily require no showing of fault or mens rea – may not be applied to a defendant who can show that compliance was objectively impossible. United States v. Park, 421 U.S. 658, 673 (1975) (sustaining conviction for strict liability offence because the statute did "not require that which is objectively impossible"). The Ninth Circuit has assumed the existence of an "objective impossibility" defense. United States v. Y. Hata & Co., Ltd., 535 F.2d 508, 510 (9th Cir. 1976); United States v. Starr, 535 F.2d 512, 515-16 (9th Cir. 1976); see also Laurie L. Levenson, Good Faith Defenses: Reshaping Strict Liability Crimes, 78 Cornell L. Rev. 401, 460 n.299 (1993) ("when it is objectively impossible for a defendant to avoid violating the law, the statute becomes arbitrary and vulnerable to a due process challenge."). For the reasons discussed supra, the objective impossibility defense is satisfied, and the SQOs violate due process.

H. The State Board Has Failed to Adequately Analyze the Economic Impacts of the Proposed SQOs

1. The State Board is required to conduct a robust analysis of the economic impacts of the proposed rule prior to its adoption

The Porter-Cologne Act requires the State Board to consider and balance the economic and environmental benefits and harms associated with the SQOs. The California Legislature was keenly aware that the State Board's actions taken pursuant to Porter-Cologne Act would have significant economic impacts. Therefore the Legislature built in a reasonableness standard to all actions taken by the State Board and the nine regional boards under Porter-Cologne. The standard sets forth the State's policy on water quality, namely that waters of the state be regulated to attain the highest quality which is reasonable, considering all demands being made and to be made on those waters and the total values involved . . . economic and social . . . ." Cal. Water Code § 13000.

The Staff Report acknowledges that economic considerations must be taken into account when adopting the SQOs. Staff Report, at 117; SAIC Report, at 1-1; Cal. Water Code § 13241(d)-(e) ("Factors to be considered . . . in establishing water quality objectives shall include . . . economic considerations [and] the need for developing housing within the region."); City of Burbank v. State Water Resources Control Bd., 35 Cal. 4th 613, 618 (2005) (California law allows consideration of economics when imposing pollutant restrictions more stringent than required by CWA). Water quality targets and allocations must take into consideration that water quality which reasonably is achievable in light of social and economic factors. Cal. Water Code § 13241 (economics must be considered in setting water quality objectives.).[12] The proposed SQOs must contain an independent analysis of their economic impacts, and they cannot simply respond to information received by the regulated community. Memorandum from William R. Attwater, Chief Counsel, State Water Resources Control Board, to Regional Water Board Executive Officers at 4 (January 4, 1994), at 4 (acknowledging that a regional board "cannot fulfill this duty [to consider economic impacts when adopting a TMDL] simply by responding to economic information supplied by the regulated community").

CEQA also requires a consideration of costs when an agency establishes a performance standard. Cal. Pub. Res. Code § 21159. The SQOs, like a water quality objective, are a quintessential performance standard. Western States Petroleum Ass'n v. South Coast Air Quality Management Dist., 136 Cal. App. 4th 1012, 1024 (2006). Indeed, the State Board has acknowledged that "numeric targets and load allocations would probably fall into the category of performance standards." Memorandum from William R. Attwater, Chief Counsel, Office of Chief Counsel of SWRCB, to Executive Officer of Santa Ana Regional Water Quality Control Board, "Do TMDLs Have to Include Implementation Plans?" (March 1, 1999) at 7.

Finally, the California Administrative Procedures Act requires that the draft SQOs contain an analysis of their economic impact. Cal. Gov't Code § 11346.3.

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12 The State Board is required to follow the procedures for adopting or amending water quality control plans. Cal. Water Code § 13393(b).

2. The SQO Does Not Reflect Economics or a Reasonable Balance Among all Factors

The State Board has not considered economics adequately in developing the proposed SQOs. Although the Staff Report contains a section entitled "Economic Considerations" (Staff Report, Section 7.4) and attaches the SAIC Report which purportedly analyzed the economic impacts of the SQOs, neither document contains a meaningful assessment of the costs of the SQO, and does not rise to the level of a consideration of economics required by law. The disclosure and analysis of costs is far too thin to inform adequately the State Board's decision making.

The minimum level of assessment the State Board must conduct for a meaningful consideration of economics and to satisfy Porter Cologne includes: (1) identifying baseline risk levels; (2) listing the benefits to be achieved; (3) identifying alternative strategies to achieve the benefits; (4) estimating the costs of each alternative; (5) assessing uncertainty; (6) comparing the cost effectiveness of each alternative; and (7) identifying the most cost-effective alternative. Absent such an assessment, the State Board is without the information to balance economic considerations versus other factors, and the public is left without any assurance that the State Board is proposing a properly balanced regulation.

The proposed SQO does not strike a reasonable balance between competing economic and environmental factors. There is no analysis of the impacts, positive or negative, on human health, and the environmental benefits of the SQO are minimal and otherwise speculative. In contrast, the economic costs of implementing the SQOs through treating stormwater and/or dredging contaminated sediments could range from several to many billions of dollars.[13] See SAIC Report, at 7-1. Attempting the dredging and stormwater treatment that may be required to implement the SQO will have significant adverse environmental impacts, including destruction of healthy benthic communities, emissions of greenhouse gases and criteria pollutants, and various land-use impacts.

3. The Draft Staff Report Does Not Contain a Sufficient Economic Analysis

The SAIC Report was commissioned to assess the economic impacts of the proposed SQOs, consistent with the requirements set forth in the California Water Code. Although it is standard environmental economic practice to identify the economic benefits assumed to accrue from improvements in environmental quality, the SAIC report does not conduct a benefits analysis. Nor does the SAIC report provide any meaningful analysis of the costs that are likely to be imposed by the proposed regulation. Further, the monitoring and stressor identification costs that are discussed in the SAIC report have internal errors and inconsistencies. The expected more significant costs associated with the proposed regulation – actions that will need to be taken to comply with the proposed regulation – are not discussed at all. Without a benefits

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13 We appreciate the State Board's acknowledgement that certain implementation measures would be necessarily, and *de jure*, infeasible and unreasonable, such as "dredging and disposal of sediment of an entire water body as a result of the sediment in the waterbody failing to meet a SQO. Dredging of this magnitude would be environmentally and economically infeasible." Staff Report, at 103.

analysis or a robust cost analysis, the SAIC report does not constitute an adequate consideration of the economic issues implicated by the proposed regulation.

The Staff Report identifies the "incremental impacts of the Plan" as, "the cost of activities above and beyond those that would be necessary in the absence of the Plan under baseline conditions, as well as the cost savings associated with actions that will no longer be needed to occur." Staff Report, at 117. The State Board's analysis of the economic impacts of the SQOs is largely limited to an examination of the expected costs of monitoring and conducting stressor identification, which combined are estimated to range from $675,900 to $1,312,400. SAIC Report, at Ex. 6-3 and Ex. 6-5. These numbers conflict with estimated costs presented in the Executive Summary of the SAIC Report, which reports that costs may range from $535,000 to $810,000. SAIC Report, at ES-3.

Aside from the errors related to the costs of monitoring and conducting stressor identification, the Staff Report and SAIC Report contain no analysis of the costs of implementation of the SQOs. "Because strategies to meet current narrative objectives at many impaired sites are still in the planning stages and the overall effects of implementation strategies are unknown, estimates of the incremental costs would be highly speculative." Staff Report, at 122 (emphasis added). Rather than estimating the cost of implementing the SQOs, the State Board simply chose not to attempt to do so. Without any support, the SAIC and the Staff Report also assumed that "it is unlikely that new or additional hot spots would be identified under the Plan that were not already identified under the [existing] hot spot program." Staff Report, at 122. The implicit assumption the State Board is making is that no additional implementation measures will be required beyond what otherwise will be required by existing programs, such as the hot spot program or TMDLs. As the proposed SQOs may in fact be a dramatic expansion of the toxic hot spot program (see Section II.C), there is no support for this assertion.

Even if the proposed SQOs were correct that the implementation costs cannot be calculated due to uncertainty over implementation measures, the State Board faces no such uncertainty in analyzing the economic benefits expected to be gained from achieving the SQOs. Without an estimate of the expected benefit, the State Board cannot begin to weigh the costs versus the expected benefits. Without cost figures or benefit figures, there is simply no information to conduct a meaningful economic analysis. The absence of such analysis renders the SQO documentation flawed.

I. Adoption of the Proposed SQOs Would Be Arbitrary and Capricious

The proposed SQOs must be based on sound scientific evidence. See Section II.A.[14] The State Board is required to adequately consider all relevant factors and demonstrate a rational connection between those factors, the choice made, and the purposes of the Porter-Cologne

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14 Cal. Water Code § 13393(b) ("The sediment quality objectives shall be based on scientific information, including, but not limited to, chemical monitoring, bioassays, or established modeling procedures, and shall provide adequate protection for the most sensitive aquatic organisms. The state board shall base the sediment quality objectives on a health risk assessment if there is a potential for exposure of humans to pollutants through the food chain to edible fish, shellfish, or wildlife.").

Act.[15] Under California law, the State Board's action will be considered "arbitrary, capricious and unreasonable" if it is without support in the evidence,[16] or is contrary to the uncontradicted evidence presented.[17] The term substantial evidence means that the evidence must be "reasonable in nature, credible, and of solid value."[18] Evidence which is "based on surmise, speculation, conjecture, and guess" does "not constitute substantial evidence."[19]

The proposed SQOs must satisfy the above arbitrary and capricious test of California law, and also cannot be entirely lacking in evidentiary support. Various aspects of the proposed SQOs, alone or in combination, do not comply with these fundamental standards for the reasons discussed in detail in the sections above and incorporated herein by reference. In sum, the proposed SQOs are arbitrary and capricious and are without the requisite evidentiary support to the extent they are not based on sound science, fail to comply with all legal requirements, and fail to achieve a reasonable balance among environmental and economic considerations. The problems with the SQOs are systemic, rendering any adoption of the SQOs as currently proposed without evidentiary support.

J. Violation of an SQO Does Not Equate To a Violation of a Federal Water Quality Standard

The SQOs are not a federal water quality standard under the Clean Water Act. Therefore, if application of the sediment triad to a particular station indicates that the station is "possibly impacted, likely impacted or clearly impacted," this conclusion does not bear on whether the overlying water body must be put on the federal Clean Water Act section 303(d) list of impaired waters.

Before a "water" may be listed on a state's 303(d) list, the state must find that "effluent limitations" adopted pursuant to Section 301 of the Clean Water Act "are not stringent enough to implement any water quality standard applicable to such waters." 33 U.S.C. § 1313(d)(1)(A) (emphasis added). First, a violation of the SQOs itself does not answer the question of whether

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15 See, e.g., California Hotel & Motel Ass'n v. Industrial Welfare Comm'n, 25 Cal. 3d 200, 212 (1979); Baltimore Gas & Elec. Co. v. Natural Res. Def. Council, 462 U.S. 87, 105 (1983) (holding that agency must demonstrate "a rational connection between the facts found and the choice made").

16 Rogers v. Retirement Bd. of San Francisco City Employees' Ret. Sys., 109 Cal. App. 2d 751, 757 (1952) ("Of course, if the local board makes findings totally unsupported by the evidence, it has acted in excess of and in abuse of its discretion, and its decision will be set aside.").

17 See, e.g., Naughton v. Retirement Bd. of San Francisco, 43 Cal. App. 2d 254, 260 (1941) (where the uncontradicted evidence showed that a police officer's preexisting heart disease was aggravated by the performance of his duties, retirement board acted arbitrarily and clearly abused discretion in denying a pension based on such disability; board's decision "must be based on something more than mere conjecture").

18 Martino v. City of Orinda, 80 Cal. App. 4th 329, 336 (2000).

19 Bracken v. W.C.A.B., 214 Cal. App. 3d 246, 257 (1989).

an effluent limitation is not stringent enough to implement a water quality standard. Further analysis would need to be conducted prior to the State Board reaching such a conclusion. Second, the SQOs are not a federal water quality standard. The term "water quality standard" is not defined in the Clean Water Act, but is generally understood to mean the beneficial uses of a water along with the criteria necessary to protect those uses. The proposed SQOs set forth a framework for determining whether criteria are met in the sediment, but this is not required by the Clean Water Act.

Setting SQOs, and eventually requiring implementation measures to achieve the SQOs, are not mandated by the Clean Water Act. As such, if municipal entities are required to take actions to meet the SQOs, such actions will be an unfunded mandate and the state must reimburse those municipalities for those costs. Cal. Const., article XIII B § 6 ("Whenever the Legislature or any state agency mandates a new program or higher level of service on any local government, the State shall provide a subvention of funds to reimburse that local government for the costs of the program or increased level of service . . . ."); County of Los Angeles v. Commission on State Mandates, 150 Cal. App. 4th 898, 917 (2007). To the extent that the state ultimately requires that a local government take actions to achieve an SQO, the state must reimburse the local government for those costs.

K. The State Board's Proposed Regulation Does Not Comply With CEQA

The State Board acknowledges that the SQOs cannot be adopted without fully complying with CEQA. Staff Report, at 3-4. The Staff Report fails to meet CEQA's requirements as described below.

1. The SQOs Are Not Excused From a CEQA Analysis Because of the State Board's Certified Regulatory Program or Alleged Inability to Conduct a Project-Level Analysis

Because the process by which the State Board proposes to adopt the SQOs is a "certified regulatory program," certified by the California Secretary of Resources, the State Board must produce a document that is "functionally equivalent" to an Environmental Impact Report ("EIR") – but not an EIR *per se*. The State Board describes the Staff Report as a "programmatic substitute environmental document" prepared "in lieu of [an] EIR." Staff Report, at 4. Lead agencies following CEQA under a "certified regulatory program" are exempted only from Chapters 3 and 4 (EIR contents/process), and Section 21167 (time period for CEQA challenges, replaced by Section 21080.5(g) for certified regulatory programs) of CEQA; such lead agencies must comply with all other CEQA provisions. The State Board cannot limit its CEQA review because it proposes to adopt the SQO under a certified regulatory program. Envtl Prot. Info. Ctr. v. Johnson, 170 Cal. App. 3d 604, 618 (1985) ("Nothing in section 21080.5 supplies a basis for concluding that the Legislature intended the section to stand as a blanket exemption from CEQA's thorough statutory scheme and its salutary substantive goals.").

As a certified regulatory program, the State Board is required to respond in writing to all significant environmental points raised in public comments. 23 Cal. Code Regs. § 3779; Cal. Pub. Res. Code § 21080.5(d)(2)(D). Failure to provide "reasoned responses" to public comments on a certified regulatory program's environmental analysis is a violation of CEQA.

Gallegos v. State Bd. of Forestry, 76 Cal. App. 3d 945, 954 (1978). The State Board also must summarize the main areas of disagreement between experts and explain its reasons for relying on one expert over another. 14 Cal. Code Regs. § 15151. Here, the State Board must provide reasoned, written responses to all of the points raised in these and all other comments. The technical and legal defects of the SQO all implicate CEQA in that they result in an inaccurate project description and baseline environmental assumptions that compromise the analysis of impacts and the evaluation of alternatives.

The program-level CEQA analysis "is not a device for deferring the identification of significant environmental impacts that the adoption of a specific plan can be expected to cause." Vineyard Area Citizens for Responsible Growth, Inc. v. City of Rancho Cordova, 40 Cal. 4th 412, 429 (2007) (citation omitted). Had the State Board conducted an in-depth analysis of just portions of the likely implementation measures, it would have found the SQO would cause significant environmental impacts that must be mitigated.

2. The Proposed SQOs Do Not Adequately Analyze the Potential Environmental Effects of Implementation Measures

The Staff Report's analysis of the potential environmental impacts of the SQOs is premised on the erroneous assertion that, because it is a program level EIR it does not need to consider any of the reasonably foreseeable environmental impacts of implementation of the SQO. Unlike, for example, a general plan amendment which allows but does not mandate any future activities, the SQOs will set firm regulatory guidelines that must be complied with. Cf. Rio Vista Farm Bureau Ctr. v. County of Solano, 5 Cal. App. 4th 351, 371 (1992). As such, the reasonably foreseeable impacts associated with implementation of the SQOs must be addressed in the proposed SQOs, regardless of the fact that it is identified as a program-level environmental document.

3. The Project Description Is Inadequate

Without a detailed, accurate project description, the CEQA process cannot yield accurate, clear results and public review is frustrated. County of Inyo v. City of Los Angeles, 71 Cal. App. 3d 185, 192 (1977). The "project" that must be described includes everything needed for implementation of the overall action. 14 Cal. Code Regs. § 15003(h). The proposed SQOs must "[d]escribe the whole action involved, including but not limited to later phases of the project, and any secondary, support, or off-site features necessary for its implementation." CEQA Guidelines, Appendix G.

The SQO documentation falls short of providing an adequate project description by proposing the SQOs and then not describing in detail the measures "necessary for its implementation." The Staff Report contains no discussion of implementation measures. Indeed, at the November 19, 2007 hearing on this matter State Board Vice-Chair Wolfe noted that the Staff Report did not adequately inform stakeholders as to how the SQOs will be implemented and requested staff to clarify the likely implementation measures and distribute that clarification to the public prior to the November 30, 2007 comment deadline. As of the date that these comments are due, that clarification has not been distributed. The lack of any direction in the proposed SQOs as to how the SQOs will be implemented leaves a significant hole in the project description.

4. The Description of the Environmental Baseline Is Inadequate

The State Board is required to analyze potentially significant effects the project may have on the environment. CEQA Guidelines § 15252(b). The State Board cannot make a meaningful assessment of the potential environmental effects (i.e., any benefits and adverse impacts) of the SQOs without first adequately characterizing the baseline environment. Save Our Peninsula Committee v. Monterey County Board of Supervisors, 87 Cal. App. 4th 99, 120 (2001).

The SQO documentation does not consider adequately the factors affecting the baseline condition of bay sediments statewide. For example, the Staff Report contains a description of the environmental setting for San Francisco Bay (Staff Report, at 14-16), but the Staff Report does not discuss the fact that the San Francisco Bay has been subject to numerous non-contaminant factors contributing to baseline, including a 79 percent loss in tidal marsh habitat during the last 200 years. "[T]he loss of these habitats accounts for most of the decline in ecological function of the tidal marsh . . . . [H]abitat losses have undoubtedly contributed to population decline." San Francisco Bay Area Wetlands Ecosystem Goals Project, Baylands Ecosystem Habitat Goals – A Report of Habitat Recommendations (1999). Moreover, the benthic ecology has been impacted by introduction of exotic species. The SQOs must include a more extensive discussion of the current baseline condition, the factors that are most responsible for contributing to that baseline condition, and the critical factors that will limit or regulate the future enhancement of ecological resources in the bay sediments statewide.

The proposed SQOs must characterize the environmental baseline for each environmental resource potentially affected by the SQOs. Among others, the proposed SQOs must contain an analysis of the following environmental resources, which the project is likely to significantly impact:

- Quantify current air quality conditions, including an assessment of criteria pollutants for which certain areas surrounding bays statewide are in non-attainment.
- Quantify current greenhouse gas emissions from the state's bays and the globe. Include an assessment of the environmental impact that global climate change is currently having on the state's bays.
- Describe the biological resources in the state's bays and in the vicinity of the state's bays that could be impacted by reasonably foreseeable implementation measures, such as dredging and other implementation activities. All rare, endangered, and threatened species in the state's bays should be identified. Wetlands, eelgrass beds, benthic communities, and other important habitats should be identified and characterized. In order to enable the public to assess the merits of project alternatives, describe any observable, toxic effects on wildlife and habitat caused by current pollutant levels in bay sediment, as compared with the adverse impacts of the reasonably foreseeable implementation measures.

5. The Proposed Regulation Does Not Adequately Assess the Environmental Impact of Implementing the SQOs

The Environmental Checklist attached to the Staff Report states that the SQOs will not result in any potentially significant impacts. See Staff Report, Appendix B. Those conclusions are unsupported, and indeed are contradicted by the Staff Report itself which states that, "if, however, permittees or responsible parties are required to institute additional controls or corrective actions to comply with the proposed aquatic life SQOs for bays, over baseline conditions, these actions could result in potentially significant environmental impacts." Staff Report, at 102 (emphasis added). The proposed SQOs include not only the establishment of SQOs, but must necessarily include those reasonably foreseeable methods of compliance with the draft proposal. The State Board must assume that the SQOs will not only be adopted, but will be implemented. Stanislaus Natural Heritage Project v. County of Stanislaus, 48 Cal. App. 4th 182, 206 (1996) ("While it might be argued that not building a portion of the project is the ultimate mitigation, it must be borne in mind that the EIR must address the project and assumes the project will be built.").

The SQO documentation does not adequately characterize the project and the environmental baseline conditions, making a full environmental review of the implementation plan impossible. But even with the limited time and information available, it is believed that the project likely will have significant environmental impacts on environmental resources, including land use, landfill capacity, air quality, global climate change, benthic communities, and species and habitat. For example, the Staff Report acknowledges that implementation of the SQOs "will generate emissions potentially contributing to GHG [greenhouse gas] levels" but does not quantify the amount of emissions the SQOs will contribute. Staff Report, at 108. Nonetheless, the Staff Report concludes that "emissions from such operations will be miniscule when considered in the context of the state emissions inventory." Id. The State Board's GHG analysis is defective for at least three reasons. One, the State Board must quantify the expected GHG emissions before it can characterize the emissions as "miniscule." Because the Staff Report does not quantify the amount of emissions including GHG emissions expected to be created due to implementation of the SQOs, there is no basis for the State Board to conclude that its contributions will be "miniscule" or that they "would not be expected to produce a measurable change in air quality." Id. Two, CEQA case law has largely rejected the "ratio" theory of environmental impacts, which is that a project does not have a significant effect on the environment because the impacts from the project are small compared with the magnitude of the existing environmental problem. Climate change is a classic example of a cumulative effects problem: emissions from numerous sources combine to create arguably the most challenging environmental problem of our time. While a particular project's GHG emissions may represent only a fraction of California's total GHG emissions, courts have rejected the notion that the incremental impact of a project is not cumulatively considerable because it is so small that it would make only a de minimis contribution to the problem as a whole. See Communities for a Better Environment v. California Resources Agency, 103 Cal. App. 4th 98, 117 (2002). An EIR may not use "the magnitude of a current problem to trivialize the project's impacts." See Kings County Farm Bureau v. City of Hanford, 221 Cal. App. 3d 692, 719 (1990). Rather, "the greater the existing environmental problems are, the lower the threshold should be for treating a project's contribution to cumulative impacts as significant." See Communities for a Better Environment, 103 Cal. App. 4th at 120. Third, the SQOs must at a minimum comply with the goals set forth in AB 32. The Staff Report identifies AB 32, but there is no analysis of whether the SQOs will be consistent with the goals set forth in AB 32. Staff Report, at 108.

6. The Proposed SQOs Omit an Assessment of Cumulative Impacts, as Required by CEQA

The full environmental impacts of the SQO cannot be ascertained until a full cumulative impacts analysis is conducted. Whitman v. Board of Supervisors, 88 Cal. App. 3d 397, 408 (1979) ("[An] agency may not . . . [treat] a project as an isolated 'single shot' venture in the face of persuasive evidence that it is but one of several substantially similar operations, each of which will have the same polluting effect in the same area. To ignore the prospective cumulative harm under such circumstances could be to risk ecological disaster.") (citation omitted). The proposed SQOs conclude in just a few sentences that "cumulative environmental impacts . . . are expected to be beneficial" although acknowledging that the implementation of the SQOs at the project level may have adverse cumulative effects. Staff Report, at 108. These conclusory statements do not constitute sufficient analysis of the project's impacts together with those of "closely related past, present, and reasonably foreseeable probable future projects." 14 Cal. Code Regs. § 15355(b).

CEQA requires analysis of cumulative impacts to use either the list approach or the summary-of-projections approach. 14 Cal. Code Regs. § 15130(b)(1). The summary-of-projections approach is appropriate only where an adopted general plan or prior certified environmental document "described or evaluated regional or area wide conditions contributing to the cumulative impact." 14 Cal. Code Regs. § 15130(b)(1)(B). There appears to be no such general plan or prior environmental document analyzing the cumulative impacts of implementing the SQOs. As such, the State Board must use the list approach. It must begin this exercise by listing all potential dredging projects, development projects on the margins of the state's bays, habitat restoration projects, recently adopted TMDLs affecting the state's bays, any likely future TMDLs affecting the state's bays, and other projects in the SQOs project areas that could affect the environmental resources impacted by the SQOs. 14 Cal. Code Regs. § 15130(b)(1)(B)(2). Once the cumulative project list is identified, the State Board must analyze the impacts of the SQOs together with those other projects. As it has not done so, there is no basis for the State Board to conclude that the SQOs along with these other projects will not result in an adverse environmental impact.

L. The State Board Failed to Provide Fair Notice of Its Proposed Rulemaking or Sufficient Time for Public Comment on the Unprecedented SQO Framework

CalChamber and its members appreciate the fact that the State Board and its consultants have spent years developing the SQOs, as reflected in the proposal's breadth and complexity. The resources that have been devoted to this effort merely underscore the need to provide additional time for the public to evaluate the complex proposal that the State Board recommended following this multi-year effort. There is a vast amount of information and materials that the regulated community must review, assimilate and comment on in the short comment period allocated to this process. We appreciate the State Board's November 9, 2007 grant of a 2-week extension for submitting comments. Given the amount of time the State Board, however, has devoted to developing the proposal, the complexity of the proposal and the potential implications of the proposed SQOs, it is not reasonable to expect the regulated community to adequately review and develop meaningful comments in an abbreviated timeframe.

The public has not been provided with sufficient information regarding the nature of the SQOs, their breadth, required implementation measures, projected environmental benefits and associated costs, thereby violating fundamental due process rights. The public has not been provided with an adequate opportunity to independently evaluate the science underlying the proposal, or to assess the significant consequences of applying the SQOs to specific waterbodies. See generally Stauffer Chemical Co. v. Air Res. Bd., 128 Cal. App. 3d 789, 794 (1982) ("principles of fairness" require a public hearing prior to agency action); California Ass'n of Nursing Homes, Sanitariums, Rest Homes and Homes for the Aged, Inc. v. Williams, 4 Cal. App. 3d 800, 807 (1970) (holding that minimum procedural requirements require "the agency to publish and mail notice of its proposed action, to provide interested persons an opportunity for hearing and to give consideration to all relevant matter presented to it").

The regulated community's ability to evaluate the proposed SQOs was hampered significantly by the fact that the State Board released supporting technical reports and analyses on a rolling basis after the September 28, 2007 Notice of Hearing, in part as follows:

Release Date	Document
9/28/07	Notice
10/02/07	Technical Report 524: Evaluation of Five Indicators of Benthic Community Condition in Two California Bay and Estuary Habitats
10/15/07	Technical Report: A Framework for Interpreting Sediment Quality Triad Data
10/24/07	Comparison of National and Regional Sediment Quality Guidelines for Predicting Sediment Toxicity in California
11/09/07	Revised Notice, extending comment period to 11/30/07
11/15/07	Development and Evaluation of Sediment Quality Guidelines Based on Benthic Macrofauna Responses
11/28/07	MLOE v. SLOE graphs

CalChamber and its members, however, still are constrained significantly in their ability to comment cogently on all of the important aspects of the State Board's proposal in the allotted timeframe. This is particularly true since the comments are now due only 10 days after the State Board's November 19, 2007 hearing (including the Thanksgiving holiday), where the public had their first opportunity to hear directly from the State Board and its staff regarding the Proposed Regulation. Furthermore, the State Board directed staff to provide additional information on implementation of the plan, which has yet to be made available. Finally, we understand that the State Board staff is developing a Guidance or Implementation Manual, that will not be made available until after the close of the comment period. Stakeholders needed additional time, and the timely disclosure of all of the information underlying the State Board's proposed SQOs, to make sense of any aspect of the proposed regulation. Courts routinely hold that notice is inadequate where it fails to inform the public of the actual scope of the agency's proposed action, or is otherwise defective as it has been in this rulemaking.[20] The State Board should take the time to ensure that the proposed SQOs are scientifically based in order to comply with the Legislature's mandates.

M. The SQOs are Void for Vagueness and Violate Due Process

California courts consistently have held that due process of law is violated by "a statute which either forbids or requires the doing of an act in terms so vague that men of common intelligence must necessarily guess at its meaning and differ as to its application." Britt v. City of Pomona, 223 Cal. App. 3d 265, 278 (1990); Franklin v. Leland Stanford Junior Univ., 172 Cal. App. 3d 322, 347 (1985). Due process requires the prohibition or regulation be clearly defined in order to provide fair notice to the public and to avoid arbitrary and discriminatory application of the standard. Britt, 223 Cal. App. 3d at 347; People v. Townsend, 62 Cal. App. 4th 1390, 1400 (1998) ("A statute must be definite enough to provide a standard of conduct for its citizens and guidance for the police to avoid arbitrary and discriminatory enforcement.").

California courts look not only at the face of the regulation, but also consider vagueness challenges to statutes in light of the facts of the case at hand. Arellanes v. Civil Service Commission, 41 Cal. App. 4th 1208, 1217 (1995) (as-applied vagueness challenge not limited to where First Amendment freedoms at risk). In determining the sufficiency of fair notice, the challenged statute must be examined in light of the conduct of the person who allegedly violated the statute. Cranston v. City of Richmond, 40 Cal. 3d 755, 764 (1985).

Under these principles, the State Board's SQOs are unconstitutionally vague as applied in the Proposed Regulation because they do not provide adequate notice to the public regarding the following:

- Application to Sites That Are Not Actual Toxic "Hot Spots" –The entire Program that the SQOs are a fundamental part of mandates that the State Board identify actual toxic hot spots, and that it establish scientifically sound SQOs for purposes of managing those hot spots. The proposed SQOs are vague and ambiguous insofar as they do not further the purposes of this enabling legislation.

- Overbroad Application Without Properly Distinguishing Between Impacted and Unimpacted Sites – The proposed SQOs interpret the lines of evidence so broadly that most, if not all, of the enclosed bays and estuaries in California likely will fail the SQOs. The public never received adequate notice that the SQOs would be

20 See, e.g., Horn v. County of Ventura, 24 Cal. 3d 605, 617-18 (1979) (notice provided by county regulations was inadequate to apprise concerned landowners of governmental actions affecting their property interests and violated purchaser's due process rights); Mortgage Investors Corp. of Ohio v. Gober, 220 F.3d 1375, 1380 (Fed. Cir. 2000) (notice inadequate when information withheld is so central to decisional process that its nondisclosure is tantamount to refusing to describe the subject or issues in rulemaking proceeding); Wagner Elec. Corp. v. Volpe, 466 F.2d 1013, 1019-20 (3d Cir. 1972) (notice inadequate where only "some knowledgeable" manufacturers would grasp link between subject notice identified and final rule).

interpreted and applied so broadly as to include the majority of waterbodies in California, even where application of the SQOs leads to illogical results such as finding stations to be impaired where the benthos is at the reference condition.

- The SQOs Give No Notice to the Public That They Will be Adjudged to be Violated on the Basis of Unsound Science – The statistical methods on which the chemistry prong is based have been recognized as scientifically unsound by numerous experts in the scientific community. It violates fundamental principles of due process to propose exceedingly low thresholds by merely relying on an association between the chemicals and the sediments. The proposed SQOs' methods are void for vagueness because they lack a valid scientific basis, the statistical associations do not establish causation between a chemical concentration and biological effects, and should not be used to develop the SQOs.

- The SQOs are Vague Because They Do Not Meet the Statutory Definition Under Section 13391.5 – The State Board is required to adopt "that level of a constituent in sediment" to reasonably protect the beneficial uses of water. Cal. Water Code § 13391.5. The public did not receive sufficient notice that this legislative mandate would be interpreted so broadly as to permit the development of such a complex framework as that being proposed.

- Discharges Are Not Given Sufficient Notice Regarding What Is Required to Comply with the Proposed SQOs -- The methods specified for dictating whether SQOs can be applied as receiving water limits are never defined. See Section II.D, supra. The proposed methods to identify a discharger or dischargers responsible for an exceedance of the SQOs are particularly vague and subjective in regions of multiple discharges. Dischargers and the public are not given sufficient notice as to how dischargers are expected to prove that the contamination is or is not related to their permitted discharge, especially if the contaminated sediment is located some distance from the discharge. Because the State Board's Proposed Regulation – as applied to dischargers in areas classified as impacted – does not give the public notice of the standards by which it will be regulated, the standard is void for vagueness and violates due process.

N. The State Board Has Not Provided All of the Documents Upon Which the TMDL Is Based as Required by the Porter-Cologne Act, APA and CEQA

The State Board has not met its burden under the Porter-Cologne Act, CEQA and the California Administrative Procedure Act to disclose and make available for public review materials upon which the SQOs are based. See Section III.L.

1. Water Code Section 13394.6

The California Legislature placed a special emphasis on the dissemination of SQO materials, requiring that Advisory Committee members, "have access to all information and documents, except for internal communications, that are prepared to implement this chapter" (i.e., the Bay Protection and Toxic Cleanup Chapter of the Water Code containing the SQO provisions). Cal. Water Code § 13394.6(c). The statute also requires the State Board to provide Advisory Committee members sufficient time to "provide the state board with its views on how that information should be interpreted and used." Id.

2. California Administrative Procedure Act

Certain provisions of the Administrative Procedure Act ("APA") apply to the State Board's adoption of the proposed SQOs and Water Quality Control Plans. Cal. Gov't Code §§ 11353(a) and (b)(1); State Water Resources Control Bd. v. Office of Admin. Law, 12 Cal. App. 4th 697, 707 (1993) (concluding that Section 11353 "amends sections of the APA providing, essentially, that any new water quality control programs must comply with the APA"). The APA requires that "[e]very agency shall maintain a file of each rulemaking that shall be deemed to be the record for that rulemaking proceeding . . . and during all subsequent periods of time that the file is in the agency's possession, the agency shall make the file available to the public for inspection and copying during regular business hours." Cal. Gov't Code § 11347.3(a). The "rulemaking file shall include: . . . (6) All data and other factual information, any studies or reports, and written comments submitted to the agency in connection with the adoption, amendment, or repeal of the regulation. (7) All data and other factual information, technical, theoretical, and empirical studies or reports, if any, on which the agency is relying in the adoption, amendment, or repeal of a regulation, including any cost impact estimates as required by Section 11346.3." Cal. Gov't Code § 11347.3(b)(6-7). Accordingly, the State Board must provide the public with all the data, factual information, technical, theoretical, and empirical studies or reports that the State Board is relying on in the adoption of the proposed SQOs and program of implementation that would apply to enclosed bays and estuaries in California.

Similarly, the APA requires that a state agency fully explain the rationale for each regulation it proposes to adopt. This rationale must be set forth in the "Initial Statement of Reasons," which must be submitted to the Office of Administrative Law ("OAL") and made available to the public upon request. Cal. Gov't Code § 11346.2. The Initial Statement of Reasons must include, *inter alia*: "An identification of each technical, theoretical, and empirical study, report, or similar document, if any, upon which the agency relies in proposing the adoption, amendment, or repeal of a regulation." Cal. Gov't Code § 11346.2(b)(2).

Accordingly, the State Board must provide the public with the Initial Statement of Reasons submitted to the OAL, which hereby is requested pursuant to Government Code Section 11346.2. In this Initial Statement of Reasons, the State Board is required to identify "each technical, theoretical, and empirical study, report, or similar document, if any, upon which . . . [the agency] relies in proposing" the SQOs. Cal. Gov't Code § 11346.2(b)(2).

3. CEQA

The content of administrative records in CEQA proceedings is governed by Public Resources Code Section 21167.6. ; subdivision (e) specifically enumerates what must be included, but does not exclude materials absent from the subdivision. See County of Orange v. Superior Court, 113 Cal. App. 4th 1, 7 (2003). The "actual text of subdivision (e) . . . contemplates that the administrative record will include pretty much everything that ever came near a proposed . . . [project] *or* to the agency's compliance with CEQA in responding to that . . . [project]." Id. at 8. The broad language of Public Resources Code Section 21167.6 encompasses any and all expert reports reviewed by the State Board, including any and all data underlying those reports.

The State Board is required to make all documents incorporated into the Staff Report available for public inspection. CEQA Guidelines § 15150(b) ("Where part of another document is incorporated by reference, such other document shall be made available to the public for inspection at a public place or public building."). As such, the State Board must disclose all technical and expert reports incorporated into the SQO proposal. The adoption of the SQOs under a certified regulatory program does not affect the State Board's obligation under CEQA to make the technical and expert reports available; the environmental documents of a certified regulatory program must be available for review and comment by the general public. Cal. Pub. Res. Code § 21080.5(d)(3)(B); Schoen v. Dep't of Forestry & Fire Protection, 58 Cal. App. 4th 556, 566 (1997).

To comply with the APA and CEQA, the State Board must make available to the public all of the documents and data considered in developing the proposed SQOs.

IV. Conclusion

For the foregoing reasons, we respectfully request that the State Board not adopt the SQOs as proposed. Instead, the SQOs should be reformulated so that they can distinguish bay and estuary sediment that is degraded from that which is not, resulting in a rule that does not vastly and improperly expand the 1999 designation of contaminated sediment in California bays and estuaries. The revised SQOs must be based on sound science, and comply with applicable legal requirements such as the Chapter 5.6 goal of identifying and managing specific and discrete sediment "hot spots." The State Board should adopt reasonable and achievable SQOs that appropriately balance environmental and economic factors. Clear methods for identifying what chemicals are causing observed impacts should be developed, and appropriate guidance and implementation measures must be established for purposes of addressing any sediment failing properly established SQOs.

QEA
Quantitative Environmental Analysis, LLC
∂c/∂t

TECHNICAL MEMORANDUM

TO:	CalChamber of Commerce General Electric Company	**DATE:**	November 30, 2007
FROM:	Elaine B. Darby, P.E. Elizabeth M. Lamoureux John P. Connolly, Ph.D., P.E., DEE	**RE:**	Review of Draft Staff Report, Water Quality Control Plan for Enclosed Bays and Estuaries, Part I. Sediment Quality
CC:		**JOB#:**	GENfra:111

Pursuant to your request, Quantitative Environmental Analysis, LLC (QEA) has reviewed the State of California State Water Resources Control Board's Water *Draft Staff Report: Water Quality Control Plan for Enclosed Bays and Estuaries, Part 1. Sediment Quality* (SWRCB 2007). The purpose of this memo is to identify and recommend approaches to resolving the issues involved in identifying and applying Sediment Quality Objectives (SQOs) in California.

Issues with Application and Implementation of the Sediment Quality Objectives

Issue 1: The approach, as described in the Staff Proposal is overly conservative and provides little ability to discriminate between impacted and unimpacted sites.

The Staff Report provides persuasive arguments supporting the need for Multiple Lines of Evidence (MLE) in establishing whether aquatic life is adversely impacted by contaminants present in sediments. These arguments express the weaknesses and confounding factors that make the individual lines of evidence poor diagnostic tools when used in isolation and lead to the fundamental principal that impacts due to contaminants should not be inferred unless the weight of the evidence supports such inference. Assuming the MLE approach is encompassed by the statutory definition of an "SQO," we believe there is real value in using the MLE principal as an integral part of the evaluation of sediment quality, so as to minimize the burden and waste of chasing non-problems. However, there are significant defects in the Staff's proposed application of the MLE approach.

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While the Staff Proposal relies on the MLE principal, it interprets the lines of evidence in such a conservative fashion that it is likely to declare that most, if not all, the enclosed bays and estuaries in the State do not meet the sediment quality objectives (SQOs). For example, the Southern California Coastal Water Research Project (SCCWRP) assessed data from multiple sources including both targeted and randomly located stations sampled over a 10-year period, applied the proposed framework provided in the Staff Proposal and found that five of seven regions within San Francisco Bay failed to meet the SQOs (SAIC 2007). The SCCWRP study also found that both regions of Newport Bay failed to meet the SQOs, as well as three of the other four Bays evaluated in Region 8 (Anaheim Bay, Huntington Harbor, Bolsa Bay, and Rhine Channel; SAIC 2007). Similarly, in Region 9, the majority of the regions of San Diego Bay failed to meet the SQOs (SAIC 2007).

There are at least three fundamental problems with the interpretation of the lines of evidence:

1. the chemistry thresholds are lower than levels that might cause substantive impacts;
2. the MLE assessment is biased toward designating a station as impacted; and
3. it is necessary only to have more than 3% of the stations as impacted to declare that the site is impacted.

The Chemistry Thresholds are Too Low

Empirical correlations using paired biological and chemical data, which are the basis for the chemical thresholds, are useful for the limited purpose of defining levels below which no effects are expected and levels above which effects are always expected. However, these correlative approaches provide little additional insight because of the co-variation among chemicals and other factors such as sediment grain size and organic content. Specifically, it is not possible to definitively demonstrate that a specific chemical is the cause of any observed adverse environmental effects using these correlative approaches. For example, a toxic sediment high in metal concentrations and low in polychlorinated biphenyl (PCB) concentration will be used in PCB model development as a positive toxic sample as long as the PCB concentration is above the mean PCB concentration for the survey -- without consideration of the possible causal effect of the metal and the lack of evidence of a causal effect of PCB.

Consider the "moderate exposure" threshold concentration. It is set using the P_{max} equation at a concentration at which an effect was found at 50% of the sites included in the dataset. In other words, the "moderate exposure" threshold concentration was clearly non-toxic at 50% of the examined cases. In fact, it was likely non-toxic at more than 50% of sites, since there is no evidence that it was the causative agent at toxic sites. In fact, one cannot rule out the possibility that the "moderate exposure" threshold is below the concentration that would cause toxicity at any site. Similar arguments can be made for the "high exposure" threshold concentration, which is defined where 34% of the sites showed no toxicity. Of particular concern is that these thresholds are often lower than mechanistic based thresholds (such as the equilibrium partitioning (EqP) approach, which explicitly accounts for site-specific factors that affect contaminant bioavailability) and often fall within the range of naturally occurring levels of contaminants (i.e.

metals such as zinc and lead). Such facts are evidence that empirical thresholds infer toxicity at non-toxic concentrations.

Mechanistic based thresholds in many instances are orders of magnitude higher than those derived by correlation. The correlation-based threshold concentrations for PCB for example are orders of magnitude lower than those estimated from EqP methods. As listed in the Staff Report, the thresholds are:

- Minimal exposure < 0.32 ppm
- Low exposure 0.32 – 0.95 ppm
- Moderate exposure 0.95 ppm – 2.8 ppm
- High exposure > 2.8 ppm.

In contrast, a study by Fuchsman et al. (2006) looking at EqP and toxicity studies at several PCB sites indicates that the minimal exposure threshold is > 300 ppm organic carbon (OC) basis (about 10 ppm at OC values typical of fine sediments).

For low molecular weight (LMW) PAHs as listed in the Staff Report, the thresholds are:

- Minimal exposure < 1.7 ppm
- Low exposure 1.7 – 4.1 ppm
- Moderate exposure 4.1 ppm – 9.3 ppm
- High exposure > 9.3 ppm.

The U.S. Environmental Protection Agency (USEPA; USEPA 2003) indicates EqP threshold values for LMW PAHs between 400 and 800 ug/g OC. Using the mid-point and 3% organic carbon sediments, the EqP threshold is 18 ppm.

For high molecular weight (HMW) PAHs as listed in the Staff Report, the thresholds are:

- Minimal exposure < 5.5 ppm
- Low exposure 5.5 – 12.5 ppm
- Moderate exposure 12.5 ppm – 26.8 ppm
- High exposure > 26.8 ppm.

However, the USEPA indicates threshold values between 800 and 1,400 ug/g OC. Using the mid-point and 3% organic carbon sediments, the EqP threshold is 33 ppm.

It is interesting to note that in all three of the above comparisons, the EqP thresholds below which **no toxicity** is expected are all **higher** than the high exposure thresholds in the Staff Report.

In addition, for some metals, the Low Exposure threshold is near or in the range of natural background (e.g., Pb, Zn).

The inability of the empirical correlations to yield meaningful toxicity thresholds is evident in the wide range of results obtained from different data sets. For example, the draft report of Bay et al. (2007) shows SQGs can vary by ten to twenty fold (e.g., cadmium, silver, several PAHs, tributytin) or even a thousand fold (PCBs). Moreover, consistent with the expectation for a correlation that lacks meaningful cause and effect, the Bay et al. results correlate with ambient chemical concentrations; the ERM values are higher when the chemical concentrations in the data set are higher. This is demonstrated in Figure 1. If the ERMs had toxicological meaning they would not correlate with median concentration.

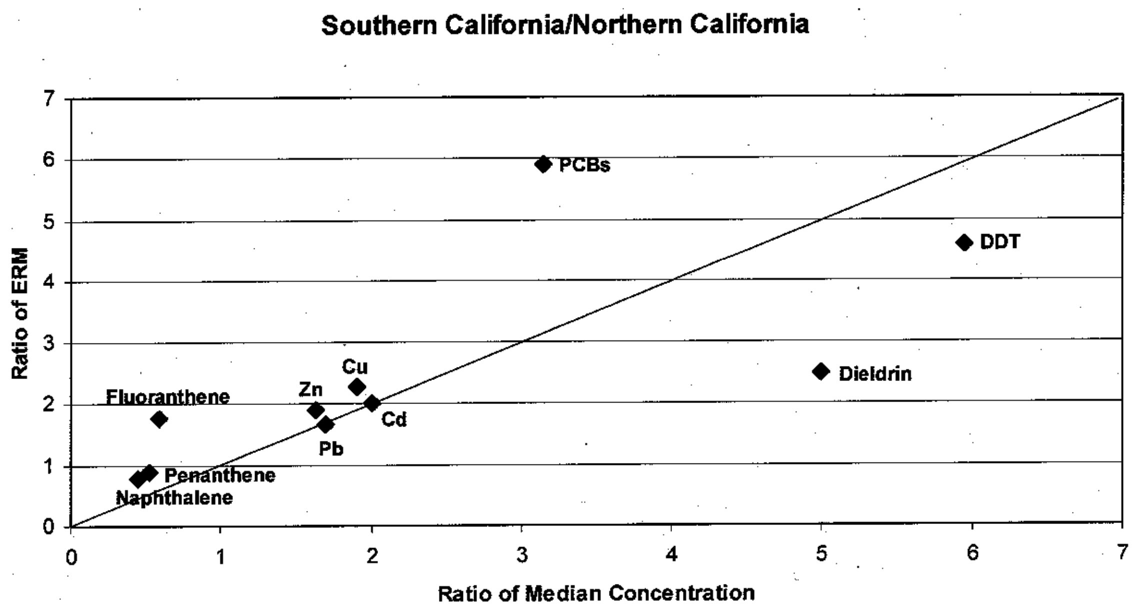

Figure 1. ERM ratios compared to median concentrations for California (data from Bay et al. 2007).

MacDonald et al. (2000) studied the differences between theoretical and empirical approaches for creating Sediment Quality Guidelines (SQGs), specifically for PCBs, and proposed a consensus based sediment effect concentration (SEC) as a means of reconciling SQGs, developed from various empirically based methods which were shown to vary by as much as two orders of magnitude.

Mechanistic approaches attempt to quantify causal effects for contaminants by addressing bioavailability, covariance, chemical interactions and ecological adaptations. Fuchsman et al. (2006) contend that cause-effects benchmarks instead of empirically derived thresholds are needed specifically for benthic invertebrates to support both predictive ecological risk assessments and retrospective evaluations of the causes of observed sediment toxicity. Fuchsman et al. (2006) question MacDonald's assertion that consensus based SECs incorporate causal effects and contend that cause-effect benchmarks based on equilibrium partitioning assessment are critical and provide an improved framework for understanding cause-effect relationships for risks to invertebrates from PCB exposure. Without direct cause-effect determinations, empirically derived thresholds based evaluations such as P_{max} and CSI may result in predicting lower concentration thresholds for effects than actually exist in the environment.

Recommendation

Chemical thresholds should rely on mechanistic approaches where feasible and should take account of background levels.

The Interpretation of the MLE Results Is Biased Toward Designating a Station as Impacted

The MLE approach is fundamentally flawed in that two lines of evidence indicating a low likelihood of impact are dismissed in favor of the single line of evidence indicating impact. A station is designated as impacted (i.e., the station assessment is Possibly Impacted, Likely Impacted or Clearly Impacted) if:

- Benthos community condition and chemistry exposure indicate little or no impact, but toxicity is high. This is especially inappropriate given that toxicity is the weakest line of evidence because: 1) factors other than toxic chemicals can cause toxicity; 2) the laboratory conditions often differ from in-situ conditions; and 3) the specified test organisms may not occur naturally at the site. The bias towards the Toxicity line of evidence is obvious in Attachment B of Appendix A, where it can be seen that under "high" toxicity, the station fails or is inconclusive *in all cases regardless of sediment chemistry exposure or benthic community condition levels.*
- Toxicity and chemistry exposure indicate little or no impact, but the benthic community is moderately or highly disturbed.

Designating a station as impacted with the findings in the above bullets is inconsistent with an MLE approach and with the following key principles set out in Appendix A (p. 17):

- Results for a single LOE shall not be used as the basis for an assessment.
- Evidence of both elevated chemical exposure and biological effects must be present to indicate pollutant-associated impacts.

The biases towards single LOE findings of impact are illustrated by combining Tables 9, 10, and 11 in the Staff Proposal. As shown in Tables 1 to 3, there are many possible MLE scenarios where a station can be classified as Possibly Impacted, even under reference and minimal chemistry exposure or toxicity.

Table 1. Station classification with minimal or low chemistry exposure.

		Toxicity			
		Nontoxic	**Low Toxicity**	**Moderate Toxicity**	**High Toxicity**
Benthos	Reference				Possibly Impacted
	Low Disturbance			Possibly Impacted or Inconclusive	Possibly Impacted
	Moderate Disturbance		Possibly Impacted	Possibly Impacted	Likely Impacted
	High Disturbance		Possibly Impacted	Possibly Impacted	Likely Impacted

Table 2. Station classification with reference benthos.

		Toxicity			
		Nontoxic	**Low Toxicity**	**Moderate Toxicity**	**High Toxicity**
Chemistry	Minimal exposure				Possibly Impacted or Inconclusive
	Low exposure				Possibly Impacted or Inconclusive
	Moderate exposure				Possibly Impacted or Inconclusive
	High exposure			Inconclusive	Likely Impacted

Table 3. Station classification with no or low toxicity.

		Benthos			
		Reference	**Low disturbance**	**Moderate disturbance**	**High disturbance**
Chemistry	Minimal exposure				Inconclusive
	Low exposure			Possibly Impacted	Possibly Impacted
	Moderate exposure			Possibly or Likely Impacted	Possibly or Likely Impacted
	High exposure			Likely Impacted	Clearly Impacted

Additional illustration of the bias of towards the toxicity single line of evidence controlling the station assessment is shown in the slides presented at the November 19, 2007 State Water Resources Control Board Hearing. For instance, every station with over 40% mortality in the toxicity test was assessed as impaired (Figure 2, SWRCB Hearing 2007) regardless of the other lines of evidence.

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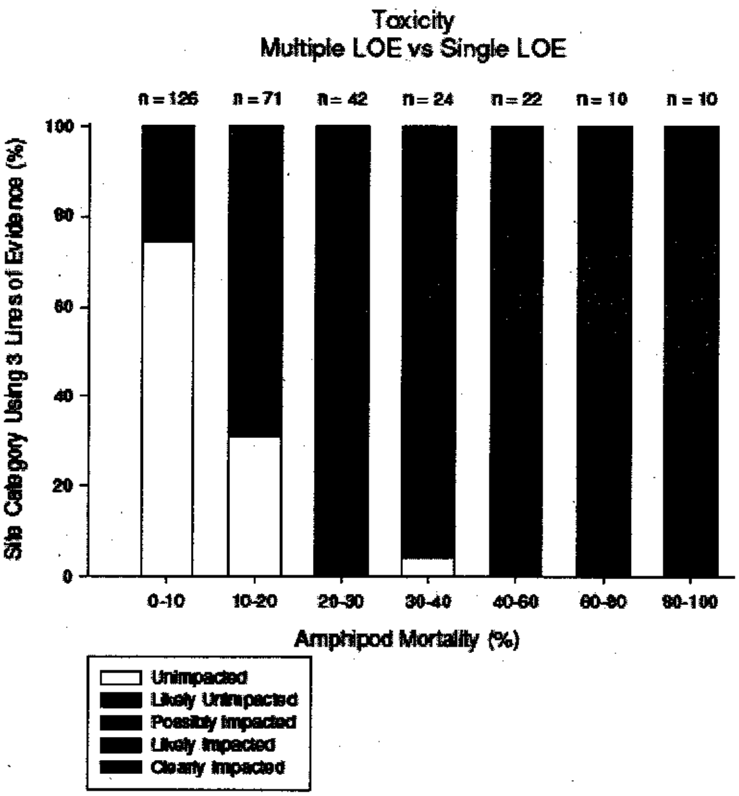

Figure 2. Multiple lines of evidence compared to single line of evidence based on toxicity measurements for stations throughout California (SWRCB Hearing Slides, 11/19/2007).

Recommendation

In the original scoping document (SWRCB 2006), "Possibly Impacted" was defined as "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." The Staff Proposal (SWRCB 2007) modified the definition to "sediment contamination at the site may be causing adverse impacts to aquatic life, but these impacts are either small or uncertain because of disagreement among LOE." Under this new definition, "Possibly Impacted" sites should not be included as impaired and the Staff Proposal should clearly state that these sites meet the protective condition until studies demonstrate otherwise. The category of Possibly Impacted should be used as a trigger for expanded monitoring, rather than the full suite of investigations triggered by a declaration of impairment.

The Choice of 3 Percent as the Allowable Frequency of Station Exceedances is Based on an Inappropriate Adoption of Water Quality Standard Procedures and Will Result in Excess and Improper Listing of Water Bodies on the State 303(d) List

The Staff Report calls for integration of the results of many single station assessments into a single watershed-based or water body assessment. At each station, sediment quality will be categorized into one of five ordered categories (Section 5.7.3). Staff recommends converting 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 non-exceedances. A binomial test would be used to determine if the proportion of exceedances is statistically greater than 3 percent. This is the approach taken in the State's current 303(d) listing policy (SWRCB 2004) for water bodies. In that case, the 3 percent refers to sample results collected over **time** i.e., the water quality standard cannot be exceeded more than 3 percent of the time. As such, it is not a precedent for setting the appropriate frequency of exceedance in **space** that would constitute a failure to meet standards. In fact, the 3 percent value is not appropriate for sediment quality because of the inherent likelihood for false positive results (i.e., declaring a station as being impacted when it is not).

False positives result because of the quantitative and qualitative variability inherent in benthic community condition and sediment toxicity evaluations. For example, a robust analysis of toxicity data by Ingersoll et al. (2000) found significant toxicity at chemical concentrations less than 10% of the Probable Effects Concentration (PEC), with almost 20% of the samples being toxic for some tests. Similarly, a USEPA analysis of the correlation between sediment chemical concentration and amphipod toxicity shows that at low concentrations, toxicity can occur at frequencies as high as 20% (USEPA 2005). Thus, it is likely that some fraction of the sampled sediments, perhaps as high as 20% in some cases, will exhibit toxicity that is unrelated to and not caused by local dischargers.

Recommendation

Staff should consider evaluating application of the binominal distribution based on a larger threshold number of samples for the null hypothesis that accounts for the likelihood of false positives. A value in the range of 20% seems appropriate. In addition, as discussed further below, minimum sample size for multi-station assessment of a single water body and minimum geographical coverage extent for individual sampling events must be specified.

Other Conservatisms That Render the Proposal Overbroad

As few as 2 stations categorized as "Impacted" can trigger exceedance of a receiving water limit. The full data set used to conduct the SQO assessment can contain as few as 2 stations. Given the variability inherent in the nature and chemistry of sediments and the large areas over which SQO assessments are likely to take place, it is not appropriate to evaluate compliance with the receiving water limit on so few data points. Moreover, this approach introduces a conservative bias. Although only 2 samples are required to declare that a water body is impaired and must be included on the State 303(d) list, 28 or more samples are required to remove waters from the State's 303(d) list.

The evaluations of each LOE include the instruction to round up evaluations that fall between categories. While this seems logical in isolation, it is yet another conservatism heaped on the various conservatisms discussed above. As such, it contributes to the likely inability of the MLE procedure to provide reasonable discriminatory power.

Recommendation

The proposal should include reasonable specifications for the minimum number of stations and minimum number of "Impacted" stations. These specifications should be tied to a desired minimum sampling density. For example, it might be appropriate to require a minimum of 10 stations per site and a minimum spatial density of one station per hectare. Further, sites should be defined by the discharge gradient of regulated dischargers. Regional scale evaluations are useful for identifying water body status, but they have little value in managing individual dischargers.

Issue 2: The proposed methods to identify a discharger or dischargers responsible for an exceedance are vague and subjective.

The Regional Board may apply SQOs to a discharger's receiving water limits permit if it determines that sediment quality is "potentially at risk" "in the vicinity" or "within discharge gradient" of a discharger (Appendix A, p. 21). Yet, these qualitative expressions of spatial association are never defined. What data should be used to make the necessary determination and how should that data be used? In sediment quality evaluations conducted in support documents (Barnett et al. 2007; SAIC 2007) the evaluation was based upon samples collected through stratified random sampling approaches which do not take discharge gradients into account. In regions of multiple discharges, how can gradient analyses be applied to determine source of contaminant? How do dischargers prove that the contamination is or is not related to their permitted discharge, especially if the contaminated sediment is located some distance from the discharge? The analyses required to determine whether sediments are "potentially at risk" will be extremely involved and costly for both dischargers and regulators. Modeling is typically used to link dischargers and receiving water quality when developing water quality-based effluent limits. Whereas relatively simple models are adequate for most water quality-based permitting, the modeling necessary to relate a discharge to sediment toxic pollutant concentrations is complicated by the numerous processes involved in sediment transport, contaminant sorption and speciation and physical and chemical interactions between the sediment and the water column. This is especially true in bays and estuaries because of the complex hydrodynamics, the influence of winds and variations in salinity. Thus, it may not be scientifically feasible, practical, or cost effective to routinely determine sediment quality potentially at risk.

For water quality applications, discharge permittees are required to identify a mixing zone, in which water quality standards do not apply. The same approach should be applied in the SQOs outlined in the Staff Report. It is illogical to require that SQOs be met in a region in which water column concentrations can exceed water quality standards.

The Staff Proposal also states that the Permittee shall be in violation of receiving water limits if it is demonstrated that the discharge is causing or contributing to the SQO exceedance. However, the Staff Report does not outline how the causal relationship between the discharges and sediment quality will be established and whose burden it is to make such a determination. The approach outlined in the Staff Report sets up a situation in which multiple dischargers are affected by a regional evaluation without determining causality.

Recommendation

Stations within the discharge mixing zones should not be considered when evaluating existing sediment conditions, and future sampling for the purpose of establishing exceedances of SQOs should be done outside mixing zones. A framework which clearly lays out how to evaluate the steps necessary to determine causality and effect should be included in the Staff Report.

Issue 3: No means is provided to determine the extent of pollution abatement to be required by the discharger or the regulatory process that will be guiding the pollution abatement.

The Staff Report provides no effective means to assess responsibility of SQO exceedances. The conceptual model provided in the Staff Report provides only a hypothesis regarding the relationship of a discharge to the SQO exceedance and sediment quality at a sampling station, which by itself cannot discriminate among multiple sources. The Staff Report does not provide any guidance to relate a pollutant-caused SQO exceedance to the extent of discharge reduction necessary to bring the water body into compliance with the receiving water limit.

The Staff Report does indicate that an exceedance would not be considered as a violation of the permit until it is demonstrated that the discharge is causing or contributing to the SQO exceedance (Appendix A, VII.C). However, this safeguard is eliminated in practice because the exceedance of multiple stations within the water body will force an exceedance of water quality standards, which would put the water body on the State's 303(d) list and force the development of a Total Maximum Daily Load (TMDL) for the water body even though it is not clear that there is a violation of the water quality standard based on the multiple lines of evidence used in the sediment quality evaluation.

The Staff Report clearly states that "[t]he sediment chemistry guidelines shall not be translated into or applied as effluent limits," Appendix A, p. 21. The Staff Report fails to provide sufficient guidance for determining how to establish effluent limits. All the Staff Report states is that "[e]ffluent limits established to protect or restore sediment quality shall be developed only after:

1. a clear relationship has been established linking the discharge to the degradation;
2. the pollutants causing or contributing to the degradation have been identified; and
3. appropriate loading studies have been completed to estimate the reductions in pollutant loading that will restore sediment quality." Appendix A, p. 21.

The document then points the Regional Boards to Appendix A, Sections VII.F and VII.G for stressor identification and site-specific management guidelines, but these sections are unclear as to who has the responsibility to develop and implement the work plans and the definition and extent of "appropriate loading studies."

The Staff Report does not address how a discharger would potentially be controlled using the findings of the SQO evaluation spelled out in Appendix A. It is assumed that this control would occur through the NPDES permitting process, but no clear steps are given to indicate exactly how a discharge permit may be evaluated and changed when an SQO is exceeded. The state's Continuing Planning Process (CPP) provides guidance as to how to implement changes in NPDES permits and Basin Plans in order to work towards attaining a water quality standard, but no mention of SQOs or the like is given in the current CPP. Does the State Board assume that the state's CPP will be amended to include consideration of the SQOs, as well? If so, a proposed approach for this type of amendment should be addressed in the current SQO plan. If not, the State Board should provide some other guidance on this issue.

In addition, the ultimate "goal" for the sediment quality is not clearly defined. For example, in the wasteload allocation portion of the TMDL process, the NPDES permits are evaluated in relation to non-point sources and suggested percent reductions for the dischargers are spelled out in the TMDL document. In the case of TMDLs, the goal is relatively clear: attainment of the water quality standard. Modeling is usually required to show that the proposed percent reductions will attain the water quality standard. If the water quality standard is narrative, there is typically an attempt to link the narrative standard through modeling, to some quantitative end-point. However, in the case of a violation of an SQO, what is the goal? Will the target be to move from "Likely Impacted" to "Possibly Impacted" or will the target be to move to "Likely Unimpacted" or "Unimpacted" levels? If the goal is to attain relatively pristine levels, or in other words, take all "Impacted" systems to "Unimpacted", this would be unrealistic and costly to many. Guidance on how to set realistic goals once a violation is determined should be spelled out in the document.

Finally, if this goal is to be attained, what level of reduction in the permitted discharge is necessary to achieve it, if any? Will modeling be required in order to ensure there is an accurate link between the SQO violation and the discharge? As mentioned in an earlier comment within this memo, there are instances where sediment concentrations can be relatively low, but the process enumerated in Appendix A still results in the sediment being "Impacted" on some level. If that is the case, what is the process for the dischargers? If the chemicals they are discharging are found at low concentrations in the sediments, it would seem prudent to then focus on other causes for the "Impacted" conclusion than on the dischargers. But, if additional control of the dischargers is warranted, how can they evaluate 10, 20 or 30 percent reductions in water based concentrations effect on the sediment quality? Will there be target values specifically driven by sediment-based chemical thresholds and will the final decisions regarding the discharge load reductions be supported by modeling? The current SQO document is relatively silent on these key issues and consequently, raises many questions for stakeholders that may be impacted if an SQO violation is determined within their system.

Recommendation

Staff needs to provide guidance on determining the link between sediment quality and discharge effluents along with a framework for when violations of the SQOs force the water body into the TMDL process. Appropriate loading studies should be defined and explicitly indicate that the fate and transport processes that govern the relationship between and discharge and sediment quality (e.g., dilution, sediment transport, speciation) must be taken into account. In addition, the report should identify exactly what studies are to be performed and indicate how the results of the studies will relate sediment quality to effluent loadings.

Issue 4: Approach could be prohibitively expensive to regional water boards, monitoring coalitions, and permitted dischargers.

All dischargers will be required by Regional Boards to perform sediment monitoring which may occur as frequently as once a year and at a minimum every three years. This monitoring will involve all three lines of evidence studies under a sediment monitoring plan that must be designed to ensure that the aggregate stations are spatially representative of the sediment within the water body. The monitoring plan must be based on a conceptual model that considers points of discharge, tidal flow and/or direction of predominant currents, historic and/or legacy conditions, nearby land and marine uses or actions, changes in grain size, salinity, water depth, and organic matter, etc. The data collection required to support this monitoring effort and to develop a model of the fate and transport of pollutants within each water body or water body segment is considerable. For example, considerable expertise and substantial data sets are necessary to calculate meaningful values for the four indices that form the basis for the benthic community condition assessment. For example, the Relative Benthic Index (RBI) requires sufficient data to compute meaningful probability distributions of six parameter values and expertise to define regionally appropriate positive and negative indicator species and threshold values coincident with real effects (rather than natural variability). Yet, no guidance is given on the number of stations, habitat types, or the appropriate spatial scale for collection of data for assessing benthic condition.

If an exceedance of the SQOs occurs, the Permittee presumably will be in violation of the SQO if it is demonstrated that the discharge is causing or contributing to the SQO exceedance by performing stressor identification studies. These studies are expensive and require modeling to support the cause and effect identification of pollutants on sediment quality. Complex data analysis will also be required to determine the extent to which sediment pollutant concentrations must be reduced to eliminate exceedance. If the water body is listed on the State's 303(d) list as impaired due to exceeding the SQOs based on as few as two samples, which may or may not be spatially representative of the water body, delisting will require MLE evaluation of 28 stations incurring considerable expense.

The support document, Economic Considerations of Proposed Sediment Quality Plan for Enclosed Bays in California (SAIC 2007) attempts to quantify incremental costs for implementing the SQOs. In this document, the authors recognize several unknowns that can not be quantified but are significant in establishing the cost impact of the Plan. One of which is the uncertainty as to how the Plan will affect the number of TMDLs that will be developed for compliance with the proposed SQOs. An estimate of incremental costs or cost-savings for any particular site is not feasible without additional site-specific information such as the magnitude and causes of water quality and sediment toxicity impairment, the number and types of sources included in the loading analysis, and the extent of water quality modeling (SAIC 2007). Establishing the link between sediment quality and water quality standards will be critical to establishing loads and discharge limits. This link will require complex models and data analysis to determine the impact of load reduction on sediment quality improvement.

Recommendation

The support documentation on economic considerations provides a starting point for evaluating the cost of implementing the Plan. However, a more detailed consideration to the unknowns is warranted as the costs for these will be considerable and perhaps an order of magnitude greater than the costs presented for monitoring.

Issues Related to Application of Methods for Site Assessment

Issue 5: The process does not take account of data inconsistencies that might exist and be evident in cross-station comparisons.

An important and missing step in the SQO is evaluating if the available data make sense. At what point and under what guidelines will the process be allowed to step back from inconclusive lines of evidence? For example, Hunt et al. (2001) investigated sites in San Francisco Bay using sediment quality triad, toxicity identification evaluations, and gradient studies. This study found conflicting chemical and biological lines of evidence. Table 4 below is an excerpt of Hunt's (2001) analysis showing chemical and biological measurements along gradients at three sites:

Table 4. Chemical and biological measurements along gradients at three sites in San Francisco Bay (excerpted from Table 6 of Hunt et al. 2001).

Partial Table	Peyton Slough (Site 1)			Mission Creek (Site 8)			Islais Creek (Site 10)		
	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower
Mean ERM Quotient	2.3	0.4	0.3	3.9	1	0.3	1.2	0.6	0.6
Biological endpoints									
Relative benthic index	0.36	0.51	0.34	0	0.34	0.65	0.22	0.25	0.43
% Amphipod survival	69	59	14	19	58	80	0	81	49
% Normal larvae	1	0	81	11	98	94	8	45	76

As the mean effects range median (ERM) quotients dropped down gradient, the % amphipod survival rate actually decreased in Peyton Slough, increased in Mission Creek and initially increased then decreased in Islais Creek down gradient. The relative benthic index followed the same trend as the % amphipod survival rate only in Mission Creek. This detailed study indicates that characterization of a site requires thorough analyses and even then may yield conflicting results from chemical and biological measurements. Gross inconsistencies among the lines of evidence strongly suggest the potential for data quality issues or the dominant impact of factors other than the considered chemicals. Addressing these types of challenges in the SQO document is imperative to ensure that proper guidance is provided by the Board to those that will be evaluating the data.

Recommendation

A survey of all data used in a site assessment for applicability, relevance, quality assurance, and quality control is a critical component of the process and should be explicitly required in Appendix A. Where the data provide conflicting evidence, particularly along a gradient of chemistry, the results should be declared to be inconclusive. Guidance should be provided regarding the follow up to such a designation. Subsequent monitoring mandated in a permit should be used to resolve the site sediment quality. If a site is rated as inconclusive in two rounds of monitoring, it should be declared to be likely unimpacted.

Issue 6: There is an inconsistency between Appendix A and Appendix C on the application of the logistic model for determining sediment chemical exposure.

The California P_{max} approach is based on the following logistic regression model (CA LRM; Appendix A, H.2., Equation 2, p. 13):

$$p = eB0 + B1(x)/(1 + eB0 + B1(x))$$

Where:

p = probability of observing a toxic effect
$B0$ = intercept parameter
$B1$ = slope parameter
x = concentration of the chemical

The inconsistency is in the application, Appendix C, Direct Effects Station Assessment Example Calculations uses the log of the chemical concentration in Equation 2 and not the concentration of the chemical.

Recommendation

Staff Report needs to specify in Appendix A that chemical concentrations in Equation 2 should be log-transformed.

Issue 7: The use of the proposed LRM is problematic for PCBs.

Field et al. (1999) states that total PCBs "provided poorer fits with the logistic model based on chi-square analyses…" In addition, the study presents the results for various metals and chemicals, but the results indicate that total PCBs tended to fit poorly with the model and the results for total PCBs were relatively sensitive to the endpoints chosen in the toxicity tests. For example, a comparison of 10, 50, and 90 percent effects levels for each amphipod species suggests that *A. abdita* is more sensitive to the effects of sediment-associated contaminants than *R. abronius*, especially for total PCB, fluoranthene, and phenanthrene (Field et al. 1999). For each of these compounds, there was almost an order of magnitude difference between the 50% effects level for different amphipod survival rates. Field et al. (1999) also state that in cases where observed toxicity may be caused by other contaminants, a data screening process was applied to filter out samples for a particular chemical when the concentration was less than or equal to the mean concentration of nontoxic samples in the same study. However, for total PCBs and fluoranthene, this screening process did not effectively eliminate high variability at low concentrations, and the resultant models did not provide as good a fit as the other models based on screened data. In 2002, Field et al. published logistic regression models based on an expanded data set (Field et al. 2002). In this study, total PCB concentrations were calculated for each sediment sample represented in the database. If concentrations of Aroclors or congeners were reported, these values were summed to determine the total PCB concentration. If fewer than 20 congeners were reported, the sum was multiplied by a factor of 2. An improved fit for PCBs was noted; however, the issue of differences in toxicity endpoints was not addressed. As a result, the applicability of the LRM approach to evaluate PCB contaminated sediments is questionable.

Recommendation

Further discussion and analyses should be provided supporting the use of this model for total PCBs in the SQO evaluation.

Conclusions

The Staff's decision to use the MLE approach to establish SQOs in California is commendable; however, serious issues exist with the implementation and application of the proposed approach. These include: 1) the approach is overly conservative and provides little ability to discriminate between impacted and unimpacted sites; 2) the proposed methods to identify a discharger or dischargers responsible for an exceedance are vague and subjective; 3) there are no means provided to determine the extent of pollution abatement required by the discharger or the regulatory process guiding the pollution abatement; and 4) the proposed approach could be prohibitively expensive to regional water boards, monitoring coalitions, and permitted dischargers. We recommend that the Staff carefully review the chemical thresholds used in the evaluation and consider mechanistic approaches and existing background levels prior to setting chemical thresholds, remove the bias toward a single line of evidence indicating impact, classify "Possibly Impacted" stations as unimpaired, increase the binomial testing from 3% exceedance to 20% exceedance for testing the null hypothesis, and specify a minimum number of stations tied to a minimum sampling density. The Staff should also develop a framework for determining if a Permittee is causing or contributing to the SQO exceedance. Important components of this framework include: 1) exempting sampling within mixing zones; 2) the steps necessary to determine causality and effect; 3) guidance on how the link between sediment quality and discharge effluent water quality will be determined; and 4) the methodology to be used to determine the level pollutant abatement that will be required. Finally, the Staff should include requirements that a survey of all data used in the site assessment for applicability, relevance, quality assurance, and quality control should be explicitly required in Appendix A. Where the data provide conflicting evidence, particularly along a gradient of chemistry, the results should be declared inconclusive.

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PROFESSIONAL HISTORY

Quantitative Environmental Analysis, LLC, President and Senior Managing Engineer, February 1998 to present
USEPA Science Advisory Board, 2005 to present
HydroQual, Inc., Principal Engineer, 1993 to January 1998
HydroQual, Inc., Consultant, 1980 to 1993
Manhattan College, Professor, 1992 to 1994
Manhattan College, Associate Professor, 1986 to 1992
Manhattan College, Assistant Professor, 1980 to 1986
U.S. Environmental Protection Agency, Environmental Scientist, 1978 to 1980
Manhattan College, Research Engineer, 1975 to 1977

EDUCATION

The University of Texas at Austin, Ph.D., 1980
Manhattan College, M.E., Environmental Engineering, 1975
Manhattan College, B.E., Civil Engineering, 1973

REGISTRATION

Professional Engineer, State of Texas (License No. 92122)
Professional Engineer, State of New York (License No. 59428)

EXPERIENCE SUMMARY

Dr. Connolly is a nationally recognized expert on contaminated sediments and eutrophication. His work has been directed to surface water and groundwater contamination problems for the purposes of allocation among potential sources, evaluation of remedial options, remedy design or wasteload allocation (TMDLs). He is expert in water quality modeling and has been involved in the development of several models commonly applied to real world problems. He is also recognized for his ability to communicate complex technical results to the range of stakeholders typically involved in projects and is frequently called on to make presentations at regulatory hearings, community meetings and national and regional technical forums. Dr. Connolly has participated in negotiations with regulatory agencies to craft consent decrees governing contaminated sediment sites.

Dr. Connolly is frequently invited to participate in government and industry sponsored workshops. He is a member of the USEPA Science Advisory Board. He has worked throughout the U.S., in Latin America, and in Europe. He has served as an expert witness for industry and government agencies and has provided testimony before the U.S. Congress and the New York State Assembly. He is also a member of the Manhattan College Council of Engineering Affairs.

TESTIMONY

Town of Oyster Bay vs. Northrop Grumman Systems Corp., United States Navy and United States of America.
For defendants United States Navy and United States of America; expert witness testimony at deposition on 6/27/07 regarding the likelihood that PCBs in the soils of a town park originated from a site on Grumman property owned by the United States Navy.

Maine Environmental Protection Board.
Expert testimony given on 5/2/07 regarding the deficiencies of a phosphorus, TSS and BOD TMDL developed for Gulf Island Pond on the Androscoggin River and the contributions of various sources to existing algal and dissolved oxygen problems.

Subcommittee on Water Resources and Environment of the U.S. House of Representatives Transportation and Infrastructure Committee Hearing on Strategies to Address Contaminated Sediments.

Expert testimony given on 7/19/01 regarding the approaches used by USEPA to address contaminated sediments.

Maine Peoples' Alliance and Natural Resources Defense Council, Inc. vs. HoltraChem Manufacturing Company, LLC and Mallinckrodt, Inc.
For defendant Mallinckrodt; expert witness testimony at deposition on 7/3/01 and at trial on 3/12/02 regarding mercury bioavailability in the Penobscot River Estuary.

United States of America vs. Montrose Chemical Corporation of California, et al.
For plaintiff United States of America; expert witness testimony at deposition from 7/13 to 7/17/98 and 4/6/00 and at trial 10/19/00 regarding the transfer of DDT and PCBs from contaminated sediment in coastal waters off Los Angeles to fish, birds and sea lions.

Kalamazoo River Study Group vs. Rockwell International, et al.
For defendant Eaton Corporation; fact witness testimony at deposition on 7/22/97, expert testimony at deposition on 1/26/98 and trial testimony on 8/17 and 8/21/98, 1/19/01 and 2/5 and 2/6/01 regarding technical analyses conducted to evaluate the PCB contributions from Eaton's Battle Creek and Marshall facilities to the Kalamazoo River.

New York State Assembly Standing Committee on Environmental Conservation Public Hearing on PCB Contamination in the Hudson River.
Expert testimony given on 3/19/97 on behalf of the General Electric Company regarding the sources of PCBs observed in Hudson River fish.

Alcoa and Northwest Alloys, Inc. vs. Accident & Casualty Insurance Company, et al.
For plaintiff Alcoa; expert witness testimony at deposition on 2/28 and 3/1/96 regarding the nature, extent and expansion of sediment contamination at Alcoa facilities in Massena, New York and Point Comfort, Texas.

MAJOR PROJECTS

Contaminated Sediments Assessment and Management

Peer Review of Contaminated Sediment Remediation Guidance for Hazardous Waste Sites
Client: USEPA
One of three national experts tasked with reviewing the draft guidance document which has been developed to provide technical and policy guidance to project managers and management teams making remedy decisions for contaminated sediment sites.

Source Allocation for Mercury in the Penobscot River Estuary
Client: Mallinckrodt, Inc.
Principal investigator for evaluation of the relative contributions of sediment and water column mercury to mercury found in resident biota. This study involved data analysis and development of a conceptual modeling explaining the probable reasons of the apparent lack of impact of elevated sediment mercury concentrations on biota mercury levels. The work was used to provide litigation support through expert testimony. Subsequent to litigation, work has focused on development of a detailed investigation plan, interaction with a court-mandated Study Panel, technical support for the client's legal team and oversight of planned field work.

Source Allocation for Mercury in the Peconic River
Client: Brookhaven National Laboratory
Principal investigator for investigations to determine the sources of methyl mercury in the fish of the Peconic River. This study involved the design of sampling programs and interpretation of data to determine the relative contributions of background sources and various sediment deposits throughout the river to methyl mercury in the water and fish. This work was conducted to satisfy a diverse group of stakeholders with differing positions on appropriate remediation. It led to a revision of the contemplated remedial action and a convergence of opinion on the best approach for the river.

Investigation of Mercury in Lavaca Bay
Client: Alcoa
Principal investigator for the evaluation of mercury sources and prediction of the impacts of remedial actions and storm events on mercury levels in sediment and biota. The project involves data analysis and the development of linked hydrodynamic, sediment transport, mercury fate and bioaccumulation models. A primary goal is the evaluation of the impact of hurricanes and other rare storms on buried mercury.

Remediation of the Hudson River PCBs Site

Client: General Electric Company

Principal investigator for various aspects of remedial design (RD), including the design and execution of an extensive pre-design sediment sampling program involving the collection of more than six thousand sediment cores, management of the RD database, determination of the dredging prisms, design and execution of the baseline and construction monitoring programs and support of the design of dredging and processing of dredged sediment. This project included the development of sophisticated data entry, data processing and data display systems that were used by the GE design team. Additional activities included direct participation in consent decree negotiations.

Analysis of the Fate of PCBs in the Hudson River

Client: General Electric Company

Principal investigator for extensive data analysis and modeling studies of the dynamics of PCBs in the Hudson River. This study involved field sampling, data analysis and the development of linked hydrodynamic, physical/chemical, sediment transport and food chain models for the purpose of predicting the effects of alternative remediation plans.

Analysis of the Fate of PCBs in the Grasse River

Client: Alcoa

Principal investigator for the determination of the impacts of contaminated sediments and point sources to PCB contamination in resident fish. Efforts include the design of field sampling programs, estimation of PCB fluxes between water and sediment, including the importance of areas of elevated concentrations and the transport and bioaccumulation in the food web. Goal is to provide a technical basis for examination of remedial options.

Assessment of Contribution of PCBs to the Kalamazoo River from Eaton Corporation

Client: Eaton Corporation

Principal investigator for the analysis of data and development of models to evaluate whether either or both of two Eaton facilities contributed measurable quantities of PCBs to the Kalamazoo River. The project involved the compilation and analysis of historical data, design and execution of a sampling program and the development of models to predict the transport of sediment and PCBs through the Kalamazoo River.

Analysis of the Fate of PCBs in the Housatonic River

Client: General Electric Company

Technical advisor for extensive data analysis and modeling studies directed to determining the appropriate remedial solution for the contaminated sediments. This study involves data analysis and the development of linked hydrodynamic, sediment transport, PCB fate and PCB bioaccumulation models. An important aspect of this project is the evaluation of the role of river flooding in PCB fate and impact of flood plain soils.

Modeling of Heavy Metal and Organic Contaminant Fate in the Pawtuxet River to Support a RCRA Facility Investigation

Client: Ciba-Geigy Corporation

Principal investigator for determination of target chemicals by qualitative risk analysis, design of a sampling program and development of a model to evaluate temporal and spatial concentration reductions resulting from remedial action alternatives including excavation and groundwater treatment.

Analysis of DDE and PCB Transfer Pathways in the Southern California Bight Ecosystem

Client: National Oceanic and Atmospheric Administration

Principal investigator for the analysis of data and development of food chain models to study the relationship between sediment contamination and levels of DDE and PCBs in fish, mammals, and birds. The purpose of this work was to establish probable sources of contamination in support of a Natural Resource Damages Assessment.

Contaminated Groundwater Assessment and Management

Evaluation of Solvent Plume Migration and Fate at the MW Manufacturing Site, Valley Township of Pennsylvania

Client: Lucent Technologies

Principal investigator for the development and application of flow and transport models to be used to predict the movement and decay of a VOC plume composed of PCE, TCE, 1,2-DCE and vinyl chloride. The goal of the project is to estimate whether the plume has achieved a steady-state configuration in response to a non-aqueous phase source and to project discharge rates to a local stream.

Modeling of Groundwater Remediation Using Vertical Groundwater Circulation Technology

Client: SBP Technologies

Principal investigator for the development of a strategy to model the treatment efficiency of *in-situ* vertical groundwater circulation technology. Work included the evaluation of circulation, nutrient dynamics and PAH biodegradation and volatilization. The goal was to develop a modeling framework that could be used to design sampling strategies and evaluate treatment efficiency.

Total Maximum Daily Load (TMDL) Investigations

Evaluation of the Phosphorus, TSS and BOD TMDL for Gulf Island Pond on the Androscoggin River, Maine

Client: Verso Paper Company

Principal investigator for the critique of the TMDL developed by Maine DEP and the examination of the contributions of point and non-point sources to algal and dissolved oxygen problems in the Pond.

San Francisco Bay PCBs

Client: General Electric Company

Principal investigator for the review and critique of a draft TMDL document issued by the San Francisco Bay Regional Water Quality Control Board. This study involved the analysis of data and modeling to provide the Board with the information necessary to correct deficiencies in the draft document with regard to natural recovery and the need for, and effectiveness of, available source control options and to develop an effective implementation strategy. It included the development of presentation materials and a face-to-face meeting with the authors of the document.

Coosa River PCBs

Client: General Electric Company

Principal investigator for the review and critique of a draft TMDL document issued by the State of Georgia. This study involved the analysis of data to provide the State with the information necessary to correct deficiencies in the draft document with regard to natural recovery and the need for, and effectiveness of, available source control options and to develop an effective implementation strategy. It included the development of presentation materials and a face-to-face meeting with the State and with EPA Region 4.

Water Quality/Eutrophication Assessment

Assessment of the Environmental Fate and Impact of ICE-B-GON on Lake Wingra, Wisconsin

Client: Chevron Research Company

Principal investigator for the laboratory determination of the degradation and oxygen utilization kinetics of the de-icing chemical, ICE-B-GON and projection of the effect of the use of this chemical on the dissolved oxygen of receiving waters using Lake Wingra as a case study.

Mathematical Modeling of Water Quality in Lake Erie

Client U.S. Environmental Protection Agency, Grosse Ile, Michigan

Project Engineer in charge of data analysis development and calibration of an eutrophication model including multiple algal species and zooplankton, and projections of the effects of reduction in point and non-point nutrient loadings on pollution indicators; lake phytoplankton, nutrient, and dissolved oxygen levels.

Analysis of Heavy Metals, Ammonia and Cyanide in the Genesee River

Client: Eastman Kodak Corporation

Project Engineer in charge of data analysis, mathematical model development and assessment of the relative impact of the Kodak treatment plant effluent on water quality in the River.

Analysis of the Fate of Toxic Chemicals in Estuaries

Client: U.S. Environmental Protection Agency, Gulf Breeze, Florida

Project Manager in charge of development of a mathematical model describing the transport and degradation of toxic chemicals in estuarine environments.

Development of Version 4.0 of the Water Analysis Simulation Program (WASP)

Client: U.S. Environmental Research Laboratory, Athens, Georgia

The purpose of this project was to modify the USEPA water quality model WASP (3.2) to provide a single modeling framework for use in all types of surface water problems including conventional and toxic pollutants under steady-state or time-variable conditions. Responsibilities included the development of the kinetic routines for the toxic chemical component of the model from those used in EXAMS II, TOXIWASP and WASTOX, integration of the WASTOX steady-state solution into WASP and providing technical assistance on all other components of model development.

Ecological Risk/Natural Resource Damage Assessments

Development of Water Quality Criteria for Wildlife

Client: U. S. Environmental Protection Agency

Principal investigator for the development of methodologies to determine water concentrations protective of aquatic feeding wildlife. Defined methods to relate laboratory toxicity estimates to wildlife species. Efforts included compilation and analysis of toxicity data, development of models to permit extrapolation of laboratory toxicity data to field animals and development of models of the relationship between water column contaminant concentrations and effects in wildlife. Initial work focused on dieldrin and DDT.

Modeling PCBs in the Aquatic Biota of Green Bay

Client: U.S. Environmental Protection Agency

Principal investigator for the development and application of a model of PCBs in the food web of Green Bay. This work is part of the Green Bay Mass Balance Study for the U.S. Environmental Protection Agency. The purpose of these studies was to evaluate the impacts of potential remediation alternatives.

Analysis of PCBs and Metals Contamination in the Biota of New Bedford Harbor, Massachusetts

Client: U.S. Environmental Protection Agency, Region I, Battelle Ocean Sciences

Project manager in charge of developing a mathematical model of the contamination of the lobster and winter flounder and their food chains in New Bedford Harbor and Buzzards Bay. Responsible for linking this model with a hydrodynamic-contaminant fate model developed by Battelle Northwest to project the response of the biota to various remedial action alternatives. This work was part of an EPA Superfund project in New Bedford Harbor.

Analysis of PCBs in the Hudson River Striped Bass and its Food Chain

Client: Hudson River Foundation, New York, NY

Project manager in charge of the development of a mathematical model describing the accumulation of PCBs in the striped bass food chain.

Analysis of Kepone Accumulation in the Striped Bass Food Web of the James River Estuary

Client: U.S. Environmental Protection Agency, Gulf Breeze, Florida

Project manager in charge of the development and application of a mathematical model describing the accumulation of the pesticide Kepone in the striped bass food chain. Projected the response of the food chain to declining exposure concentrations.

Pathogen Fate and Transport

Development of a Framework for Predicting the Fate of Genetically Engineered Microorganisms in Surface Water Systems

Client: U.S. Environmental Protection Agency, Environmental Research Laboratory, Gulf Breeze, Florida

Principal investigator for the development of a model of the population dynamics of bacteria, phytoplankton and zooplankton in surface waters and application of this model to predicting the risk associated with the introduction of genetically engineered bacteria to these environments. Population dynamics models were developed for the Delaware River and Mirror Lake.

Modeling Fate and Transport of Pathogenic Organisms in Mamala Bay, Hawaii

Client: Mamala Bay Study Commission

Principal investigator for review of historical data, design of a sampling program and development and calibration of a mathematical model of pathogen fate in Mamala Bay. Goal is to determine pathogen sources and level of control necessary to meet water quality goals.

Evaluation of Cryptosporidium Sources and Fate in Milwaukee, Wisconsin

Client: Sara Lee Corporation

Principal investigator for the evaluation of the likely contribution of various potential sources to the Cryptosporidium responsible for a disease outbreak in the city of Milwaukee.

Hydraulic Engineering

Hydraulic Analysis of the Fairfield, New Jersey Sewer System

Client: Lee Purcell Associates, Inc.

Project engineer in charge of determining the capacity and flow characteristics of an in-place sewer system. Developed a gradually varied flow analysis for this purpose.

HONORS

Diplomate Environmental Engineer by Eminence, American Academy of Environmental Engineers, 2002
Manhattan College Environmental Engineering Alumni Club Service Award, 1994

PROFESSIONAL ACTIVITIES

Affiliations

American Academy of Environmental Engineers
Sigma Xi - The National Scientific Research Society
Society of Environmental Toxicology and Chemistry
American Society of Limnology and Oceanography
Water Environment Federation

Committees and Advisory Boards

2005	USEPA Science Advisory Board
1997	USEPA Technical Qualifications Board to review promotion application
1991-96	New York Water Environment Association Outstanding Paper Award Committee
1990-95	DuPont Technical Advisory Board for Evaluation of HMPA Releases at their Spurance Plant in Richmond, VA
1990	USEPA Exploratory Research Review Panel

Invited Participation in Technical Workshops

Addressing Uncertainty and Managing Risk at Contaminated Sediment Sites. St. Louis, MO October 26-28, 2004 – Steering Committee Member.

SERDP/ESTCP Contaminated Sediments Workshop. Arlington, VA August 10-11, 2004.

Stability of Chemicals in Sediments. San Diego, CA April 8-10, 2003 – Steering Committee Member.

Sediment Stability Workshop. New Orleans, LA, January 22-24, 2002 – Steering Committee Member.

U.S. EPA Forum on Contaminated Sediments. Alexandria, VA, May 30-June 1, 2001.

National Research Council Workshop on Bioavailability. Washington, D.C., November 12, 1998.

SETAC Pellston Workshop: Re-evaluation of the State of the Science for Water Quality Criteria Development. Fairmont Hot Springs, MT, June 25-30, 1998.

National Academy of Sciences National Symposium on Contaminated Sediments. Washington, D.C., May 27-29, 1998.

SETAC Pellston Workshop: Reassessment of Metals Criteria for Aquatic Life Protection. Pensacola, FL, February 10-14, 1996.

California EPA Workshop on Critical Issues in Assessing Ecological Risk. Asilomar, CA, January 23-25, 1995.

USEPA Workshop on Taura Syndrome. Gulf Breeze, FL, August 2-3, 1994.

USEPA Workshop on Modeling Uncertainty. Buffalo, NY, February 3-5, 1991.

USEPA Workshop on Sediment Quality Criteria. Grosse Ile, MI, March 29-30, 1990.

Industry Sponsored Workshop on the Environmental Impacts of the Deicer Calcium-Magnesium-Acetate. Albany, NY, February 27, 1990.

USEPA Workshop on Biotechnology Risk Assessment. Breckenridge, CO, January 11-15, 1988.

SETAC Workshop on Risk Assessment. Breckenridge, CO, August 17-21, 1987.

PRESENTATIONS

Overview of the 2005 Grasse River Remedial Options Pilot Study. Fourth International Conference on Remediation of Contaminated Sediments, Savannah, GA, January 22-25, 2007.

Challenges to Monitoring and Assessing Natural Recovery. Third International Conference on Remediation of Contaminated Sediments, New Orleans, LA, January 27, 2005.

Monitoring to Support the Dredging Remedy on the Upper Hudson River. Third International Conference on Remediation of Contaminated Sediments, New Orleans, LA, January 26, 2005.

Adaptive Management as a Measured Response to the Uncertainty Problem. Addressing Uncertainty and Managing Risk at Contaminated Sediment Sites, St. Louis, MO, October 27, 2004

Optimal Use of Conceptual and Mathematical Models at Contaminated Sediment Sites. Addressing Uncertainty and Managing Risk at Contaminated Sediment Sites, St. Louis, MO, October 27, 2004

Sampling of Sediment and Water in the Upper Hudson River to Support the USEPA Dredging Remedy. Hudson River Environmental Society Conference, RPI, Troy, NY, October 5, 2004

Nature and Causes of Non-Particle Related Contaminant Releases in Large River Systems. Workshop on Environmental Stability of Chemicals in Sediments, San Diego, CA, April 10, 2003

Management of Contaminated Sediments. NSF US/Italy Workshop on Sediments, Arlington, VA, December 10, 2002

Use of Sound Science to Develop a Defensible Site Model. U.S. EPA Forum on Managing Contaminated Sediments, Alexandria, VA, May 31, 2001.

A Quantitative Framework for Evaluating Contaminated Sediment Sites. SETAC 20th Annual Meeting, Philadelphia, PA, November 14-18, 1999.

Prediction of Natural Recovery and the Impacts of Active Remediation in the Upper Hudson River. SETAC 20th Annual Meeting, Philadelphia, PA, November 14-18, 1999.

Evaluation of Remedial Alternatives for Contaminated Sediments: A Coherent Decision-Making Approach. National Research Council, National Symposium on Contaminated Sediments, Washington, D.C., May 28, 1998.

Applications of Models to the Risk Assessment Problem. Chesapeake Biological Laboratory, Solomans, MD, November 1, 1996.

Use of Food Web Models to Evaluate Bioaccumulation Data. National Sediment Bioaccumulation Conference, Bethesda, MD, September 11, 1996.

Assessment and Remediation of Contaminated Sediments at MGP Sites. Electric Power Research Institute, Monterey, CA, August 28, 1996.

Modeling the Environmental Fate and Transport of Metals. 26th Pellston Workshop: Reassessment of Metals Criteria for Aquatic Life Protection, Pensacola, FL, February 11, 1996.

Toxicologically Based Ecological Risk Assessment. California EPA Workshop on Critical Issues in Assessing Ecological Risk, Asilomar, CA, January 24, 1995.

Data Requirements for the Development and Use of Water Quality Models. USEPA Conference on Quality Assurance in Environmental Decision Making, IBM T.J. Watson Research Center, Yorktown Heights, NY, November 2, 1994.

Mathematical Modeling of the Bioaccumulation of Hydrophobic Organics. National Biological Survey, Columbia, MO, August 25, 1994.

A Model-Based Evaluation of PCB Bioaccumulation in Green Bay Walleye and Brown Trout. International Association for Great Lakes Research 36th Conference on Great Lakes Research, De Pere, WI, June 7, 1993.

Bioaccumulation Modeling of Micropollutants in the Field. International Workshop on Mechanisms of Uptake and Accumulation of Micropollutants, Veldhoven, The Netherlands, May 25, 1993.

Keynote Presentation. NIEHS Sponsored Workshop on the Bioaccumulation of Hydrophobic Organic Chemicals in Aquatic Organisms, June 29, 1992.

Modeling the Role of Bacteria in Carbon Cycling. Gordon Research Conference, New Hampton, New Hampshire, June 17, 1992.

Calcium Magnesium Acetate Biodegradation and its Impact on Surface Waters. Symposium on the Environmental Impact of Highway Deicing, University of California, Davis, October 13, 1989.

Food Chain Modeling in the Green Bay Mass Balance Study. International Association for Great Lakes Research 32nd Conference on Great Lakes Research, Madison, WI, June 2, 1989.

Modeling the Fate of Bacteria in Aquatic Systems. American Society for Microbiology Annual Conference, New Orleans, LA, May 18, 1989.

Application of a Food Chain Model to Evaluate Remedial Alternatives for PCB-Contaminated Sediments in New Bedford Harbor, MA, Superfund '88, Washington, D.C., November 29, 1988.

Modeling the Accumulation of Organic Chemicals in Aquatic Animals. Joint USA/USSR Symposium: Fate of Pesticides and Chemicals in the Environment, The University of Iowa, Iowa City, IA, November 15, 1987.

Modeling Kepone in the Striped Bass Food Chain of the James River. Virginia State Water Control Board, Richmond, VA, August 15, 1983.

Predicting the Effects of Toxic Chemicals in Natural Water Systems. U.S. Environmental Protection Agency, Environmental Research Lab, Athens, GA, November 3, 1982.

Modeling Toxic Substances in Aquatic Food Chains. Clarkson College Environmental Engineering Graduate Program, Potsdam, NY, October 29, 1982.

Predicting the Effects of Toxic Chemicals in Natural Water Systems. U.S. Environmental Protection Agency, Environmental Research Lab, Gulf Breeze, FL, September 13, 1982.

Modeling of Fate of Toxic Chemicals in Aquatic Systems. U.S. Environmental Protection Agency, Office of Toxic Substances, Washington, D.C., March 16, 1982.

PUBLICATIONS

Comment on "The Long-Term Fate of Polychlorinated Biphenyls in San Francisco Bay, (USA)". Connolly, J.P., C.K. Ziegler, E.M. Lamoureux, J.A. Benaman and D. Opydke, *Envion. Toxicol. Chem.* 24:2397-2398, 2005.

p,p'-DDE Bioaccumulation in Female Sea Lions of the California Channel Islands. Connolly, J.P. and D. Glaser, *Continental Shelf Res.* 22:1059-1078, 2002.

A model of p,p'-DDE and total PCB bioaccumulation in birds from the Southern California Bight. Glaser D, J.P. Connolly, *Continental Shelf Research* 22:1079-1100, 2002.

Use of a Bioaccumulation Model of p,p'DDE and Total PCB in Birds as a Diagnostic Tool for Pathway Determination in Natural Resource Damage Assessments. Glaser, D. and J.P. Connolly, *Continental Shelf Res.* In press.

Modeling of Flood and Long-Term Sediment Transport Dynamics in Thompson Island Pool, Upper Hudson River. Ziegler, C.K., P. Israelsson and J.P. Connolly, *Water Quality and Ecosystem Modeling* 1:193-222, 2000.

Modeling of Natural Remediation: Contaminant Fate and Transport. Peyton, B.M., T.P. Clement and J.P. Connolly, In: *Natural Remediation of Environmental Contaminants: Its Role in Ecological Risk Assessment and Risk Management,* Swindoll, C.M., R.G. Stahl & S.J. Ells, eds., SETAC Press, 472 p., 2000.

The Use of Ecotoxicology and Population Models in Natural Remediation. D. Glaser and J.P. Connolly, In: *Natural Remediation of Environmental Contaminants: Its Role in Ecological Risk Assessment and Risk Management,* Swindoll, C.M., R.G. Stahl & S.J. Ells, eds., SETAC Press, 472 p., 2000.

A Model of PCB Fate in the Upper Hudson River. Connolly, J.P., H.A. Zahakos, J. Benaman, C.K. Ziegler, J.R. Rhea and K. Russell, *Environ. Sci. Technol.* 34:4076-4087, 2000.

Modeling the Fate of Pathogenic Organisms in the Coastal Waters of Oahu, Hawaii. Connolly, J.P., A.F. Blumberg and J.D. Quadrini, *J. Environ. Eng.* 125:398-406, 1999.

Bacteria and Heterotrophic Microflagellate Production in the Santa Rosa Sound, Fl. Coffin, R.B. and J.P. Connolly, *Hydrobiologia* 353:53-61, 1997.

Hudson River PCBs: A 1990s Perspective. Rhea, J., J. Connolly and J. Haggard, *Clearwaters*, 27:24-28, 1997.

Modeling the Environmental Fate and Transport of Metals. Connolly, J.P., In: *Reassessment of Metals Criteria for Aquatic Life Protection,* Bergman H.L. and E.J. Dorward-King, eds., SETAC Press, 1997.

The Use of Vertical Groundwater Circulation Technology: A Preliminary Analysis of the Fate and Transport of Polycyclic Aromatic Hydrocarbons in a Shallow Aquifer. Connolly, J.P. and J.D. Quadrini, In: *In Situ Bioremediation and Efficacy Monitoring,* Spargo, B.J. ed., Naval Research Laboratory, NRL/PU/6115-96-317, 1996.

A Model of Carbon Cycling in the Planktonic Food Web. Connolly, J.P. and R.B. Coffin, *J. Envir. Eng.* 121:682-690, 1995.

The Impact of Sediment Transport Processes on the Fate of Hydrophobic Organic Chemicals in Surface Water Systems. Ziegler, C.K. and J.P. Connolly, *Toxic Substances in Water Environments: Assessment and Control,* Proceedings of the Water Environment Federation Specialty Conference, May 14-17, 1995.

Uncertainty in Bioaccumulation Modeling. Glaser, D. and J.P. Connolly, *Toxic Substances in Water Environments: Assessment and Control,* Proceedings of the Water Environment Federation Specialty Conference, May 14-17, 1995.

Toxicologically Based Ecological Risk Assessment. Connolly, J.P., In: *Critical Issues in Assessing Ecological Risk,* Summary of Workshop held at Asilomar Conference Center, Pacific Grove, CA, University Extension, University of California, Davis, January 23-25, 1995.

Availability of Dissolved Organic Carbon to Bacterioplankton Examined by Oxygen Utilization. Coffin, R.B., J.P. Connolly and P.S. Harris, *Mar. Ecol. Prog. Ser.* 101:9-22, 1993.

Do Aquatic Effects or Human Health End Points Govern the Development of Sediment-Quality Criteria for Nonionic Organic Chemicals? Parkerton, T.F., J.P. Connolly, R.V. Thomann and C.G. Urchin, *Environ. Toxicol. Chem.* 12:507-523, 1993.

An Equilibrium Model of Organic Chemical Accumulation in Aquatic Food Webs with Sediment Interaction, Thomann, R.V., J.P. Connolly and T.F. Parkerton, *Environ. Toxicol. Chem.* 11:615-629, 1992.

Modeling the Accumulation of Organic Chemicals in Aquatic Food Chains. Connolly, J.P. and R.V. Thomann, In: *Fate of Pesticides and Chemicals in the Environment,* Schnoor, J.L. ed., John Wiley & Sons, Inc., 1991.

Modeling Carbon Utilization by Bacteria in Natural Water Systems. Connolly, J.P., R.B. Coffin and R.E. Landeck. In: *Modeling the Metrobolic and Physiologic Activities of Microorganisms,* C. Hurst, ed., John Wiley & Sons, Inc., 1991.

Application of a Food Chain Model to Polychlorinated Biphenyl Contamination of the Lobster and Winter Flounder Food Chains in New Bedford Harbor. Connolly, J.P., *Environ. Sci. Technol.*, 25(4):760-770, 1991.

The Relationship between PCBs in Biota and in Water and Sediment from New Bedford Harbor: A Modeling Evaluation. Connolly, J.P., In: *Persistent Pollutants in the Marine Environment*, C.H. Walker and D. Livingstone, eds., Pergamon Press, Inc., 1991.

Fate of Fenthion in Salt-Marsh Environments: II. Transport and Biodegradation in Microcosms. O'Neill, E.J., C.R. Cripe, L.H. Mueller, J.P. Connolly and P.H. Pritchard, *Environ. Tox. Chem.* 8(9):759-768, 1989.

A Thermodynamic-Based Evaluation of Organic Chemical Accumulation in Aquatic Organisms. Connolly, J.P. and C.J. Pedersen, *Environ. Sci. Technol.* 22(1):99-103, 1988.

Mathematical Models - Fate, Transport and Food Chain. O'Connor, D.J., J.P. Connolly and E.J. Garland, In: *Ecotoxicology: Problems and Approaches*. Lavin, S.A., M.A. Harwell, J.R. Kelly and K.D. Kimball, eds., Springer-Verlag, New York, 1988.

Simulation Models for Waste Allocation of Toxic Chemicals: A State of the Art Review. Ambrose, Jr., R.B., J.P. Connolly, E. Southerland, T.O. Barnwell, Jr. and J.L. Schnoor, *J. Wat. Poll. Con. Fed.* 60(9):1646-1655, 1988.

The Great Lakes Ecosystem - Modeling the Fate of PCBs. Thomann, R.V., J.P. Connolly and N.A. Thomas, In: *PCBs and the Environment, Vol 3*, Waid, J.S. ed., CRC Press, Inc. Boca Raton, Florida, pp. 153-180, 1987.

A Post Audit of a Lake Erie Eutrophication Model. DiToro, D.M., N.A. Thomas, C.E. Herdendorf, R.P. Winfield and J.P. Connolly, *J. Great Lakes Res.* 13(4):801-825, 1987.

Movement of Kepone (Chloradecone) Across an Undisturbed Sediment-Water Interface in Laboratory Systems. Pritchard, P.H., C.A. Monti, E.J. O'Neill, J.P. Connolly and D.G. Ahearn, *Environ. Tox. Chem.*, 5:647-658, 1986.

Bioaccumulation of Kepone by Spot (*Leiostomus xanthurus*): Importance of Dietary Accumulation and Ingestion Rate. Fisher, D.J., J.R. Clark, M.H. Roberts, Jr., J.P. Connolly and L.H. Mueller, *Aquatic Tox.* 9:161-178, 1986.

A Model of Kepone in the Striped Bass Food Chain of the James River Estuary. Connolly, J.P. and R. Tonelli, *Estuarine, Coastal & Shelf Science* 20:349-366, 1985.

Predicting Single Species Toxicity in Natural Water Systems. Connolly, J.P., *Environ. Tox. Chem.* 4:573-582, 1985.

WASTOX, A Framework for Modeling Toxic Chemicals in Aquatic Systems, Part II: Food Chain. Connolly, J.P. and R.V. Thomann, U.S. Environmental Protection Agency, Gulf Breeze, FL, EPA 600/3-85-017, 1985.

A Model of PCB in the Lake Michigan Lake Trout Food Chain. Thomann, R.V. and J.P. Connolly, *Environ. Sci. Tech.* 18(2):65-71, 1984.

WASTOX, A Framework for Modeling Toxic Chemicals in Aquatic Systems. Connolly, J.P. and R.P. Winfield, U.S. Environmental Protection Agency, Gulf Breeze, FL, EPA 600/3-84-077, 1984.

Adsorption of Hydrophobic Pollutants in Estuaries. Connolly, J.P., Armstrong, N.E. and R.W. Miksad, ASCE *J. Envir. Eng. Div.* 109(1):17-35, 1983.

Calculated Contribution of Surface Microlayer PCB to Contamination of the Lake Michigan Lake Trout. Connolly, J.P. and R.V. Thomann, *J. Great Lakes Research* 8(2):367-375, 1982.

Mathematical Modeling of Water Quality in Large Lakes, Part 2. Di Toro, D.M. and J.P. Connolly, Lake Erie, U.S. Environmental Protection Agency, Ecological Research Series, EPA-600/3-80-065, 1980.

The Effect of Concentration of Adsorbing Solids on the Partition Coefficient. O'Connor, D.J. and J.P. Connolly, *Water Research* 14(10):1517-1523, 1980.

ELIZABETH M. LAMOUREUX

CONTACT INFORMATION

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(201) 930-9890
(201) 930-9805 *fax*
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PROFESSIONAL HISTORY

Quantitative Environmental Analysis, LLC. Managing Scientist, January 2003 to present

Quantitative Environmental Analysis, LLC. Senior Project Scientist, January 2001 to 2002

Quantitative Environmental Analysis, LLC. Project Scientist, August 1998 to December 2000

Marine Sciences Research Center, State University of New York at Stony Brook, Research Assistant, 1995 to 1998

Nassau County Community College, Professor of Environmental Science, 1995 to 1996

Division of Environmental Contaminants, U.S. Fish and Wildlife Service, Dean John A. Knauss Marine Policy Fellow, 1994 to 1995

Marine Sciences Research Center, State University of New York at Stony Brook, Research Assistant, 1991 to 1993

Fanning, Phillips & Molnar, Environmental Scientist, 1990 to 1991

RGM Liquid Waste Removal Corp., Environmental Compliance Officer, 1989 to 1990

Pednault Associates, Department Head of Wet Laboratory, 1987 to 1989

EDUCATION

Marine Sciences Research Center, State University of New York at Stony Brook, Ph.D. Candidate

Marine Sciences Research Center, State University of New York at Stony Brook, M.S., Marine Environmental Sciences, 1995

State University of New York at Buffalo, B.A., Environmental Studies, 1986

EXPERIENCE SUMMARY

Ms. Lamoureux has 17 years of experience as an environmental scientist, with particular expertise in the bioavailability and bioaccumulation of contaminants, as well as in risk assessment. Her work centers on the compilation and management of large databases, the analysis and integration of environmental data, and computer modeling. She also evaluates risk assessment methodology used to develop sediment and water quality criteria and cleanup targets. Her extensive experience in the performance of experimental laboratory studies provides an important foundation for the development of realistic, effective solutions to environmental problems. She presents technical papers at scientific conferences and participates in local conferences and national societies.

Ms. Lamoureux has experience with the study of environmental problems in the private sector, in government, and in academia. Her Ph.D. research involved the investigation of the role of desorption in controlling the bioavailability of sediment-associated hydrophobic organic contaminants. She acquired invaluable experience in the areas of environmental contaminant fate in biological systems and in environmental risk assessment while working at U.S. Fish and Wildlife Service National Headquarters in Washington, D.C. Her Master's work focused on the use of a source-specific tracer to study the fate and transport of organic matter and contaminants at the 106-Mile Deep Water Disposal Site. Ms. Lamoureux has also worked in the general area of environmental characterization at consulting firms and at an environmental test laboratory.

MAJOR PROJECTS

Upper Hudson River Dredging

Client: General Electric Company

Involved in the development of the baseline monitoring program for Upper Hudson River dredging operation. Currently is involved in the analysis of data generated through the baseline monitoring program. Additionally, Ms. Lamoureux is also manages analysis support for habitat delineation and restoration efforts.

Bioaccumulation Modeling of PCBs in the Upper Hudson River

Client: General Electric Company

Manages the bioaccumulation model developed for the Upper Hudson River. Responsibilities include constructing model inputs, performing model simulations and processing and interpreting model output. Also conducts model projections to evaluate the relative benefits of various source control and dredging scenarios on PCB levels in resident fish.

PCBs in the Upper Hudson River

Client: General Electric Company

Currently oversees the management and analysis of Hudson River contaminant databases collected through various monitoring programs. Projects involve looking at the temporal and spatial trends of PCBs and other contaminants in Hudson River sediments and biota.

San Francisco Bay PCBs TMDL review

Client: General Electric Company

Involved in a critical analysis of the mass balance and food web models developed for the San Francisco Bay Total Maximum Daily Load (TMDL). Develops approaches to understand the sources and loadings of PCBs to the Bay and identification of data gaps. Reviews issues related to PCB load allocation and target concentrations for fish and sediment.

Fox River/Green Bay Remedial Investigation and Feasibility Study

Client: ThermoRetec, Inc. for Wisconsin Department of Natural Resources

Ms. Lamoureux was responsible for revision of the PCB aquatic food web bioaccumulation model for the Lower Fox River and Green Bay for the RI/FS.

Bioavailability of Sediment-Sorbed Hydrophobic Contaminants

Client: Hudson River Foundation

Conducted research to further understand the mechanisms that control the bioavailability of sediment-sorbed hydrophobic contaminants to deposit-feeding organisms. Research included a combination of field and laboratory studies; the level of contaminant bioaccumulation measured in the field and laboratory were compared with measured contaminant desorption rates. Experiments were designed to look at the effects of the quality and quantity of organic and soot sediment carbon content, sediment aging, the dynamics of sediment diagenesis, species, organism size, gut surfactant level, and feeding strategy, on contaminant desorption and assimilation efficiency. Results suggest that gut surfactant level is the most important mechanism controlling hydrophobic contaminant assimilation in deposit-feeders, although the quality and quality of organic and soot sediment carbon content also play a major role. Research conducted as part of doctoral work.

Fate and Availability of Linear-Alkyl Benzenes Released from Underwater Electrical Power Transfer Lines

Client: Northeastern Utilities

Conducted an analysis of linear-alkyl benzenes (LABs) in Long Island Sound sediments. Study also involved the analysis of source material and fingerprint matching to identify leaks in underwater electrical power cables. Additionally measured LAB bioavailability to oysters through a transplanting experiment.

Effect of Ship-Derived Coal Wastes on Benthic Habitats

Client: EPRI/Sea Grant

Participated in a project that looked at the effects of coal, taconite, and ash deposited on Lake Ontario sediments as a result of ship washing practices, on the benthic community. Ms. Lamoureux was responsible for the analysis of PAH concentrations and desorption rates, as well as bioaccumulation in the amphipod *Mysis relicta.*

FIFRA Review of Pesticide Toxicity Data

Client: U.S. Fish and Wildlife Service

Ms. Lamoureux was responsible for reviewing pertinent toxicity data and providing technical assistance to the USEPA during the registration and re-registration of several pesticides proposed for agricultural use under the *Federal Insecticide, Fungicide, and Rodenticide Act* (FIFRA).

Effect of Increase in Organic Load and Anthropogenic Compounds on Bathypelagic Environments

Client: NOAA

Participated in a multi-disciplinary project to determine the effects that the increased organic load and anthropogenic compounds derived from ocean disposal of sewage sludge at the 106-Mile Deep Water Sewage Sludge Disposal Site had on the local bathypelagic environment. Specifically, Ms. Lamoureux looked at the spatial distribution of organic contaminants, including linear alkylbenzenes, which served as a tracer of sewage sludge inputs

Cycling of Fatty Acids in an Anoxic Estuarine Basin

Client: National Science Foundation

Participated in an intensive study to understand the cycling of volatile fatty acids in the Pettaquamscutt River Estuary, a permanently anoxic basin. Role involved the measurement of fatty acid turnover rates just below the oxycline.

Quantification of Parameter Loadings for Section 303 Permit Compliance

Client: Town of Huntington

Ms. Lamoureux was the project manager for a Section 303 Permit compliance investigation of sources of coliform loadings to Huntington Harbor in Long Island Sound. Loads were determined through shoreline surveys, effluent and stormwater monitoring, overland flow estimates, and enumeration of waterfowl.

Landfill Monitoring

Client: Town of East Hampton

Participated in the design, installation, and analysis of a landfill monitoring system for gas and liquid phase contaminants at the East Hampton Town Landfill on Long Island, NY.

PROFESSIONAL ACTIVITIES

Affiliations

International Association for Great Lakes Research
Society of Environmental Toxicology and Chemistry

PRESENTATIONS

Lipid Normalization in Fish: Why It Does or Doesn't Help and What To Do About It. Lamoureux, B. and D. Glaser. Society for Environmental Toxicology and Chemistry Annual Meeting, Austin, TX, November 2003.

Resistant Desorption of PCBs from Lower Hudson River Estuary Sediments: Implications for Understanding the Distribution and Bioaccumulation of PCB Congeners. Brownawell, B.J and E.M. Lamoureux, Society of Environmental Toxicology and Chemistry 20th Annual Meeting, Charlotte, NC, 14-18 November, 1999.

Sediment Soot Content as a Control on Bioavailability of Hydrophobic Organic Compounds. Lamoureux, E.M. and B.J. Brownawell, Society of Environmental Toxicology and Chemistry 19th Annual Meeting, Charlotte, NC, 15-19 November, 1998.

The Relationship between Carbon and Contaminant Absorption in Deposit-feeding Invertebrates. Lopez, G., A. McElroy, B.J. Brownawell, E.M. Lamoureux, and M. Ahrens, Society of Environmental Toxicology and Chemistry 18th Annual Meeting, San Francisco, CA,16-20 November 1997.

Assimilation of Sediment-Sorbed Hydrophobic Organic Contaminants by Deposit-Feeders as a Function of Desorption Rate and Extent. Lamoureux, E.M. and B.J. Brownawell, Society of Environmental Toxicology and Chemistry 18th Annual Meeting, San Francisco, CA,16-20 November 1997.

Desorption of PCBs, PAHs, and LABs from Marine Sediments. Lamoureux, E.M. and B.J. Brownawell, American Chemical Society 213th National Meeting, Las Vegas, NV, 7-11 September 1997.

The Effect of Contaminant Desorption on Assimilation of Sediment-sorbed Hydrophobic Contaminants by Deposit-feeders. B.J. Brownawell, E.M. Lamoureux, A. McElroy, G. Lopez, and M. Ahrens, Society of Environmental Toxicology and Chemistry 17th Annual Meeting, Washington, DC, 17-21 November 1996.

The Role of Desorption in Controlling the Bioavailability of Sediment-Sorbed Hydrophobic Contaminants. Lamoureux, E.M., and B.J. Brownawell, Gordon Research Conference, Environmental Science: Water, New Hampton, NH, June 1996.

The Behavior of Linear Alkylbenzenes (LABs) and Other Sewage Sludge Tracers in Sediments Below the 106-Mile Deep Ocean Disposal Site. Lamoureux, E.M., B.J. Brownawell and M. Bothner, Society of Environmental Toxicology and Chemistry 15th Annual Meeting, Denver, CO, 30 October – 3 November 1994.

The Application of Linear Alkylbenzenes as Tracers of Sewage Sludge at the 106-mile Deep Water Municipal Sewage Sludge Disposal Site. Lamoureux, E.M. and B.J. Brownawell, 12th Biennial International Estuarine Research Federation Conference, Hilton Head, NC, 14-18 November, 1993.

PUBLICATIONS

Comment on "The Long-Term Fate of Polychlorinated Biphenyls in San Francisco Bay, (USA)". Connolly, J.P., C.K. Ziegler, E.M. Lamoureux, J.A. Benaman, and D. Opdyke. *Environ. Toxicol. Chem.* 24(10): 2397-2400, 2005.

The Influence of Soot on Hydrophobic Organic Contaminant Desorption and Assimilation Efficiency. Lamoureux, E.M. and B.J. Brownawell. *Environ. Toxicol. Chem.* 23(11): 2571-2577, 2004.

The Effect of Body Size on Digestive Chemistry and Absorption Efficiencies of Food and Sediment-Bound Organic Contaminants by the Polychaete *Nereis Succinea*. Ahrens, M.J., J. Hertz, E.M. Lamoureux, G.R. Lopez, A.E. McElroy, and B.J. Brownawell. *Journal of Experimental Marine Biology and Ecology*, 263, 185-209, 2001.

The Role of Digestive Surfactants in Determining Bioavailability of Sediment-Bound Hydrophobic Organic Contaminants to Two Deposit-Feeding Polychaetes. Ahrens, M.J., J. Hertz, E.M. Lamoureux, G.R. Lopez, A.E. McElroy and B.J. Brownawell, *Marine Ecol. Prog. Ser.* 212, 147-157, 2001.

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CONTACT INFORMATION

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PROFESSIONAL HISTORY

QEA, LLC, Managing Engineer, 2006 to present
The University of Texas at Austin, Graduate Research Assistant, Environmental and Water Resources, 2005 – 2006
The University of Texas at Austin, Outreach Program Coordinator, 2004
Angelina College, Instructor of Chemistry and Engineering, 1993–2003
Dow Chemical, U.S.A. Senior Production/Senior Research Engineer, 1982 – 1988

EDUCATION

The University of Texas at Austin, M.S., Environmental and Water Resources Engineering, 2006
Texas A & M University, M.E., Chemical Engineering, 1985
The University of Texas at Austin, B.S., Chemical Engineering, 1981

REGISTRATION

Professional Engineer, State of Texas (Lic. No. 61702)

EXPERIENCE SUMMARY

Ms. Darby's experience is in water and sediment quality in natural systems and industrial processes. Her recent graduate research in Environmental and Water Resources Engineering at The University of Texas at Austin focused on treatment and re-use of co-produced waters from oil and gas exploration and production. Her studies also included water quality modeling, utilizing GIS in water resources, water pollution chemistry, groundwater contaminant fate and transport, and water resources planning and management.

Since joining QEA, Ms. Darby has supported a variety of projects relating to water, soil and sediment quality, such as investigating diel dissolved oxygen conditions under varying flow regimes for Texas streams. This work supports modified river management along the lower Colorado River to meet future water demands. Additionally, Ms. Darby has developed expertise in sediment quality assessment and emerging state level regulations. This includes research into methodologies and practices for evaluating sediment toxicity, benthic community disturbances, contributions due to point source and non-point source discharges, and development of total daily maximum loads which involve contaminant sediment and water column partitioning.

Ms. Darby provides QEA with a foundation in industrial water quality experience. While working for Dow Chemical, U.S.A. as a Senior Engineer in research and production Ms. Darby completed water and solvent balances to design a solvent recovery process for the process waste water resulting in several hundred thousand dollars savings per year in raw material and waste water treatment costs. In addition, she received a patent for a new process for producing high purity epoxy resins which was driven in part due to the improvements in waste water effluent allowing implementation in international regions with stringent waste water regulations.

MAJOR PROJECTS

Water Quality/Water Resources

LCRA-SAWS Diel Dissolved Oxygen Modeling Project

Client: Lower Colorado River Authority, San Antonio Water System

Supervised the development of a box model simulating the daily variation of dissolved oxygen as a function of macrophyte production and respiration, reaeration, and sediment oxygen demand. Comparisons of predicted dissolved oxygen swings under future with and without Project conditions were provided.

LCRA-SAWS Diel Dissolved Oxygen White Paper Project

Client: Lower Colorado River Authority, San Antonio Water System

Review and analyses of research and modeling efforts for the Colorado River below Austin on diel dissolved oxygen. QEA, LLC, 2006, "Lower Colorado River Diel Dissolved Oxygen White Paper." Final Report; Austin, TX; Prepared for Lower Colorado River Authority and San Antonio Water System, November 2006.

Natural Eutrophication/Reservoir Aging

Client: Texas Water Conservation Association, Nutrient Criteria Committee

Investigation of natural eutrophication occurrence and related data analyses of eutrophication measures in selected Texas reservoirs.

Impact of Remedial Options Pilot Study Operations on Re-suspension of Contaminants

Client: Aluminum Company of America

In-depth study of sediment and water quality data collected during remedial options pilot study to identify contributions to re-suspension of contaminants to the water column as a function of in-stream operations.

Nutrient Water Quality Criteria

Internal research and development

Review of current approaches to setting numeric water quality criteria for nutrients across the United States as mandated by the US EPA. Comparisons of methodologies and user perception surveys being used to determine regional and site specific criteria.

<u>Contaminated Soils and Sediments Assessment and Management</u>

Determination of Soil Cleanup Levels

Client: General Electric Company

Responsible for development of a site specific work plan for determining soil clean up levels for ten designated compartments. Clean up levels will be determined based upon site specific partition coefficients for multiple contaminants and physical constraints of the industrial site.

Evaluation of PCB Load Assessment of Industrial and Municipal Dischargers into San Francisco Bay

Client: General Electric Company

Comparison of industrial and municipal discharger PCB loads to San Francisco Bay and evaluations of the contributions of these loads to the total watershed loadings and existing sediment contamination levels.

Analyses of Methodologies and Practices Utilized by State Regulatory Agencies for Sediment Assessment

Client: General Electric Company

Review of current recommended methodologies and practices for sediment quality assessment as directed by state level regulations and guidelines.

Comparisons of Logistic Regression Models, Empirically Derived Thresholds, and Theoretical Modeling Approaches for Defining Sediment Quality Objectives

Client: General Electric Company

Detailed study of the variances and predictability of models and thresholds on sediment toxicity.

<u>Global Climate Change and Carbon Sequestration</u>

Near-Surface Modeling and Monitoring for CO_2 Sequestration

Internal research and development

Investigation into development of a near-surface CO_2 fate and transport model to identify long-term monitoring, measurement, and verification options that are cost effective and time sensitive to protect environment and human health.

PROFESSIONAL ACTIVITIES

<u>Affiliations</u>

American Institute of Chemical Engineers

Texas Water Conservation Association
Texas Society of Professional Engineers

Invited Participation in Technical Workshops

ATEEC Fellows Institute on Environmental Technology. Ten-day NSF Advanced Technology workshop at University of Northern Iowa. Cedar Rapids, IA. June, 1998.

PUBLICATIONS

Re-use of Produced Water, Obstacles and Issues. Darby, E. B., Water Environment Federation, Industrial Water Quality Conference Proceedings, August, 2007.

Economic and Engineering Assessment of a Surfactant Modified Zeolite/Vapor Phase Biofilter Process for Treating Produced Water. Darby, E.B., *Masters Thesis.* The University of Texas, Environmental and Water Resources Engineering. May 2006.

Pilot Scale Test of a Produced Water Treatment System for Organic Compounds. Sullivan, E., L. Katz, K. Kinney, S. Kwon, L. Chen, E. Darby, R. Bowman, C. Altare, 13th Annual International Petroleum Environmental Conference. San Antonio, TX. *Published in Proceedings.* October 17-20, 2006.

PRESENTATIONS

Re-use of Produced Water, Obstacles and Issues. Darby, E. B. Water Environment Federation, Industrial Water Quality Conference 2007, Providence, RI, August 1, 2007.

Assessment of a Surfactant Modified Zeolite/Vapor Phase Biofilter Process for Treating Produced Water. Darby, E.B., Proceedings of the Texas Section-ASCE Fall 2006 Meeting, San Antonio, TX, October 11-14, 2006.

New Opportunities for Re-Use of Produced Water – Water Quality and Permitting Issues. Darby, E.B., Presented at Annual Meeting of the Geological Society of America. Salt Lake City, UT. October 16, 2005.

ENTRIX

MEMORANDUM

November 29, 2007

TO: Ms. Valerie Nera
Director
Agriculture, Resources & Privacy
California Chamber of Commerce
1215 K Street, Suite 1400
Sacramento, California 95812-1736

Mr. Joe Kelly
President
Montrose Chemical Corporation of California
801 Edgehill Road
Wilmington, Delaware 19807

FROM: John Giesy, Ph.D. & Paul Mehrle, Ph.D., ENTRIX

RE: Evaluation of California State Water Resources Control Board's Proposed Statistical Methods for Determining Sediment Quality Objectives (SQOs) for Enclosed Bays and Estuaries in California

EXECUTIVE SUMMARY

The California State Water Resources Control Board (SWRCB) has proposed two methods for classifying levels of impairment of surficial sediments and developing Sediment Quality Objectives (SQOs) for enclosed Bays and Estuaries in California. SWRCB's proposed methodology uses three types of information: (1) the concentrations of chemicals in sediments, (2) the toxicity of sediments under controlled laboratory conditions to surrogate species, and (3) the benthic invertebrate community structure. The methodology is based on the Sediment Quality Triad (SQT) approach, first suggested by Chapman et al. (1989) with a subsequent decision-making framework (Chapman and Anderson 2005). ENTRIX evaluated SWRCB's proposed methods to determine whether they were scientifically sound using established scientific benchmarks, and to determine whether they could be used reliably and predictably to identify a specific cause of observed toxicity (versus merely relying on an association between the chemicals and the sediments) to support threshold values in SWRCB's *Draft Staff Report: Water Quality Control Plan for Enclosed Bays and Estuaries, Part 1, Sediment Quality* (SWRCB 2007).

In particular, this study focused on evaluating the strength of relationships between concentrations of various contaminants in sediments and estimates of toxicity and evaluating the statistical basis of the California Logistic Regression Models (Cal-LRM) and Chemical Score Indicator (CSI) methods for establishing threshold concentrations in selected marine sediment data. While the use of a multiple lines of evidence (MLOE) approach as proposed for development of the SQOs may be appropriate as an abstract proposition (assuming the approach is encompassed by the statutory definition of "SQO"), the statistical methods proposed by SWRCB to predict potential impairment of sediments from concentrations of individual chemicals in sediments are completely without scientific merit and should not be used in the process. The application of sound science by the SWRCB should result in an approach that informs one about the causal relationship between chemical concentration in sediments and biological effects that has a high reliability and spatial generality (predictability) in its application. It is evident from reviewing SWRCB's proposal that the proposed methodology fails to meet this fundamental objective of sound science. As currently drafted, the SQOs are scientifically unsound because application of these two statistical methods do not aid in establishing a causal relationship, are not reliable, and do not provide predictable results in application.

There were three overall objectives of ENTRIX's evaluation: (1) to determine the applicability of Cal-LRM and CSI methods for evaluating sediment quality; (2) to identify any limitations in applying LRM and CSI methods for evaluating certain contaminants of interest (e.g., DDT and PCBs); and (3) to evaluate the two methods' ability to provide ecologically and statistically defensible sediment toxicity guidelines. A summary of major activities and findings of the present study are given below.

- ENTRIX conducted an extensive search for relevant data for use in meeting the project objectives. The search included both the peer-reviewed literature and government agency publications.
- ENTRIX examined a number of data sets and associated report documents to ensure that the information was technically defensible and accurate using Quality Assurance/ Quality Control procedures. Approximately 15,000 records of co-occurring measurements were examined.
- Based on a literature review, ENTRIX found that both the Cal-LRM and CSI methods have inherent limitations. We confirmed conclusions previously reached by other investigators, which include that both methods (1) cannot inform one about the causal relationship between chemical concentration and biological effects; (2) cannot account for factors critically important in determining bioavailability of chemicals; and (3) cannot account for biological effects due to unmeasured concentrations of other chemicals or chemical mixtures.
- An underlying assumption in successfully applying either the Cal-LRM and CSI method for classifying levels of impairment of sediments or establishing SQOs or

sediment clean-up goals is being able to find ecologically and statistically significant relationships between individual biological effects and contaminant concentrations. After extensive graphical and statistical analyses, no such relationships were found to exist.

- For Selected California Harbor sediments, ENTRIX determined that use of either Cal-LRM and CSI methods-based toxicity threshold concentrations of Total DDT or Total PCB for setting injury or sediment clean-up levels would not be justified since these thresholds failed to distinguish between toxic and non-toxic effects for any of the toxicity endpoints considered. Hence, developing SQOs based on these thresholds is not likely to achieve the intended beneficial biological response.
- Even if additional data are obtained and a more thorough ecological and statistical evaluation of the Cal-LRM and CSI methods is conducted, it is unlikely that either of these methods would accurately predict thresholds for toxicity of individual chemicals, even in geographically-restricted areas or in sediment samples taken in close proximity. The methods do not meet the basic assumptions for a valid scientific approach that should include assisting in understanding the cause-effect relationship, reliability, and predictability.
- The State Board has not provided to the public all of the materials upon which it has relied in forming the SQOs, which renders a complete analysis of the SQO impossible. For example, we are informed that the State Board has conducted a comparative analysis of the likely results if the MLOE approach is applied, versus a single line of evidence. Furthermore, we understand that the State Board staff is preparing a Guidance or Implementation Manual that has not been released for public review. We reserve the right to revise our analysis after these and other documents are made available to us for review.
- For all these reasons, as set forth in further detail below, it is scientifically unsound for the SWRCB to use the proposed statistical methods to predict potential impairment of sediments. The SWRCB is proposing exceedingly low thresholds and is merely relying on an association between the chemicals and the sediments to support its threshold values. The two statistical approaches proposed by SWRCB do not have a valid scientific basis and should not be used to develop the SQOs.

ENTRIX

Evaluation of Statistical Methods for Predicting Threshold for Effects and SQOs, Such as the Cal-LRM and CSI methods

INTRODUCTION

Over the past 15-20 years, concerns have arisen over the biological impacts associated with chemical contaminants that have accumulated in both marine and freshwater sediments. These concerns have motivated development of several methods aimed at deriving sediment quality criteria for providing long-term management of contaminated sediments.

At many areas of concern, concentrations of a wide range of chemicals have been measured in sediments. The goal of regulators and risk assessors was to use this information on complex mixtures to predict the potential toxicity of individual chemicals. Methods were developed to try and predict the threshold concentrations for individual chemicals by relating synoptic measurements of measured total concentration of a contaminant with the observed effect in either a toxicity test (bioassay) conducted under laboratory conditions or populations or structure of the benthic invertebrate community expressed as absolute and relative measures of community structure, expressed as a range of different indices. These approaches make a number of assumptions. While there are a number of statistical assumptions made, a few of the more critical assumptions include: (1) the bioavailability of chemicals does not vary among locations; (2) the effect of each chemical is independent of the effects of other chemicals; and (3) a cause-and-effect relationship can be established between specific chemicals and effects observed in the sediments. Each of these assumptions must be met in order for the approach to be scientifically sound, and for it to serve as a technically valid basis for regulating contaminated sediments.

The Cal-LRM and CSI methods are statistically based, in that they rely on comparing measured biological effect responses in test sediments (either field-collected or chemically spiked) with the same responses in control sediments. A statistical test is then used to determine whether or not these responses are significantly different from one another. The outcomes of these tests are used as partial decision criteria to classify each sediment sample as being either an *effect* (i.e., response is significantly different from the control) or *no effect* (i.e., response is not significantly different from the control). Once each sample is properly classified, the methods employ quite different techniques in assessing the relationship between biological effect classification and concentration of a contaminant. Both methods require "matching" or "co-occurrence" data (i.e., sediment chemistry and toxicity or effects data that have been measured at the same location at the same time) from field and laboratory studies. Biological responses may include various sediment bioassays and benthic infaunal community structure measurements with matching concentration values on a dry-weight basis (Calabrese and Baldwin 1993).

Almost from the beginning of the development of these types of statistical methods, it was recognized by many in the scientific community that these assumptions were almost never met. Many environmental scientists therefore rejected the scientific validity of these methods. However, some agencies continued to pursue these methods, presumably because they "had nothing better", or they felt that they needed to make use of the chemical information and there was a need to tie adverse effects to individual chemicals in an attempt to assign causality. While there may be perceived strengths or advantages of using co-occurrence data (such as that used in the Cal-LRM or CSI methods) to evaluate sediment quality (some of which are discussed below) the lack of scientific validity and poor predictability of these methods clearly outweigh any perceived utility in establishing valid SQOs. At best, the perceived strengths support these approaches as generic or informal screening tools for assessing sediment quality. The following are several perceived strengths and advantages of the Cal-LRM and CSI methods:

1. *The Cal-LRM and CSI methods are supported by a comprehensive co-occurrence database.* Co-occurrence databases have been recently used in a number of investigations to assess sediment quality. An extensive co-occurrence database on the biological effects of sediment associated chemicals called biological effects database for sediments (BEDS) and similar databases have been used based on existing data. This large database can be interpreted and used as a tool for evaluating the potential for adverse biological effects at various chemical concentrations and can provide a limited degree of confidence on the resultant guidelines. Unfortunately, the confounding effects of multiple contaminants make it impossible to identify the cause or the source and the method, due to multiple counting of synoptically observed effects with multiple contaminants overestimates the predicted effects of any one chemical.

2. *In general, both approaches are not difficult to develop.* The approaches are considered to be practical because data can be used to generate numerical thresholds for a variety of chemicals, many of which typically accumulate in sediments. Generation of threshold effects can be accomplished relatively quickly. The influence of chemical mixtures is incorporated into the data when field data are used. They apply to a wide range of benthic species and endpoints, and incorporate direct measurements taken in situ. As such, given that these methods are relatively simple to apply these attributes are considered to give the approaches broad applicability. However, as discussed below, the ease of use of the methods undermines its reliability. However, simplicity is not a virtue if the predictions are not accurate.

3. *The approaches consider both effects and no effects data to generate thresholds.* In contrast to the Cal-LRM and CSI, most methods do not rely heavily on single data points. Therefore, outliers in the Cal-LRM and CSI methods carry less weight in calculating guidelines. By including both effects and no effects data, detailed tables can be constructed to evaluate the potential biological significance of co-occurrence

data. While both types of data are included, due to the confounding effects of the presence of multiple chemicals and the lack of consideration of bioavailability, there are a disproportionately large number of false positives.

4. *The databases used for deriving Cal-LRM and CSI values provide a basis for evaluating thresholds.* The co-occurrence database is arranged in ascending order of chemical concentration in a tabular format. This format permits expansion of the database, calculation of the distribution of *effects* and *no effects* entries surrounding the guideline, and determination of the reliability (or degree of confidence) of each threshold. These thresholds could then be used within a risk assessment framework for assessing contaminated sediments. Unfortunately, the methods do not allow for the determination of accurate or precise thresholds. The methods can discriminate those locations that are clearly toxic, but not those that are not. This leads to an inordinate number of false positives. This can be clearly seen in plots of the data where no toxicity was observed even though the *Cal LRM* predicted that there would be toxicity.

5. *The statistical methods from which the Cal-LRM and the CSI methods were derived have undergone extensive peer review.* The methods have been published in the peer reviewed literature. It has received support from a wide variety of user groups and has been adopted by Canada as part of sediment guideline derivation processes. Accordingly, the favorable reviews that have been received emphasize the importance and utility of the methods in deriving numerical guidelines. However, even though the methods have been reported in peer-reviewed journals, the fact remains that they violate the underlying assumptions and result in poor predictive capability. While they are easy to apply and regulatory agencies would like to use them, when tested in court cases, they have been found to be wanting. Peer review approval of the State Board's word does not mean that the peer reviewers believes that the SQOs are a reasonable tool for managing sediments, including the development of site-specific implementation plans. Unfortunately, simply because the methods have been peer-reviewed, does not make them accurate or precise or even accepted by the majority of the scientific community. In fact, when the methods were critiqued by the staff, a number of deficiencies were identified. Simply being reviewed does not overcome the basic scientific inadequacies of the proposed method.

6. *The methods implicitly consider bioavailability and chemical mixture effects.* Since co-occurrence field data are used to generate guidelines, various factors such as organic carbon that may influence bioavailability as well as the effects of mixtures of chemicals are implicitly considered. While this is true if the chemical toxicants present and their relative concentrations remain exactly the same, since this is not the case, the generality of applicability of the methods among locations is poor. This is why different values are needed for the northern and southern areas.

DISADVANTAGES OF THE METHODS

There are a number of inherent limitations or disadvantages in using the Cal-LRM and CSI methods for evaluating sediment quality. Those listed below apply specifically to the *Cal-LRM* method and, more generally, to the CSI method. Due to these significant limitations, it is not scientifically valid to use these methods as a regulatory tool in addressing sediment quality.

1. *The Cal-LRM method does not aid in understanding cause-and-effect relationships.* The method assumes associations between chemical concentrations and biological effects rather than supporting development of cause-and-effect relationships. Any number of variables such as unmeasured chemicals, ammonia, hydrogen sulfide, and dissolved oxygen content in sediments could affect sediment toxicity and species responses.

2. *The Cal-LRM method does not account for factors affecting chemical bioavailability.* The method may not account for other factors affecting chemical bioavailability such as grain size and acid volatile sulfide (AVS) content of sediment-sorbed materials (e.g., Nebeker et al. 1989; DiToro et al. 1990). These data are infrequently reported in the open literature and often precludes their use in deriving threshold values. This results in the development of thresholds that may be both under- and over-protective of benthic species (MacDonald 1994).

3. *The Cal-LRM method attempts to establish absolute sediment guidelines.* The *Cal-LRM* method typically delineates ranges of chemical concentrations that are probably, possibly, and not likely to be associated with adverse biological effects (MacDonald 1994; Long et al. 1990, 1992, 1995; Smith et al. 1996a). The method typically recognizes the uncertainty associated with the prediction of adverse effects from sediment-associated chemical measurements and such recognition is believed to enhance defensibility of the guidelines (CCME 1995). However, delineation of ranges was all but ignored by MacDonald (1997) and hence, the inherent uncertainty surrounding thresholds for the Southern California Bight was ignored, substantially reducing what limited utility they may possess.

4. *Values developed using the method may not reflect chronic responses.* Chronic data are often sparse or absent for a given chemical and hence, the guidelines generated will not reflect chronic responses of benthic species (Chapman 1989; MacDonald 1994).

5. *Guidelines developed by the Cal-LRM method may not be applicable for sediments with atypical levels of total organic carbon (TOC) or other factors.* Care must be exercised when applying the guidelines at a given site because they do not account for factors affecting bioavailability. For example, if sediments in an area contain relatively high or low TOC content, then the thresholds generated may not be

applicable (MacDonald 1994). This is because the ameliorating effects of TOC may reduce the bioavailability of organic chemicals thus rendering them over-protective.

6. *The Cal-LRM method does not explicitly consider effects as a result of bioaccumulation.* The method does not explicitly account for potential bioaccumulation of chemicals in benthic organism tissues nor does it account for potential adverse effects on species that may ingest these benthic species (MacDonald 1994; Smith et al. 1996a). Proponents of the method argue that the method indirectly (or implicitly) considers bioaccumulative effects because the expression of adverse effects includes effects due to bioaccumulation (Smith et al. 1996a). However, because the bioavailable fraction of each constituent varies among locations and the absolute and relative concentrations vary among locations, this is not true.

7. *The Cal-LRM method requires relatively large co-occurrence databases and may not be generally applicable.* In particular, the *Cal-LRM* method requires approximately 20 co-occurring observations associated with an *effect* response (e.g., toxicity significantly different than a control) and an additional 20 co-occurrences of a *no effect* response (CCME 1995). In addition, the concentration of each chemical of interest should vary by at least 10-fold among sampling sites. Finally, statistical procedures used should be presented in detail and test methodology must follow standard protocols (CCME 1995). There may be a need to develop LRM models for different regions, depending on the mixtures of relative concentrations of contaminants.

8. *The Cal-LRM method does not account for effects due to mixtures of chemicals, only a single chemical.* The reliance of the method on co-occurrence data precludes the possibility of separating individual chemical effects from samples where multiple chemicals exist (Adams et al. 1992; Chapman 1989). This limitation is highly relevant to the Southern California Bight, as several chemicals other than DDT and PCBs are also present in sediments.

Both methods share the assumption that there is an inherently strong association between the concentration of a contaminant and a synoptically measured biological effect, implying a true cause-and-effect relationship between the variables. Furthermore, the methods imply that the magnitude of an adverse effect would decrease if contaminant levels were to be reduced below a threshold concentration. The statistical methods are generally considered to be site-specific, meaning that derived threshold values for contaminants are not strictly applicable to areas outside of where they were developed. On the other hand, the Cal-LRM method employs geographically broad-based co-occurrence data for deriving contaminant thresholds and, therefore, values have typically been applied to sites that are far-removed from one another. Specific key assumptions inherent to the Cal-LRM method and its reliability and predictability that were originally made by its developers are listed below:

- *"An underlying assumption of the Cal-LRM and CCS approaches is that, if enough data are accumulated, a pattern of increasing incidence of biological effects should emerge with increasing contaminant concentrations"* (Long et al. 1995).
- *The Cal-LRM and CCS approaches assume that "associations between effects and chemical concentrations would be more credible if based upon data from many different studies than if based upon data from only one approach or experiment"* (Long 1990).
- *"The Cal-LRM and CCS approaches assume that the use of a large database accounts for interactions between chemicals in complex mixtures, for effects of unknown or unmeasured chemicals or materials, for factors other than measured chemical concentrations that may affect species responses, and that indicators of bioavailability and effects can be determined based on field and/or laboratory data"* (Chapman 1989).

However, since these key assumptions that are necessary to make the methods scientifically sound are never met, it is essentially impossible to develop a predictive relationship for individual chemicals from synoptic measures of exposure to complex mixtures and responses, either in bioassays or in field measurements of benthic invertebrate populations and communities. Sound science dictates that these methods should have predictive power, yet they do not. A good example of this is given by the staff of the SWRCB. When they examined the proposed methods, it was found that the coefficients of determination (a measure or relatedness between concentrations of individual chemicals and outcomes) were very small. In many cases, the correlation between the magnitude of exposure to a chemical (concentration in sediments) and the adverse effects were much less than 10%. Said another way, more than 90% of the time there was no relationship between concentration of the chemical in the sediment and biological response. In some cases there were observed effects at very small concentrations of a chemical and in other situations, exposure to relatively large concentrations of the same chemical resulted in no adverse effects. The reasons for the underestimation of effects are due to the fact that the actual biological availability of chemicals varies among locations and is always less than 100%. The overestimation of effects is due to the fact that the benthic invertebrates are never exposed to only a single chemical. The effects observed may be due to a variety of things other than the specific chemical in question, so when all of the effects are attributed to a single chemical the threshold for adverse effects is underestimated.

CORRELATION AND ANALYSES OF VARIANCE

The Cal-LRM and CSI approaches assume that there is a strong association between endpoint response and contaminant concentration. In particular, the Cal-LRM method claims that if enough data are examined, a direct relationship should be evident between adverse effect and increasing concentration. In order to examine this assumption, various endpoints and contaminants were selected for correlation analysis. In those instances where data were from different sources or encompassed areas within and outside of Southern California, analyses of variance were also conducted to determine whether sources or areas were significantly different from one another. Where significant differences were found, an examination of the overall pattern of relationship between effect and concentration was conducted.

As set forth in further detail in Appendix A attached hereto, Pearson correlation coefficients between transformed endpoint measurements and chemical concentrations were determined for marine and freshwater sediment data. The results of these analyses were used to evaluate the accuracy and predictive power of the proposed Cal-LRM and CSI methods for sediments from California.

In general, the analyses fail to demonstrate the existence of any meaningful correlation between selected endpoint responses and contaminant levels in either marine or freshwater sediments. Furthermore, there were instances in which statistically significant differences were found in the magnitude of an endpoint response among areas or among data sources within an area, yet no significant differences were found with respect to the co-occurring concentration of a contaminant. Such inconsistencies immediately call into question the validity of assuming an inherent direct relationship between the magnitude of contamination and the magnitude adverse biological effects using field observations. While this assumption is typically valid for carefully controlled laboratory dose-response tests using a single contaminant, it is rarely satisfied from field observation where samples are often taken across multiple gradients in critical environmental variables other than contaminant levels. Furthermore, the magnitude of field-based responses for a single endpoint is often a function of a complex mixture of contaminants, and it is not ecologically or statistically reasonable to ignore such complexity. The combination of effects due to environmental gradients and complex contaminant mixtures precludes simply applying the assumption of cause-and-effect (dose-response) to field observations. Neglecting such effects in the establishment of sediment quality guidelines or clean-up levels for contaminants is scientifically unjustifiable.

Cal-LRM and CSI DETERMINATIONS

Cal-LRM and CSI-based thresholds derived for establishing sediment quality using selected field observations lead to values that have no toxicological or statistical meaning. Results presented below (as well as additional examples in Appendix A) follow from the fact that no relationships between toxicity responses and contaminant levels exist in these data. This is another reason why the SWRCB's proposed approach is not scientifically justified.

Comparisons between *effect* and *no effect* station groups for Total DDT and Total PCB using the endpoints amphipod mortality, sea urchin development, and sea urchin fertilization found that the means were significantly different from one another. Thus, only the single test comparing Total PCB sediment content for sea urchin development was statistically significant (P=0.0043). Results of all other tests were not significant, leading to the conclusion that *effect* stations cannot be distinguished from *no effect* stations on the basis of the concentration of Total DDT or Total PCB. In the single instance where *effect* and *no effect* stations were significantly different, the mean concentration of Total PCB in the *no effect* group was actually higher than in the *effect* group. This result is, of course, contrary to what would otherwise be expected if DDT content in sediment were exerting a negative impact on sea urchin developmental toxicity. In general, these results do not support using the concentration of Total DDT or Total PCB taken alone, to explain the different toxicity designations in the endpoints considered. These results also demonstrate the inability of being able to predict sediment toxicity response with any acceptable degree of statistical confidence on the basis of arbitrarily chosen levels of contaminant concentration.

CONCLUSIONS

Based on the statistical evaluations and rationales described herein, the Cal-LRM and CSI methods do not form a sound scientific basis on which the SWRCB can establish SQOs. Statistical methods, such as the Cal-LRM and CSI, which rely on a co-occurrence database have limited usefulness. They can be used to examine associations between levels of contamination and biological effects, but they do not support claims of cause-and-effect. As a result, these methods might only be appropriate as screening tools to identify sediments in areas that may require more detailed evaluation. The evaluations presented in this report suggest that it is not scientifically sound to use either method to support the specification of SQOs or site-specific sediment cleanup goals.

Proponents of the Cal-LRM method recognized certain disadvantages that limit its use in establishing SQOs (Cal EPA, 2007). They indicated that (1) guidelines generated in this manner should not be used alone in deriving site-specific cleanup goals and (2) other sources of information and data should be obtained before developing site-specific sediment quality objectives. Guidelines developed under this methodology are designed to be used as generic or informal screening tools for assessing sediment quality applied over broad geographic areas. These authors emphasized that the guidelines should be used with other sources of information such as background concentrations of chemicals, further biological assessment (e.g., toxicity test using field-collected sediments, benthic diversity and abundance analyses), and site management considerations before reaching any conclusions regarding sediment quality.

The limitations of such statistical approaches have been summarized by other authors, such as O'Connor et al. (1998) who stated that "...ERM exceedances should only be taken to indicate that further analysis is in order. They should never be taken, by themselves, to mean that sediment is exerting a toxic effect upon the environment or that there would be any benefit to decreasing its chemical content". The authors of this report concur with these statements, which are supported by findings in the present report.

Other authors such as MacDonald (1994) and Long et al. (1995) concluded that the guidelines developed for Total DDT, p,p'-DDE, total PCB, and mercury based on these types of statistical analyses of co-located chemical concentrations and effects were not "reliable" or "predictable." Reliability refers to the ability of the guidelines to correctly predict adverse sediment effects in the area of interest and predictability measures the ability of the guidelines to correctly predict adverse effects outside the area of interest (MacDonald 1997). MacDonald (1994) and Long et al. (1995) reached this conclusion based on sediment quality guidelines that were generated to be protective of marine and estuarine sediments on Florida's coasts and of sediments in all areas of the US and Canada, respectively. As stated by MacDonald (1994), "As mentioned elsewhere in this document, SQAGs (Sediment Quality Assessment Guidelines) alone are not adequate to reliably predict biological effects in contaminated sediments". Similarly, Long et. al (1995) stated that "Relatively poor relationships were observed between the incidence of effects and the concentrations of mercury, total PCBs, total DDT and p,p-DDE".

RECOMMENDATIONS

It is strongly recommended that the two proposed statistical approaches to determining SQOs, the Cal-LRM and CSI, do not have a scientific basis and should not be included in the development of SQOs or classification of the degree of potential impairment of sediments. Before they could be applied, a method would need to be developed to account for or correct for the violation of basic assumptions that must be met in order for the methods to be scientifically sound. It might be possible, through the use of toxic equivalency approaches and application of measures of biological availability to account for variation in bioavailability among locations and to predict effects due to exposures to chemical mixtures. To date, no such robust method has appeared in the published literature despite the fact that statistical methods based on synoptic measures of exposure and response continue to be considered as the basis for establishing SQOs. Such an evaluation likely would receive broad acceptance in the scientific community and should be published in a peer-reviewed journal.

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MacDonald, D.D. 1997. Sediment Injury in the Southern California Bight: Review of the Toxic Effects of DDTs and PCBs in Sediments, Volumes I and II. National Oceanic and Atmospheric Administration, April 1997.

O'Connor, T.P., K.D. Daskalakis, J.L. Hyland, J.F. Paul and J.K. Summers. 1998. Comparisons of sediment toxicity with predictions based on chemical guidelines. Environ. Toxicol. Chem. 17:468-471.

Smith, S.L., D.D. MacDonald, K.A. Keenleyside and C.L. Gaudet. 1996a. The development and implementation of Canadian Sediment Quality Guidelines. In: M. Munawar and G. Dave (Eds.). Development and Progress in Sediment Quality Assessment: Rationale, Challenges, Techniques & Strategies. SPB Academic Publishing, Amsterdam, The Netherlands, pp. 233-249.

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APPENDIX A

CORRELATION AND ANALYSES OF VARIANCE - EXAMPLES

Pearson correlation coefficients between transformed endpoint measurements and chemical concentrations were determined for marine and freshwater sediment data. In the following examples, we present the results of analyses that were conducted and discuss their implications for the accuracy and predictive power of the proposed Cal-LRM and CSI methods for sediments from California.

Lead in Marine Sediments. Comparisons between reference data for lead content in Southern California area sediments having co-occurring amphipod mortality measurements are presented. It was found that the MacDonald (1994) data had significantly higher concentrations of Lead (P=0.00382) than did data reported by Fairey et al. (1996). However, it was also found that amphipod mortality was significantly greater for the Fairey et al. data (P=0.00022). Correlations of the Fairey et al. and MacDonald data show the linear correlation between variables is ρ=-0.154 and for the MacDonald data, ρ=0.278. In neither case, is a strong association between mortality and Lead content evidenced.

Comparisons made using MacDonald (1994) data for sedimentary lead content in areas within and outside of Southern California having co-occurring measurements of amphipod mortality also showed essentially no relationship between the concentration of lead in the sediments and adverse effects. No statistically significant differences were found among the areas for lead content or mortality (P=0.07646 and P=0.15921, respectively). A correlation of mortality against lead content for the combined data yielded a linear correlation coefficient of ρ=0.226.

Two additional correlations of the association between lead content in Southern California area sediments and sea urchin development and fertilization toxicity, respectively found that for the development endpoint, the correlation with lead content was ρ=0.226 and for fertilization ρ=-0.147. Neither of these coefficients indicated a strong association between toxicity endpoints and sedimentary lead content.

Lead in Freshwater Sediments. Correlations of benthic invertebrate (infaunal) density, species diversity, and density of *mollusca* against the concentration of lead found little relationship between concentrations in sediment and adverse effects. Provided that sedimentary lead content exerts a singular influence on the values of these variables, then we would expect to observe a monotonically decreasing association in each of these cases. No such trends are evident for density or diversity (ρ=0.041 and ρ=0.126, respectively). For density of *mollusca*, the trend is correct (ρ=-0.348) but it is clearly not monotonic and only 12% of the variation in density is explained by the linear association.

Mercury in Marine Sediments. Comparisons between areas within (Fairey et al. 1996) and outside (MacDonald 1994) of Southern California for sedimentary mercury having co-occurring amphipod mortality measurements exhibited no statistically significant relationships and no threshold for effect could be determined. These comparisons revealed that both the concentration of mercury and mortality are significantly lower for sediments outside of the Southern California area (P=0.00331 and P=<0.00001, respectively). Correlations of mortality against mercury content showed no meaningful linear association is apparent between the variables (ρ=0.-061 and ρ=0.263, respectively).

Comparisons of areas were also conducted for sedimentary mercury having co-occurring measurements of sea urchin development. Lead concentration in sediment was found to be significantly less in sediments outside of Southern California (P=0.01176). In contrast, areas did not differ significantly in development toxicity (P=0.07656), although this conclusion must be viewed as tentative given the level of the P-value. Correlations of mercury content against development toxicity showed no meaningful evidence of a linear association between the variables (ρ=0.254 and ρ=0.123, respectively).

One additional correlation of sea urchin fertilization against mercury content for Southern California area sediments found no apparent linear association between the variables (ρ=-0.064).

Mercury in Freshwater Sediments. The associations between sedimentary mercury and benthic invertebrate (infaunal) density (ρ=0.052), species diversity (ρ=-0.263), amphipod density (ρ=-0.045), and density of mollusca (ρ=0.011) were evaluated. It is clear from these correlations that no linear association can be claimed between the different endpoint measurements and concentration of mercury in sediments.

Zinc in Marine Sediments. Comparisons between areas within (Fairey et al. 1996) and outside (MacDonald 1994) of Southern California for sedimentary zinc having co-occurring amphipod mortality measurements revealed that the concentration of zinc is not significantly different for these sediments (P=0.05582) but that mortality is very significantly lower in sediments outside of the southern California area (P=<0.00001). Correlations of mortality against zinc content found no linear association apparent between the variables, evidenced by the correlation for areas within (ρ=-0.153) and outside (ρ=0.266) of Southern California.

Comparisons of areas within (Fairey et al. 1996) and outside (MacDonald 1994) of Southern California for sedimentary zinc having co-occurring sea urchin development measurements found that areas differed significantly in zinc content (P=0.00504) and that sediments outside of Southern California were lower in concentration. However, it was also found that areas probably did not differ significantly in development (P=0.07492). Correlations of zinc content against development demonstrated an apparent good linear association between the variables in either case. The correlation between variables for sediments within the Southern California area is ρ=0.171 and ρ=0.189 for sediments outside of Southern California.

One additional assessment of the association between zinc content and sea urchin fertilization toxicity in Southern California area sediments found no apparent linear relationship between the variables is evident (ρ=-0.143).

Total PCB in Marine Sediments. Comparisons between the Fairey et al. (1996) and MacDonald (1994) data for Total PCB content having co-occurring amphipod mortality measurements in Southern California area sediments found that these data did not differ significantly for Total PCB content (P=0.42892) but that the Fairey et al. data exhibited significantly higher mortality (P=<0.00001). A correlation of Total PCB against mortality for the MacDonald data yielded a linear correlation coefficient of ρ=0.574; that is, approximately 33% of the total variation in these data could be explained by a linear association between the variables. A similar correlation analysis of these data in the original (non-transformed) space suggests that mortality is an increasing exponential function of the concentration of sedimentary Total PCB. There is a very apparent outlying observation in these data occurring at a concentration of approximately 5 μg Total PCB/g TOC and associated mortality of 95%. If that one observation were to be neglected, for example, on the basis of poor laboratory testing procedures for either toxicity testing or chemical concentration determination, then the linear correlation between the variables would be improved considerably. It would, however, not be ecologically reasonable to attempt to model mortality solely as a (exponential) function of concentration. There were undoubtedly other relevant environmental variables that also affected mortality which were not measured and, therefore, could not be included in the model. Neglecting these other unknown variables would lead to a very misleading model that only Total PCB content in these sediments determines amphipod mortality. A correlation of the Fairey et al. (1996) data shows that, in contrast to the MacDonald data, there is very little linear association between variables (ρ=-0.060).

Comparisons between the Fairey et al. (1996) and MacDonald (1994) data for Total PCB content having co-occurring sea urchin fertilization measurements in Southern California area sediments found that these data sources did not differ significantly for either Total PCB content or fertilization (P=0.18614 and P=0.80104, respectively). A correlation for the combined data shows that there is no apparent linear association between the variables as evidenced by a correlation coefficient of ρ=-0.043.

One additional correlation of sea urchin development toxicity against Total PCB content in Southern California area sediments found the linear correlation between these variables is ρ=0.052, indicating very little association among values.

Total PCB in Freshwater Sediments. A correlation of benthic invertebrate density against sedimentary PCB content was found to be ρ=0.042, indicating very little association among values.

Sum DDT in Marine Sediments. Correlations of the toxicity endpoints amphipod mortality, sea urchin development, and sea urchin fertilization against Sum DDT content in Southern California area sediments (Fairey et al. 1996) resulted in no apparent linear association between endpoints and Sum DDT content (ρ=-0.196 and ρ=-0.061, respectively). Fertilization toxicity does show a trend in accordance with expectation (that is, lower fertilization with higher concentration), having a linear correlation coefficient of ρ=-0.288. However, this apparent trend is largely influenced by several toxicity measurements at concentration values above approximately 2.7 μg Sum DDT/g TOC and, overall, only about 8% of the total variation in the data can be explained by a linear association.

Sum DDD in Freshwater Sediments. Correlations of benthic invertebrate density and species diversity against Sum DDD content showed essentially no linear association with concentration (ρ=-0.183 and ρ=-0.052, respectively).

Sum DDE in Freshwater Sediments. Correlations of benthic invertebrate density and species diversity against Sum DDE content resulted in little linear association with concentration (ρ=-0.187 and ρ=0.032, respectively).

Total DDT in Marine Sediments. Comparisons between the Fairey et al. (1996) and MacDonald (1994) data for Total DDT content having co-occurring amphipod mortality measurements in Southern California area sediments did not differ significantly for Total DDT content (P=0.29759). However, data reported by Fairey et al. data exhibited significantly higher mortality (P=0.02490). Correlations of these data yielded a correlation coefficient of ρ=-0.084 while the data reported by MacDonald (1994) yielded ρ=0.090. In neither case, is there a strong association between mortality and Total DDT content.

Comparisons between the Fairey et al. (1996) and MacDonald (1994) data for Total DDT content having co-occurring sea urchin fertilization measurements in Southern California area sediments found that these data sources did not differ significantly for Total DDT content or development toxicity (P=0.80104 and P=0.63995, respectively). While the overall trend in association appears to be in accordance with expectation (i.e., lesser fertilization at higher concentration), the association is largely influenced by a single toxicity observation at approximately 67 μg Total DDT/g TOC. In addition, no strong linear correlation between the variables exists (ρ=-0.323).

ENTRIX

John P. Giesy, Ph.D.

Distinguished Scientist and Technical Director

Discipline/Specialty

- Ecotoxicology
- ecological risk assessment
- natural resource damage assessments
- PCBs, Dioxins, PAHs, Radioisotopes, Metals, Chlorinated Hydrocarbons

Education

- Ph.D., Limnology, Michigan State University, 1974
- M.S., Limnology, Michigan State University. 1971
- B.S. (Honors), Biology, Alma College. 1970

Professional Affiliations

- American Chemical Society
- American Society of Limnology and Oceanography
- Ecological Society of America
- International Association for Great Lakes Research
- International Association for Sediment Water Science
- Sigma Xi-Michigan State University Chapter
- Society for Environmental Geochemistry and Health
- Society of Environmental Toxicology and Chemistry (SETAC)

Biographical Listings

- Dr. Giesy is listed in 23 biographical listings, including *Who's Who in the World*

Summary of Qualifications

Dr. Giesy is an environmental toxicologist specializing in aquatic toxicology & sediment toxiocology, but has a strong background in limnology, fisheries biology, and avian toxicology. In particular, his expertise includes: fate and effects of trace substances in aquatic ecosystems, trace metal speciation, cycling and toxicity, simulation models of environmental fates of trace substances, microcosms, biochemical toxicology (biomarkers), aquatic & wildlife toxicology, polycyclic-aromatic, hydrocarbons, photo induced toxicity in aquatic organisms, avian toxicology and habitat requirements, planar, halogenated, hydrocarbons (PCBs, PCDD, and PCDF), and chlorinated compounds.

Dr. Giesy has conducted studies for state and federal agencies and industries. He has served as a consultant to governments and industries throughout the world.

Relevant Experience

Dr. Giesy has conducted a number of research projects on the fates and effects of trace contaminants. A total of more than $15,000,000 has been awarded to him to conduct these studies. A few of the current and recent projects are listed below. A complete listing of projects is available upon request. In addition, Dr. Giesy serves as a consultant to many state and federal agencies, foundations, and corporations.

- **U. S. Environmental Protection Agency.** "Toxicity of Sediments of the Trenton Channel, Michigan."
- **Consumers Power Co.** "Effects of Hydroelectric Projects on Eagle Populations in Michigan."
- **U. S. Environmental Protection Agency Superfund.** "Bioavailability of Lead to Swine-fed Soil Contaminated with Lead Sulfide."
- **U. S. Army, Aberdeen Proving Grounds.** "Satellite Telemetry of Adult Bald Eagles."
- **U. S. Fish and Wildlife Service.** "Development of an Automated Carbon Chromatography System for the Pre-analysis Separation of Non-ortho-substituted PCB Congeners."
- **U. S. Fish and Wildlife Service.** "Relationships Between Toxic Chemicals in Double-Crested Cormorant Eggs and Birth Defects."
- **U. S. Environmental Protection Agency, ERL Duluth.** "Method for Sediment Toxicity Assessment."

- **U. S. Environmental Protection Agency, Great Lakes National Program Office.** "A Study of the Lower Saginaw River and Adjoining Saginaw Bay: PCBs and Trace Metals."
- **Inland Steel Co.** "Assessment of the Toxicity of Sediments in Indiana Harbor."
- **General Electric Co.** "Effects of Microbial Reductive Dechlorination of PCBs on Their Toxicity."
- **U. S. Environmental Protection Agency.** "Systemic Availability of Lead to Young Swine from the Chronic Administration of Lead-Contaminated Substrates."
- **Michigan Department of Natural Resources.** "Toxicity of Great Lakes Fish to River Otter (*Lutra canadensis*)."
- **U. S. Environmental Protection Agency.** "Transfer of Selected Halogenated Organic Compounds from the Sediments of the Lower Saginaw River and Saginaw Bay to Fish and Fish Eating Water Birds."
- **Great Lakes Protection Fund.** "Assessment of Genetic Diversity of and Contaminants in Bald Eagles."
- **U. S. Department of Agriculture.** "Novel Recombinant Human Cell Lines for Detection of Toxic Polyhalogenated Aromatic Compounds."
- **U. S. Department of Agriculture, National Needs Graduate Fellowships Program.** "Water Science Fellowship Training Program."
- **U. S. Fish and Wildlife Service.** "Effects of PCBs and Related Compounds in the Chicken as an Avian Model."
- **NIEHS.** "Development of a Novel Cell Line for the Assessment of the Effects of Planar Chlorinated Hydrocarbons."
- **U. S. Forest Service Challenge Grant.** "Bald Eagle Population Biology and Contaminants in Chippewa, Superior and Hiawatha National Forests."
- **University of Wisconsin.** "Concentrations of Contaminants in Birds."
- **U. S. Department of Agriculture.** "Contaminants in Bald Eagles and Eagle Population and Habitat Analysis."
- **U. S. Environmental Protection Agency, ERL-Duluth.** "Assessment of Effects of Planar Hydrocarbons in Birds of Saginaw Bay, Michigan."
- **Consumers Power Co.** "Assessment of Michigan Bald Eagle Populations."
- **U. S. Environmental Protection Agency.** "A Pilot Study for Contaminant Uptake in Two Species of Albatross in the North Pacific Ocean."
- **U. S. Fish and Wildlife Service.** "Contaminants in Great Lakes Birds."
- **U. S. Department of Interior.** "Assessment of Productivity and Contaminant Exposure on Nesting Bald Eagles in Michigan."
- **Michigan Great Lakes Protection Fund.** "Analysis Methods and Biochemical Mechanisms of Chlorinated Aromatic Compounds in Biota of the Great Lakes."

- **Dow-Corning Corp., Midland, MI.** Science advisory group (SAG) for silicones in the environment jointly with Procter & Gamble Co. Reassessment of silicones in the environment.

- **East Lansing, Waste Water Treatment Plant.** Bioassay for waste water permitting.

- **ECETOC, Brussels, Belgium.** Briefing on estrogenic compounds in the environment.

- **Environment Canada: Great Lakes University Research Council.** Review of research proposals. Technical subcommittee to review "Guidelines on collection, storage, manipulation of whole sediment, pore water, elutriates and solvent extracts of sediments for toxicity testing and chemical characterization."

- **Environmental Policy Center Law Companies Environmental Group.** Review of risk dialogue group documents.

- **U. S. Environmental Protection Agency, Environmental Biology Review Panel of the Exploratory Research Program ORD.** Review of proposals submitted to the program, including travel to study panel meetings.

- **Florida Department of Environmental Protection, Tallahassee, FL.** Task force on water pollution control. Metals in fish effects on fish, mercury and cadmium. 1983.

- **Gardner, Carton and Douglas, Chicago, IL.** Expert witness PCB contamination and suspended solids loading to Waukegan, WI Harbor, for Outboard Marine Corp.

- **Georgia Pacific Corp.** Litigation dioxins in fish and human health assessment.

- **Greely and Hanson Inc, Chicago, IL.** Assessment of the use of "Microtox"R as a rapid screening tool for acute toxicity studies.

- **Herchel Hobson, Attorney at Law, Beaumont, TX.** Litigation, hexachlorobenzene and hexachlorobutadiene in fishes, class action suit.

- **Hoechst-Roussel Agri-Vet Company, Sommerville, NJ.** Review of testing protocols for agricultural chemical ecotoxicology. General consultant on agricultural chemical ecotoxicology.

- **Home Insurance Company.** See Tressler et al.

- **Honigman, Miller, Schwartz and Cohn, Attorneys at Law, Detroit, MI, with Wendt Consulting, Inc., Alma, MI.** Review of PCB contamination at Hitachi Industrial Site, Edmore, MI.

- **HydroQual, Inc, Mahwah, NJ.** Design of study for registration of Chlorpyriphos for Turf Grass applications.

- **Idaho Board of Education Specific Research Grant Program.** Review of research proposals.

- **Inland Steel Corp, E. Chicago, IL.** Development of sediment toxicity monitoring program.

- **Jones, Day, Reavis and Pogue, Attorneys at Law, Washington, D.C.** Litigation, dioxins in fish from a pulp and paper mill. Wildlife hazard assessment. Bioavailability. Cancer risk.

- **Jones, Jones & Alexander, Cameron, LA.** Litigation, hexachlorobenzene and hexachlorobutadiene in fishes, class action suit.

- **Kemper Insurance Co.** See Tressler et al.

- **Kimberly-Clark, Inc.** Advisory Group, fates and effect of chlorinated dioxins and similar compounds. Lead consultant on litigation involving dioxins in the environment.
- **King and Spaulding, Washington, D.C.** Litigation, dioxins in fish from a pulp and paper mill. Cancer risk. Bioavailability.
- **Latham & Watkins, Attorneys at law, San Diego, CA.** DDT contamination litigation. Sediment contamination, effects on benthic invertebrates, fish, birds. Ecological risk assessment.
- **Limnotech Inc, Ann Arbor, MI.** Optimization of sampling plan for U. S. Environmental Protection Agency, water quality monitoring and the wasteload allocation program. Litigation land developers vs. Fairfax County, VA. Assessment of effects of treatment of Occuquon Reservoir with copper sulfate. General waste and runoff water allocation problem.
- **MAXUS Energy Corp.** Sediment monitoring and assessment.
- **Michigan Department of Natural Resources.** Comment on documents and proposed actions.
- **Michigan Department of Public Health.** Development of advisories for consumption of fish from the Great Lakes by humans.
- **Minnesota Mining and Manufacturing, Inc., Minneapolis, MN.** Served as the lead environmental consultant for the corporation, answered questions and reviewed programs.
- **Moneco Consultants, Ltd., Calgary, Alberta, Canada.** Review of water quality criteria documents. Benzene and chlorinated benzenes.
- **Montana Power Company.** Metal contamination in the Clark-Fork River System. Lead, cadmium, zinc and arsenic from mine wastes. Monitoring program design.
- **Montrose Chemical Co., Los Angeles, CA.** Los Angeles Harbor, CA, litigation. Natural resource damage assessment of DDT. Richmond Harbor, CA, litigation. Natural resource damage assessment of DDT.
- **National Agricultural Chemical Association (NACA), Washington, D.C.** Development of testing protocols to determine the environmental impact of agricultural chemicals.
- **National Air and Stream Improvement Institute (NCASI), Kalamazoo, MI.** Briefing on chlorinated dioxins in the environment to officials of pulp and paper industries, Chicago, IL.
- **New York State Department of Conservation.** "Biothreat" model for hazard assessment of hazardous waste sites.
- **NOVA WGBH Television, Boston, MA.** Review of programing on environmental issues.
- **Nutter, McClennen and Fish, Attorneys at Law, Boston, MA.** Expert witness, PCB contamination of New Bedford Harbor. With AVX Corporation and Balsam Environmental Consultants.
- **O'Brien and Gere, Syracuse, NY.** Remediation study of chloride contamination in Onondaga Lake, NY.
- **Occidental Petroleum, Inc.** Sediment monitoring and assessment.
- **Ontario Ministry of the Environment, Water Resources Branch, Toronto, Ontario, Canada.** Comprehensive review of: Water quality criteria development document on benzene and substituted benzenes in the aquatic environment. Laboratory sediment biological testing protocol.

- **Organization for Economic Cooperation and Development, Paris, France.** Development of sediment quality criteria.
- **Paul-Hastings-Janofsky and Walker, Attorneys at Law, Stanford, CT.** Arsenic poisoning case.
- **Pillsbury, Madison, and Sutro, Attorneys at Law, Los Angeles, CA.** Expert witness, case development and document review - PCB's, DDT in sediments, sediment quality criteria
- **Proctor and Gamble, Inc. Cincinnati, OH.** Science advisory group on silicones in the environment.
- **Research and Evaluation Associates, Inc. Chapel Hill, NC.** Review of *ad hoc* document submitted to U. S. Environmental Protection Agency entitled "96-hr flow-through toxicity study of butylbenzyl phthalate to the freshwater crayfish, *Procambarus sp.*"
- **Reminger and Reminger, Attorneys at Law, Cleveland, OH.** Trace metal contamination of soil.
- **Residuals Management Inc., Madison, WI.** Fate of PCBs in Shiawassee River.
- **Rhoades, McKee and Boer, Attorneys at Law, Grand Rapids, MI.** For Farmers Home Insurance. Groundwater contamination from solid waste landfill. Soil and groundwater contamination from leaking underground storage tank.
- **City of Rochester, MI.** Bioassays for waste water permitting.
- **Risk and Decision Processes Center, Philadelphia, PA.** Citing a hazardous waste facility.
- **Roberts, Betz and Bloss Attorneys at Law, Grand Rapids, MI.** Groundwater contamination from municipal, solid waste landfill. Expert witness - litigation preparation deposition.
- **Ropes and Gray, Attorneys at Law, Boston, MA.** Natural rsource damages due to DDT and PCB cntamination of Los Angeles Harbor.
- **Saginaw National Watershed Initiative.** Technical Steering Committee.
- **SETAC Foundation for Environmental Education, Pensacola, FL.** Chairman, Board of Directors, 1992-1993.
- **Silicones Environmental Health & Safety Council.** Science Advisory Group (SAG) for silicones in the environment.
- **South Florida Water Management District, West Palm Beach, FL.** Review of research results, "The Influence of Phosphorus on Mercury Cycling and Bioaccumulation in the Everglades."
- **Thorsrud, Cane & Paulich, Seattle, WA.** Expert witness: ASARCO, Inc. vs. American Home Assurance Co. Metal contamination. Environmental insurance case.
- **Tolley, Fisher and Verwys, Attorneys at Law, Grand Rapids, MI.** Litigation on fish kill by insecticide Endosulfan®.
- **Tressler, Soderstrom, Maloney and Priess, Attorneys at Law, Chicago, IL.** Litigation on PCB, BOD and total ioisotopes, PAHs dissolved solids in Kalamazoo River, MI, for Kemper and Home Insurance Companies.
- **Upjohn Corp., Kalamazoo, MI.** Environmental monitoring for organic and inorganic contaminants.

- **U. S. Army Corps of Engineers, Buffalo District Office.** Design of program for monitoring of residues leaching from contained dredge material disposal sites in Buffalo Harbor.
- **U. S. Department of Interior, National Sea Grant Program.** Scientific panel to review Chesapeake Bay Toxics Research Program.
- **U. S. Environmental Protection Agency, Office of Research and Development.** Review of core research program. Chair person of SETAC *ad hoc* review committee.
- **U. S. Environmental Protection Agency/U. S. Department of Justice, Washington, D.C.** Expert witness, United States of America against Petro Processors of Louisiana, Inc.
- **U. S. Fish and Wildlife Service, Great Lakes Fisheries Laboratory.** ATP analysis in fish eggs, effects of xenobiotics on fish eggs, trace metal speciation.
- **VCI (Verband Der Chemische Industrie Deutschland), Frankfurt, West Germany.** 1988. Development of systems to rank hazardous materials
- **Warren Waste to Energy Inc, Warren, MI.** Assessment as release of metals from fluidized bed incineration of municipal waste for energy recovery from waste. Permitting with State of Michigan.
- **Watson and Harrison, Attorneys at Law, Tuscaloosa, AL.** Evaluation of chloride in effluents from coal methyl productions to the Chaba River, AL.
- **Womble and Carlyle, Attorneys at Law, Charlotte, NC.** 1993. Litigations with pulp and paper mills.
- **W.W. Engineering & Science, Grand Rapids, MI.** Review of report on sediment toxicity assessment for St. Mary's River, MI.

Employment History

- ENTRIX, Inc., Distinguished Scientist and Technical Director, 1995 to date
- Professor & Canada Research Chair, University of Saskatchewan; Department of Veterinary Biomedical Sciences & Toxicology Centre, 2006 to date.
- Michigan State University, Professor, 1981 to 2006; Professor Emeritus 2006 to date.
- University of Florida, Adjunct Assistant Professor of Environmental Engineering, 1978 1981
- Emory University, Adjunct Assistant Professor of Biology, 1978 1981
- University of South Carolina Aiken Campus, Instructor of Biology, 1976
- University of Georgia, Adjunct Assistant Professor, Zoology, 1976 1980
- Savannah River Ecology Laboratory, Research Ecologist, 1976-1981
- Alma College, Instructor of Biology, 1972

Honors and Awards

- **Sigma Xi Junior Investigator Research Award**, Michigan State University Chapter, 1989

- **CIBA-GEIGY Agricultural Recognition Award**, Environmental Science, 1990
- **Willard F. Shephard Award**, Michigan Water Pollution Control Association, 1992
- **International Man of the Year-Environmental Toxicology**, International Biographical Centre, 1992-1993
- **Distinguished Professor Award**, Michigan State University, 1993
- **QUINTESSENCE: Excellence in Environmental Contamination & Toxicology Award**, 1994
- **Vollenweider Environmental Science Award**, Awarded annually by Environment Canada Government (Canadian Center For Inland Waters, Burlinton), 1994
- **Founders Award**, Society of Environmental Toxicology & Chemistry (SETAC), 1995

Presentations and Publications

Presentations

Dr. Giesy has made 1000 presentations world wide. These include local, national and international meetings of scientific societies (see section on memberships in professional societies), invited presentations to workshops and symposia and invited lectures and seminars. He has also chaired numerous sessions at scientific meetings.

Publications

Dr. Giesy has published 587 peer reviewed works: 48 book chapters and 169 journal communications, 3 feature articles, 3 published reviews, 14 special publications, written 1 book and edited 5 books. A complete listing is available upon request.

ENTRIX
ENVIRONMENTAL CONSULTANTS

Paul M. Mehrle, Jr., Ph.D.

Senior Vice President & Technical Director

Discipline/Specialty

- Ecological Risk Assessment
- Environmental Chemistry
- Water Quality Assessments
- Environmental Risk Management
- Natural Resource Damage Assessment
- Litigation Strategy & Support

Education

- Ph.D., Biochemistry, University of Missouri, 1971
- M.A., (Zoology), University of Missouri, 1969
- B.A., (Biology), Rhodes College, 1967

Professional Affiliations

- American Chemical Society/Member of the Pesticide Chemistry Division and Environmental Chemistry Division
- President, SETAC Foundation for Environmental Education, 1998 - 2004
- SETAC, Senior Editor of *Environmental Toxicology and Chemistry*, 1989-1995
- Society of Environmental Toxicology & Chemistry (SETAC), President, 1994

Summary of Qualifications

Dr. Mehrle is an environmental toxicologist and chemist with over 30 years of experience in ecological risk assessments, environmental chemistry, water quality and sediment quality criteria assessments, natural resource damage assessments, and international regulatory compliance of chemicals. His areas of expertise are in environmental fate and effects of chemicals including petroleum hydrocarbons, pesticides, PCBs, dioxins and furans, industrial and specialty chemicals, inorganics and metals, pharmaceuticals, and consumer products. He has lead investigations related to CERCLA and RCRA issues and developed strategies for risk-based closures at contaminated sites. He has many years of experience in providing strategy development for managing environmental liabilities and for supporting litigation cases. For 22 years Dr. Mehrle was a research scientist for the U.S. Fish and Wildlife Service, where he conducted research and managed multidisciplinary environmental toxicology and chemistry programs focused on management of natural resources. Following his career with the U.S. Department of the Interior, Dr. Mehrle worked for six years for a leading international contract research laboratory as Vice President and Director of Environmental Toxicology and Chemistry. In this capacity, he assisted chemical and pharmaceutical manufacturers and consumer product companies in environmental safety evaluations and global regulatory compliance of new chemical products. Dr. Mehrle has served as a consultant and science advisor to global chemical manufacturers and consumer product companies, federal and state governments, international government organizations, and law firms.

Relevant Experience

- Dr. Mehrle has directed a variety of projects on the fate and effects of chemicals for the purposes of management of natural resources and international regulatory compliance. He has designed and implemented environmental assessment projects as well as provided financial management and strategic planning activities for environmental projects during his career. A brief description of representative project activities are listed below.
- Consultant and science advisor to numerous paper and pulp mill companies on the risk to natural resources of dioxins, furans, and other trace contaminants in effluents.
- Science advisor to numerous law firms on litigation strategies, risk assessments, and liability management related to the paper and pulp mills, chemicals, pesticides and petroleum industries.
- Consultant to state and federal governments on the risk of PCBs, dioxins, furans, pesticides, metals (cadmium, lead, arsenic, zinc, copper,) and chemical formulations to natural resources.

- Project manager and science advisor on studies evaluating the toxicological significance of trace metal mixtures including cadmium, lead, zinc and copper in aquatic habitats impacted by point source and non-point source releases.
- Advisor to state and federal government agencies on derivation of water quality criteria and sediment quality criteria.
- Consultant to mining companies on the fates and effects of lead, arsenic, cadmium and zinc in aquatic ecosystems and evaluation of sublethal responses relative to viability of fish populations.
- Science advisor to global chemical companies and consumer product companies on registration and regulatory compliance for new chemicals and formulations in the U.S., Europe and Canada.
- Invited participant in international symposia in Europe, Russia, and Canada on the risk of chemical contaminants to aquatic ecosystems.
- Directed environmental safety assessment programs on polymers, silicone compounds, and surfactants for major chemical manufacturers.
- Science advisor for research projects related to toxicological assessment of acid/metal interactions for U.S. EPA and state governments concerned with acid deposition in aquatic habitats.
- Science advisor on design and implementation of regulatory testing programs for agrochemical manufacturers for compliance with U.S. FIFRA and European Union registration requirements.
- Consultant and scientific advisor to numerous industries, governments and law firms on environmental risk assessment and liability management of chemicals and consumer products.

Publications

Peer-Reviewed, Published Papers

- Mehrle, P.M., D. Stalling and R. Bloomfield. 1971. Serum amino acids in rainbow trout as affected by DDT and dieldrin. Comp. Biochem. Physiol. 38B:373-377.
- Mehrle, P.M. and W.R. Fleming. 1970. The effect of early and midday prolactin injections on the lipid metabolism of Fundulus kansae held on a constant photoperiod. Comp. Biochem. Physiol. 36:597-603.
- Grant, B.F., P.M. Mehrle and T.R. Russell. 1970. Serum characteristics of spawning paddlefish (Polyodon spathula). Comp. Biochem. Physiol. 37:321-330.
- Grant, B.F. and P.M. Mehrle. 1970. Chronic endrin poisoning in goldfish, Carassius auratus. J. Fish. Res. Bd. Canada. 30:31-40.
- Mehrle, P.M. 1971. Amino acid metabolism of rainbow trout (Salmo gairdneri) as affected by chronic dieldrin exposure. Ph.D. dissertation, University of Missouri, Columbia, Missouri. (Dr. Richard Bloomfield, Advisor).
- Mehrle, P.M. and R.A. Bloomfield. 1974. Ammonia detoxifying mechanisms of rainbow trout altered by dietary dieldrin. Toxicol. Appl. Pharm. 27:355-356.
- Mehrle, P.M., M.E. Declue, and R.A. Bloomfield. 1972. Phenylalanine metabolism as altered by dietary dieldrin. Nature, 238:462-463.

- Mehrle, P.M. 1969. The effect of early and midday prolactin injection on the lipid metabolism of Fundulus kansae held on a constant photoperiod. Masters Thesis, University of Missouri, Columbia. (Dr. Warren R. Fleming, Advisor).
- Mehrle, P.M. and M.E. Declue. 1973. Phenylalanine determination in fish serum: Adaptation of a mammalian method to fish. Anal. Biochem. 52:660.
- Lockhart, W.L., J.F. Uthe, A.R. Kenney and P.M. Mehrle. 1972. Methylmercury in northern pike (Esox lucius): Distribution elimination, and some biochemical characteristics of contaminated fish. J. Fish. Res. Bd. Canada, 29:1519-1523.
- Mehrle, P.M., W.W. Johnson and F.L. Mayer. 1974. Nutritional effects on chlordane toxicity in rainbow trout. Bulletin Environ. Contam. Toxicology 12(5):513-517.
- Mayer, F.L. and P.M. Mehrle. 1974. Effects of the dimethyl amine salt of 2,4-D on fathead minnow growth and reproduction. Presented at 14th Meeting of the Weed Society of America, Feb. 12-14, Las Vegas, Nevada.
- Mayer, F.L., P.M. Mehrle and W.P. Dwyer. Toxaphene effects on reproduction, growth, and mortality. Ecological Research Series, EPA-600/3-75-013, Environmental Protection Agency, Corvallis, Oregon, Nov. 1975.
- Mehrle, P.M. and F.L. Mayer. 1975. Toxaphene effects on growth and bone composition of fathead minnows. J. Fish. Res. Bd. Canada 32:592-598.
- Mehrle, P.M. and F.L. Mayer. 1975. Toxaphene effects on growth and development of brook trout. J. Fish. Res. Bd. Canada. 32:609-613.
- Mehrle, P.M. and F.L. Mayer. 1977. Bone development and growth of fish as affected by toxaphene. Pages 301-314 in I.H. Sufet, ed. Fate of Pollutants in Air and Water Environments, Advances in Environmental Science and Technology, Wiley Interscience Publisher, New York.
- Mayer, Foster L., Paul M. Mehrle and Herman O. Sanders. 1977. Residue dynamics and biological effects of polychlorinated biphenyls in aquatic organisms. Archives of Environmental Contaminants and Toxicology, 5(4), pp. 449-509.
- Mayer, F.L., P.M. Mehrle and W.P. Dwyer. Toxaphene: Chronic toxicity to fathead minnows and channel fish. Ecological Research Series. No. EPA-600/3-77-069. U.S. EPA, Duluth, MN 48 p.
- Mayer, F.L. and P.M. Mehrle. 1978. Backbone Collagen and Hydroxyproline Metabolism in Toxicological Studies with Fishes. Symposium on Effects of Pollutants on Aquatic Ecosystems. Proceedings of the 2nd USA Symposia on The Effects of Pollutants upon Aquatic Ecosystems. U.S. Environmental Protection Agency EPA-600/3-78-076 158p.
- Mehrle, P.M. and F.L. Mayer. 1976. Di-2-ethylhexylphthalate: Residue dynamics and biological effects in fathead minnows and rainbow trout. pp. 519-524 in D.D. Hemphill, ed. Proceedings of the Conference on Trace Substances in Environmental Health, University of Missouri, Columbia, MO.
- Mayer, F.L., P.M. Mehrle and P.L. Crutcher. 1978. Interaction of vitamin C and toxaphene in channel catfish. Trans. Amer. Fish. Soc. 107:326-333.

- Mayer, Foster L. and Paul M. Mehrle. 1977. Toxicological aspects of toxaphene in fish: A summary Proceedings of the 42nd North American Wildlife and Natural Resources Conference Transactions, Wildlife Management Institute, Washington, D.C. pp. 365-373.

- Mauck, Wilbur L., Paul M. Mehrle and Foster L. Mayer. Effects of the Polychlorinated Biphenyl Aroclor 1254 on growth and bone development in brook trout. J. Fish..Res. Board. Canada 35:1084-1088, 1978.

- Mehrle, Paul M., Mack T. Finley, Larry Ludke, Foster L. Mayer and T.E. Kaiser. 1979. Bone development in black duck as affected by dietary toxaphene. Pesticides Biochemistry and Physiology 10:168-173.

- Mayer, F.L., P.M. Mehrle and R.A. Schoettger. 1977. Collagen metabolism in fish exposed to organic chemicals. pp. 31-54 in R.A. Tubb, ed. Recent Advances in Fish Toxicology: A symposium. Ecological Research Series No. EPA-600/3-77-085. U.s. Environmental Protection Agency, Corvallis, Oregon.

- Mehrle, P.M., F.L. Mayer and Johnson. Dietary quality in fish toxicology: Effects on Acute and Chronic Toxicity, Aquatic Toxicology and Hazard Evaluation, ASTM STP 634, F.L. Mayer and J.L. Hamelink, Eds., ASTM, 1977, pp. 269-280.

- Mayer, F.L., W.J. Adams, M.T. Finley, P.R. Michael, P.M. Mehrle and V.W. Sarger. Phosphate ester hydraulic fluids: An aquatic environmental safety assessment of Pydraul 50E and 15E. pp. 103-123 in Dr. Branson and K.L. Dickson, Eds. Aquatic Toxicology and Hazard Assessment, ASTM Special Technical Publication 737, Philadelphia, PA.

- Mehrle, P.M. and F.L. Mayer. 1980. Clinical tests in aquatic toxicology: State of the Art. Presented at Society of Toxicology National Meeting. New Orleans, LA. March 13, 1979. Environ. Health Persp. 34:139-143.

- Woodward, D.F., P.M. Mehrle, and W.L. Mauck. 1981. Accumulation and sublethal effects of a Wyoming crude oil in cutthroat trout. Trans. Amer. Fish. Soc. 110:427-445.

- Mayer, F.L., P.M. Mehrle and R.A. Schoettger. 1980. Trends in aquatic toxicology in the United States: A Perspective. Proceedings of the Third USA-USSR Symposium on the Effects of Pollutants Upon Aquatic Ecosystems. EPA-600/9-80-034.

- Mehrle, P.M., F.L. Mayer and D.R. Buckler. Kepone and Mirex: Effects on bone development and swim bladder composition in fathead minnows. Transactions of American Fisheries Society 110:638-643. 1981.

- Hamilton, S.J., P.M. Mehrle, F.L. Mayer and J.R. Jones. 1981. Method to evaluate mechanical properties of bone in fish. Transactions of American Fisheries Society 110:708-717.

- Hamilton, S.J., P.M. Mehrle, F.L. Mayer and J.R. Jones. 1981. Mechanical properties of bone in channel catfish as affected by vitamin C and toxaphene. Transactions of American Fisheries Society 110:718-724.

- Ludke, J.L., T. Haines, M. Ribick, P. Mehrle and S. Hamilton. Contaminant studies in Atlantic coast striped bass: detection and significance of residues. Symposium on "Striped Bass: Environmental Risks in Fresh and Saltwater"' 112th Annual Meeting American Fisheries Society, Hilton Head Island, South Carolina, September 1982.

- Mehrle, P.M. and F.L. Mayer. Biochemistry and Physiology. 1985 Chapter in Fundamentals of Aquatic Toxicology, G. Rand and S. Petrocelli, Eds., Hemisphere Publishing Corporation, N.Y., N.Y. 666 pp.

- Mehrle, P.M., T.A. Haines, J.L. Ludke, F.L. Mayer and M.A. Ribick. 1982. Relationship between body contaminants and bone development in East coast striped bass. Trans. Am. Fish. Soc. 111:231-241.

- Mehrle, P.M. Pesticides: Addressing Present and Future hazards to Aquatic Resources. Invited paper at Chemical Hazards Workshop, Canada Centre for Inland water, Department of Fisheries and Oceans, Burlington, Ontario. September 10-18, 1985.
- Buckler, D.R., P.M. Mehrle, L.C. Cleveland and F.J. Dwyer. 1987. Influence of pH on the toxicity of aluminum and other inorganic contaminants to East coast striped bass. Water, Air and Soil Pollution 35:97-106.
- Mehrle, P.M., L.C. Cleveland and D.R. Buckler. 1987. Chronic Toxicity of an Environmental Contaminant Mixture to Larval Striped Bass. Water, Air and Soil Pollution 35:107-118.
- Hamilton, S.J., P.M. Mehrle and J.R. Jones. 1987 Cadmium saturation technique for measuring metallothionein in brook trout. Trans. Amer. Fish. Soc. 116: 541-550.
- Hamilton, S.J., P.M. Mehrle and J.R. Jones. 1987 Evaluation of metallothionein measurements as a biological indicator of stress from cadmium in brook trout. Trans. Am. Fish. Soc. 116:551-560.
- Hamilton, S.J. and P.M. Mehrle. 1986. Metallothionein: Review of its importance in assessing stress from metal contaminants. Trans. Am. Fish. Soc. 115:596-609.
- Dwyer, F.J., C.J. Schmitt, S.E. Finger and P.M. Mehrle. Biochemical changes in Longear Sunfish induced by lead, cadmium, and zinc from mine tailings. J. Fish. Biology - in press.
- Mehrle, P.M., D.R. Buckler, E.E. Little, L.M. Smith, J.D. Petty, P.H. Peterman, D.L. Stalling, G.M. DeGraeve, J.J. Coyle and W.J. Adams. 1988. Toxicity and Bioconcentration of 2,3,7,8-TCDD (Dioxin) and 2,3,7,8-TCDF (Furan) in Rainbow Trout. Environmental Toxicology and Chemistry 7(1): 47-62.
- Huggett, R.J., R.A. Kimerle, P.M. Mehrle, H.L. Bergman, eds. Biochemical, Physiological, and Histological Markers of Anthropogenic Stress. Proceedings of the Eighth Pellston Workshop, Keystone, Colorado. Lewis Publishers, Chelsea, MI., 1992. 347 pp.

Peer-Reviewed, Published Abstracts

- Mehrle, P.M. 1970. Liver transaminases and serum amino acids of rainbow trout (Salmo gairdneri) as affected by dieldrin. Paper presented at the 32nd Midwest Fish and Wildlife Conference, Winnipeg, Manitoba. (Abstract).
- Mehrle, P.M. and R.A. Bloomfield. 1971. Amino acid metabolism of rainbow trout (Salmo gairdneri) as affected by dietary dieldrin. Paper presented at 162nd National Meeting of the American Chemical Society, Sept. 1971. Washington, D.C. (Abstract).
- Mehrle, P.M. and M.E. Declue. 1972. Effect of dietary dieldrin on phenylalanine metabolism of rainbow trout. Presented at 163rd National Meeting of the American Chemical Society, April 1972, Boston, Mass. (Abstract).
- Mayer, F.L., P.M. Mehrle and H.O. Sanders. 1972. Residue dynamics and biological effects of polychlorinated biphenyls in aquatic organisms. 164th National Meeting of American Chemical Society, New York City, Sept. 1972. (Abstract).
- Crutcher, P.L. and P.M. Mehrle. 1973. Glucose metabolism of channel catfish as altered by dietary toxaphene: An evaluation of liver and pancreas pathology. 35th Midwest Fish and Wildlife Conference, St. Louis, Missouri, Dec. 2-5. (Abstract).

- Mayer, F.L., P.M. Mehrle and W.P. Dwyer. 1973. Brook trout fry development as affected by toxaphene. 35th Fish and Wildlife conference, St. Louis, Missouri, Dec. 2-5. (Abstract).
- Mehrle, P.M., F.L. Mayer and W.W. Johnson. 1973. Diet quality in fish toxicology: Concern for nutritional quality and contaminants. 35th Fish and Wildlife Conference, St. Louis, Missouri, Dec. 2-5. (Abstract).
- Mayer, F.L., P.M. Mehrle and W.P. Dwyer. Fathead minnow growth and reproduction as affected by 2,4-D-DMA. Presented at the 36th Midwest Fish and Wildlife Conference, Dec. 1974. Indianapolis, Ind. (Abstract).
- Mehrle, P.M., F.L. Mayer and W.P. Dwyer. Toxaphene effects on growth and bone composition of fathead minnows. Presented at 36th Midwest Fish and Wildlife Conference. Dec. 1974. Indianapolis, Ind. (Abstract).
- Mehrle, P.M. Contaminants in fish and fish food. Fish Feed and Nutrition Workshop, Portland, Oregon, Nov. 9-11, 1976. (Abstract).
- Mayer, F.L. and P.M. Mehrle. Vitamin C distribution in channel catfish. 15th Meeting of Society of Toxicology, March, 1976. Atlanta, GA. (Abstract).
- Mehrle, P.M. and F.L. Mayer. Vitamin C influences toxaphene intoxication in channel catfish. 172nd National Meeting of America Chemical Society, Aug. 30 - Sept. 4. San Francisco, California. (Abstract).
- Mehrle, P.M. and F.L. Mayer. Fish intoxications: Their signs, diagnosis and control. 7th Annual Mid-west Fish Disease Workshop, July 14-15, LaCrosse, Wisconsin. (Abstract).
- Mehrle, P.M. Toxicological problems in fish health. Midwest Fish Disease Workshop, July 1977, Iowa State University, Ames, Iowa. (Abstract).
- Mehrle, P.M. Chemical contaminants in warm water fish culture. Warm Water Fish Culture Workshop. Little Rock, Ark. January 24, 1979. (Abstract).
- Mehrle, P.M. Approaches in aquatic toxicology. Aquatic Contaminants Short Course, University of Georgia, Athens. March 1980. (Abstract).
- Mehrle, P.M. and F.L. Mayer. Clinical tests in aquatic toxicology. Fish Health Workshop, Great Lakes Fisheries Commission, Geneva Park Conference Center, Longford Mills, Ontario, Canada. November 16-19, 1981. (Abstract).
- Dwyer, F.J., C.J. Schmitt, S.E. Finger and P.M. Mehrle. Bioavailability of Pb from Mine Tailings to Longear Sunfish. 189th Annual Meeting, American Chemical Society, Miami Beach, FLA., April 28 - May 3, 1985. (Abstract).
- Henry, M., P.M. Mehrle, J.B. Hunn and E.E. Little. Evaluation of the biological effects of lowered pH and aluminum on brook trout and midge followed by subsequent addition of limestone for remedial action. Fifth Annual Meeting, Society of Environmental Toxicology and Chemistry, Arlington, VA. November 4-7, 1984. (Abstract).
- Mehrle, P.M. and J.L. Ludke. Impacts of Contaminants on East Coast Striped Bass. 7th International Estuarine Research Conference. Estuarine Research Federation, Virginia Beach, VA., October 23-26, 1983. (Abstract).

- Mayer, F.L. and P.M. Mehrle. Biochemical responses of fish to contaminant stress. Symposium on Safer Chemicals Through Molecular Design. Sponsored by the U.S. EPA, Oak Ridge National Laboratory, and Society of Toxicology. Arlington, VA. September 11-15, 1983. (Abstract).

- Hamilton, S.J. and P.M. Mehrle. Utility of bone development measurements as indicators of contaminant stress in fish. 114th Annual Meeting American Fisheries Society, Cornell University, Ithaca, N.Y. August 13-16, 1984. (Abstract).

- Mehrle, P.M. Hazard assessments in Aquatic Toxicology. Hazardous Waste Management Institute, College of Engineering, University of Missouri, Columbia. August 10, 1984. (Abstract).

- Mehrle, P.M., D.R. Buckler, L.M. Smith, J.D. Petty, D.L. Stalling, P.H. Peterman, G.M. DeGraeve, J.M. Coyle and W.J. Adams. 2,3,7,8-TCDD and 2,3,7,8-TCDF chronic toxicity to rainbow trout. Tenth ASTM Symposium on Aquatic Toxicology and Hazard Assessment. New Orleans, LA. May 4-6, 1986. (Abstract).

- Petty, J.D., L.M. Smith, P.H. Peterman, P.M. Mehrle, D.R. Buckler, D.L. Stalling, G.M. DeGraeve and J.M.Coyle. Bioconcentration of TCDD and TCDF of Rainbow Trout. 7th Annual Meeting of the Society of Environmental Toxicology and Chemistry. Alexandria, VA. November 4-6, 1986. (Abstract).

- Dwyer, F.J., P.M. Mehrle and J.T. O'Connor. Lead-induced responses in bluegill sun fish: An approach for evaluating the biological significance of lead residues in the aquatic environment. 59th Annual Conference of the Water Pollution Control Federation. Los Angeles, CA. October 5-9, 1986. (Abstract).

- Mehrle, P.M. Overview of Contaminant Research Needs in the Chesapeake Bay. Workshop on Long-Range Research Needs for Chesapeake Bay Living Resources. Sponsored by the Maryland Department of Natural Resources and the University of Maryland, Port Deposit, Maryland. February 3-5, 1987. (Extended Abstract).

- Mehrle, P.M. Impacts of Contaminants on East Coast Striped Bass. Conference on Acidification and Anadromous Fish of Atlantic Estuaries. Sponsored by The Hudson River Foundation, West Point Military Academy, West Point, N.Y. October 15-18, 1985. (Abstract).

- Mehrle, P.M., T. LaPoint and C. Ingersoll. Research Needs in Environmental Risk Assessment. Workshop on Consensus Research Needs and Priorities in Environmental Risk Assessment. Sponsored by the Society of Environmental Toxicology and Chemistry August 16-21, 1987, Breckenridge, Colorado (Extended Abstract).

- Petty, J.D., L.M. Smith, P.H. Peterman, P.M. Mehrle, D.R. Buckler, D.L. Stalling, G.M. DeGraeve and J.M. Coyle. Bioconcentration of TCDD and TCDF by Rainbow Trout in a Flow-Through Exposure Society Environmental Toxicology and Chemistry, November 6, 1986, Alexandria, VA. (Abstract).

- Mehrle, P.M., D.R. Buckler, E.E. Little, L.M. Smith, J.D. Petty, D.L. Stalling, G.M. DeGraeve, J.M. Coyle and W.J. Adams. 2,3,7,8-TCDD and 2,3,7,8-TCDF Chronic Toxicity to Rainbow Trout: Effects on Survival, Growth and Behavior. SETAC Annual meeting, November 6, 1986. Alexandria, VA. (Abstract).

- Coyle, J.M. and P.M. Mehrle. TCDD and TCDF: Toxicity and Bioconcentration in early life stages of rainbow trout. Presentation at Environmental Protection Agency R-VII Workshop on Environmental Problems, September 17, 1987, Kansas City, MO. (Abstract).

- Dwyer, F.J., P.M. Mehrle and J.T. O'Connor. An approach for evaluating the biological significance of lead residues in the aquatic environment. Water Pollution Control Federation Annual Meeting, October 6-9, 1986, Los Angeles, California. (Abstract).

- Mehrle, P.M., J.J. Coyle, D.R. Buckler and W.J. Adams. Chlorinated Dioxin and Furan Toxicity to Rainbow Trout. Frontiers in Analytical Biochemistry, C.W. Gehrke Scientific Program, University of Missouri, Columbia, Mo. November 20, 1988.(Abstract).

Special Reports, Testimonies, Symposia And Professional Activities

- Schoettger, R.A. and P.M. Mehrle. Contaminants in fish feeds, oils and ingredients. Proceedings of Fish Feeds and Nutrition Workshop. Rapid City, South Dakota, Sept. 26-28, 1972

- Schoettger, R.A. and P.M. Mehrle. Contaminants in fish feeds. 2nd Fish Feed and Nutrition Workshop. Fort Collins, Colorado, Sept. 18-20, 1973.

- Mehrle, P.M. and R.A. Schoettger. Contaminants in fish feeds. Proceedings of the 3rd Fish Feed and Nutrition Workshop, Cortland, N.Y., Sept. 21-23, 1974.

- Mehrle, P.M. Testimony in DDT cancellation hearing. Prepared summaries of research at request of the Environmental Protection Agency. 1971.

- Mehrle, P.M. Testimony in ALDRIN/DIELDRIN cancellation hearing. Served as Expert Witness at Request of the Environmental Protection Agency, November 1973.

- Mehrle, P.M. Toxaphene and Fish. MAN AND MOLECULES, national radio show sponsored by the American Chemical Society, May 1975. Transcript #752, ACS, Washington, D.C.

- Mehrle, P.M. Testimony in lawsuit "Superior Catfish Co. vs. National Pet Food Co. and Farmers Warehouse Co.", Superior Court, State of California, Shasta County, Redding California. Served as expert witness on contaminant impacts on channel catfish at request of Superior Catfish Co., February 1976.

- Mehrle, P.M. Testimony in State of Missouri vs. Russell Bliss, Circuit Court of Jefferson County, Missouri. Served as expert witness for State of Missouri Attorney General's office on the toxicological significance of polychlorinated biphenyls in aquatic organisms, May 23, 1979.

- Mehrle, P.M. Testimony in United States of America vs. Union Corporation, Metal Bank of America, et al. Served as expert witness for U.S. Environmental Protection Agency in the U.S.A. District Court for Eastern District of Pennsylvania, June 1980.

- Mehrle, P.M. Program Review for research projects "Toxicological assessment of acid/metal interactions in cold water and warmwater fish" and "Emplacement of limestone gravel in spring upwelling as a possible mitigation measure in acidic brook trout lakes". Presentations before National Acid Precipitation Assessment Program, Effects Research Review, North Carolina State University, Raleigh, N.C., February 21-25, 1983.

- Mehrle, P.M. Review of EPA water quality criteria for toxaphene. A Review of the EPA Red Book, Quality Criteria for Water, American Fisheries Society, Water Quality Section, April 1979, pp. 207-209.

- Mehrle, P.M. and R. Gray. Conveners and organizers of "Water Quality Issues in the 1980's: An International Perspective". A symposium sponsored by the Water Quality Section of the American Fisheries Society with participants from the USSR, Italy, Canada, and USA at the 112th AFS National Meeting in Hilton Head, S.C., September 1982.

- Mehrle, P.M. Convener and organizer of "Biological Indicators of Contaminant Stress on Aquatic Resources", a symposium sponsored by the ASTM, October 1982, St. Louis, Missouri.

- Stalling, D.L., P.M. Mehrle and W.R. Crummet. Convener and organizer of Symposium on Environmental Toxicology and Chemical Analysis. Association of Official Analytical Chemistry (AOAC) Centennial Meeting. Participants from USA, Japan, Germany, and Canada. Washington, D.C. October 29 - November 2, 1984.
- Mehrle, P.M. Invited participant to Third USA-USSR Symposium on the Effects of Pollutants upon Aquatic Ecosystems: Theoretical Aspects of Aquatic Toxicology, Borok, USSR. Member of invited US delegation to visit laboratories in Moscow, Leningrad, Borok, and Lake Baikal, USSR. July 1980.
- Mehrle, P.M. Chairman and Organizer, Symposium on Toxicity and Bioconcentration of Dioxins in Aquatic Life: An Update. Seventh Annual Meeting, Society of Environmental Toxicology and Chemistry. Alexandria, VA. November 4-6, 1986.
- Mehrle, P.M. Advisor to the Attorney General State of Missouri in Missouri Hazardous Waste Management Commission vs. International Paper Company, Joplin, MO. Served as expert witness and scientific advisor on fate and effects of wood preservations from hazardous waste sites in groundwater, June - August 1985. Jefferson City, MO.
- Mehrle, P.M. Research Priorities in Environmental Risk Assessment. Invited participant in workshop on risk assessment sponsored by The Society of Environmental Toxicology and Chemistry. Breckenridge, Colorado, August 1987.
- Mehrle, P.M. Appointed to Advisory Panel on Groundwater Issues in The State of Missouri by Director of Agriculture, State of Missouri, Jefferson City, MO., February 1988.
- Mehrle, P.M. Impacts on Atmospheric Emissions on Aquatic Resources. Invited participant in workshop sponsored by The Power Plant Research Program. State of Maryland, Annapolis, Maryland, April 7, 1988.
- Mehrle, P.M. Invited participant in Organization for Economic Cooperative Development (OECD) Workshop on Ecological Effects Assessment, sponsored by the OECD and hosted by the United States, June 13-17, 1988, Washington DC.
- Mehrle, P.M. Invited participant in the workshop Water Quality Criteria to Protect Wildlife Resources. Sponsored by the Office of Water Regulations and Standards, U.S. Environmental Protection Agency, Washington, D.C. March 1989.
- Mehrle, P.M. Co-organizer and invited participant to the workshop The Existing and Potential Value of Biomarkers in Evaluating Exposure and Environmental Effects of Toxic Chemicals. Keystone, Colorado. July 1989.
- Mehrle, P.M. Chairman, Pulping Effluents in the Aquatic Environment Panel sponsored by The Procter and Gamble Company. Consultant to The Procter and Gamble Company on paper and pulp mill issues related to aquatic environments. 1989.
- Mehrle, P.M. Invited member of the Toxicology Round Table, National Agricultural Chemicals Association, Washington D.C., May 1990-1994.
- Mehrle, P.M. Consultant to John Gould, Lane, Powell, Spears and Lubersky, Attorneys at Law, Portland, Oregon, representing James River Corporation, Boise Cascade Corporation and Pope and Talbot Corporation on chemical impacts from paper and pulp mills. June 1990.
- Mehrle, P.M. Invited participant by the U.S. EPA in Peer Review of Land Application of Sludge from Pulp and Paper Mills Using Chlorine and Chlorine-Derivative Bleaching Processes: Proposed Rule for Human

Dietary and Ecotoxicological Risks. Designated leader for the aquatic risk assessment of the proposed TSCA Test Rule.

- Mehrle, P.M. FDA Environmental Assessments; Present and Future. Chairman and organizer of Scientific Symposium at the 12th Annual Meeting of the Society of Environmental Toxicology and Chemistry, Seattle, Washington, 1991.

- Mehrle, P.M. Consultant and expert witness to Watkins Ludlam & Stennis, Attorneys at Law, Jackson, MS, representing Weyerhauser Corporation on assessment of risks to chemicals from paper and pulp mills. 1992.

- Mehrle, P.M. Consultant to Kimberly-Clark Corporation, Atlanta, GA, on assessment of risks to chemicals from effluents and paper and pulp mills. 1992.

- Mehrle, P.M. Consultant and expert witness to Taylor, Porter, Brooks and Phillips, Attorneys at Law, Baton Rouge, LA, representing Combustion, Inc. on environmental risk of chemicals from a hazardous waste site. 1993 & 1994.

- Mehrle, P.M. Consultant to Campbell, George & Strong, Attorneys at Law, Houston, TX. Represented numerous clients on confidential environmental risk management issues. 1999-2003.

- Mehrle, P.M. Ropes & Gray, Attorneys at Law, Boston, MA. Represented consortium of clients on confidential risk management issues. 1997-2000.

- Mehrle, P.M. Holland & Knight, Attorneys at Law, Tampa, FL. Provided deposition (Opposition to Class Certification) on impacts of pesticides to aquatic environments. Rink et al. Vs. Cheminova, Inc., U.S. District Court, Tampa Division. January 22, 2001.

- Mehrle, P. M. Phelps Dunbar, Attorneys at Law, Baton Rouge, LA. Provided Deposition (Opposition to Class Certification) on impacts of chemicals related to Union Pacific train derailment. August 2001.

- Mehrle, P. M. Lightfoot, Franklin & White, Attorneys at Law, Birmingham, AL. Provided strategy and data review related to class action litigation on impacts of chemicals to aquatic life related to release of chemicals from an agricultural chemical manufacturing plant. 2002– 2003.

- Mehrle, P.M. Heller Ehrman White & McAuliffe, Attorneys at Law, San Francisco, CA. Provided strategy development, data review, and two depositions related to litigation involving fate & transport of chemicals in Los Angeles Harbor coastal waters and sediments. 2003 - 2004.

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Re: Comments on "Economic Considerations of Proposed Sediment Quality Plan for Enclosed Bays in California," Prepared by SAIC, September 18, 2007

Dear Ms. Nera, Mr. Kelly, and Mr. McAlister,

I appreciate the opportunity to submit this comment concerning the State Water Resources Control Board's proposed Water Quality Control Plan for Enclosed Bays and Estuaries in California, Sediment Quality Objectives (SQOs).

In particular, I am commenting on the report entitled "Economic Considerations of Proposed Sediment Quality Plan for Enclosed Bays in California," prepared by Science Applications International Corporation (SAIC) of Reston, VA. My comments are divided into three sections. The first section describes how the SAIC report assesses economic impacts. The second section compares this approach to the requirements of a proper economic analysis as required by Porter-Cologne. The third section of this comment letter details a number of errors and discrepancies in the economic analysis I identified during the course of my examination.

I have attached a copy of my curriculum vitae to this letter. I am a founder and principal of Berkeley Economic Consulting, Inc., an independent economic research firm located in Berkeley, CA, and specializing in environmental, labor, energy and natural resource economics.

I am also a professor of environmental and resource economics at UC Berkeley, and am the co-director of the Berkeley Water Center – a research center sponsored by the Colleges of Engineering and Natural Resources, and the Lawrence Berkeley National Laboratory.

Executive Summary

The SAIC report was commissioned by the State Water Resources Control Board to assess the economic impacts of the proposed SQOs, consistent with the requirements set forth in the California Water Code. Although it is standard environmental economic practice to identify the economic benefits assumed to accrue from improvements in environmental quality, the SAIC report does not conduct a benefits analysis. Nor does the SAIC report provide any meaningful analysis of the costs that are likely to be imposed by the proposed regulation. Further, the monitoring and stressor identification costs that are discussed in the SAIC report have internal errors and inconsistencies. The expected more significant costs associated with the proposed regulation – actions that will need to be taken to comply with the proposed regulation – are not discussed at all. Without a benefits analysis or a robust cost analysis, the SAIC report does not constitute an adequate consideration of the economic issues implicated by the proposed regulation.

Description of Approach Taken by SAIC

The SAIC economic analysis report attempts to explain the factors and considerations necessary to assess the economic impact of the proposed Sediment Quality Objectives Plan (Plan). The report is organized as follows:

- the first section provides background and a description of the economic analysis;
- the second section explains the factors affecting sediment quality;
- the third describes the baseline for the analysis;
- section four describes the proposed plan;
- the fifth section describes the incremental impact of the Plan;
- the sixth section explains the methods of compliance; and
- the final section is an analysis of statewide costs.

The information in Section 1 describes the Porter-Cologne Act and the scope of the economic analysis and the report organization. The report "addresses whether the proposed SQOs are currently being attained, the incremental impact of the Plan on actions related to improving sediment quality, the pollution control and remediation methods available to achieve compliance with the Plan, and the costs of those methods."[1]

Section 2 of the report explains the considerations necessary when assessing sediment toxicity.[2] In the event that the factors affecting sediment quality are not readily identifiable it is necessary

[1] Economic Considerations of Proposed Sediment Quality Plan for Enclosed Bays in California September 18, 2007. P. 1-1
[2] *Ibid* P. 2-1

to perform a Toxicity Identification Evaluation (TIE).[3] In addition the chemicals that are the main causes of sediment toxicity are listed with detailed descriptions.[4] The general pollutant categories are metals, pesticides, polychlorinated biphenyls, and polynuclear aromatic hydrocarbons.[5] According to SAIC, "sediments that do not support a diverse community are either toxic or have inputs and disturbances that dominate such that a healthy, balanced benthic community cannot be established. The proposed Plan is concerned only with sediments that are impaired due to the presences of toxic pollutants that cause or have the potential to cause impacts to benthic communities or human health."[6] The SAIC report further describes the sediment qualities that affect bioavailablity of contaminants.[7] These factors influence the economic analysis because they are integral to determining the level of clean up and the remediation actions necessary for the suite of pollutants that may be present.

In Section 3, SAIC presents a series of baseline conditions that are used to evaluate the economic impacts of implementing the Plan. The baseline conditions include "current objectives and policies regulating activities and pollutant discharges that affect sediment quality, ongoing cleanup and remediation activities, and planned or anticipated cleanup and remediation actions that have not yet been completed [e.g., total maximum daily load development (TMDL) and implementation schedules]."[8]

The report takes existing objectives for screening values of fish contaminants from the Office of Environmental Health Hazard Assessment.[9] Section 3 of the report also describes the costs for and description of the current monitoring plans that have been conducted or will be conducted as a result of the Regional Water Boards requirements.[10] A discussion of the major discharge categories is also included. The categories of dischargers are municipal, industrial, storm water, abandoned and inactive mines and atmospheric deposition. Municipal and industrial dischargers are regulated through the National Pollutant Discharge and Elimination System (NPDES) permit program.[11] A summary of the permitted facilities that discharge to the bays is presented in this section. The Regional Water Boards regulate most storm water dischargers under general permits:[12] "General permits often require compliance with standards through an iterative approach based on storm water management plans (SWMP), rather than through the use of numeric effluent limits. In other words, permittees implement best management practices (BMPs) identified in their SWMPs."[13] Dischargers included under the general permits are

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[3] *Ibid*
[4] *Ibid*
[5] *Ibid* P. 2-2
[6] *Ibid*
[7] *Ibid* P. 2-4
[8] *Ibid* P. 3-1
[9] *Ibid*
[10] *Ibid* P. 3-2
[11] *Ibid* P. 3-4
[12] *Ibid* P. 3-5
[13] *Ibid*

municipal, industrial, construction and the California Department of Transportation (Caltrans).[14]

Nonpoint source pollution may originate from several sources including agricultural operations, forestry operations, urban areas, boating and marinas, active and historical mining operations, atmospheric deposition, and wetlands. Note that, in many cases, discharges from these sources can be regulated as point sources (i.e., discernible, confined, and discrete conveyances).[15] The State and Regional Water Quality Boards have legal authority to regulate nonpoint source pollution under the Porter-Cologne Act. The Regional Water Boards do not usually assign nonpoint sources numeric effluent limits; rather they primarily rely on implementation of the BMPs to reduce pollution.[16] The exiting impaired waters and the associated contaminants of concern are detailed in this section as well. "Under the CWA, Section 303(d), states are required to develop a list of water quality limited segments, establish priority rankings for the segments, and develop action plans, or TMDLs, to improve water quality. The State Water Board's existing 303(d) Listing Policy (SWRCB, 2004) indicates that a water segment will be listed as impaired if the sediments exhibit statistically significant toxicity based on a binomial distribution of the sampling data and exceedances."[17] There are 64 listings for impaired waters in California.[18] The sediment cleanup and remediation activities as well as the TMDL's for bays and estuaries are listed in this section. Regional Water Boards issue cleanup and abatement orders which provide the cleanup level that responsible parties will be required to achieve.[19]

Section 4 of the SAIC report describes the applicability of the proposed Plan, implementation procedures, and monitoring requirements.[20] "The Plan protects estuarine and marine habitat and rare and endangered species beneficial uses, and commercial and sport fishing, aquaculture, and shellfish harvesting beneficial uses by protecting benthic aquatic life and human health, respectively; Aquatic Life – Benthic Community Protection: Pollutants in sediments shall not be present in quantities that, alone or in combination, are toxic to benthic communities in bays and estuaries implemented using the integration of multiple lines of evidence (MLOE) as described in Section V of the Plan."[21] In regard to human health, "[p]ollutants shall not be present in sediments at levels that bioaccumulate in aquatic life to levels that are harmful to human health."[22] The Plan specifies that sites with unimpacted and likely unimpacted sediments achieve the sediment quality objectives, whereas sites with clearly impacted, likely impacted, and possibly impacted sediments exceed the sediment quality objectives.[23] If sediments fail to meet the narrative objectives, the Plan specifies that a sequential approach consisting of the following

[14] *Ibid*
[15] *Ibid* P. 3-10
[16] *Ibid*
[17] *Ibid* P. 3-17
[18] *Ibid* P. 3-18 to 3-21
[19] *Ibid* P. 3-32
[20] *Ibid* P. 4-1
[21] *Ibid*
[22] *Ibid*
[23] *Ibid* P. 4-4

tasks is necessary to manage the sediment appropriately: Confirmation and characterization of pollutant-related impacts, Pollutant identification, and Source identification.[24]

Section 5 discusses the incremental economic impacts that are the heart of most regulatory analyses. This section discusses the "potential incremental impacts of the proposed Plans and implementation procedures for affected bays and estuaries, and provides estimates of these impacts associated with the aquatic life (benthic community protection) SQO based on an initial assessment of available monitoring data for bays performed for the State Water Board by the Southern California Coastal Water Research Program (SCCWRP) in 2007."[25] The report states that the incremental costs that are associated with the sediment quality objectives are directly related to the monitoring and assessment efforts that would be required for sites lacking sufficient data to classify them. An identification of each of the sites with data is detailed in the SAIC report.[26] If the sites are currently listed as impaired further information is provided as to the cleanup efforts currently underway and the standards implemented such as Total Maximum Daily Load (TMDL) and Consolidated Toxic Hot Spots Cleanup Plan.[27] The costs of these efforts are not included in the economic analysis due to the fact that they are currently underway and would be implemented in the absence of the Plan.[28] In the event that they are classified as impaired, the suite of costs would include the development of a TMDL and the cleanup costs associated with sites exceeding the developed numeric sediment quality targets.[29]

Section 6 concerns compliance and identifies potential means of compliance with the Plan, and the associated costs of those measures.[30] Additional monitoring may be needed for those bays and estuaries with insufficient data to assess compliance with the Plan. For those waters exceeding the proposed objectives, stressor identification studies may also be needed.[31]

Sample collection costs may vary based on factors such as water depth, sediment characteristics (which may cause unsuccessful grabs that need to be repeated), and distance between stations. The number of stations from which data should be collected will vary based on water body-specific factors including: area, tidal flow and/or direction of predominant currents, historic and or legacy conditions in the vicinity of the water body, nearby land and marine uses or actions, beneficial uses, potential receptors of concern, changes in grain size, salinity, water depth, and organic matter, other sources or discharges in the immediate vicinity of the water body.[32] Each sample is expected to cost between $3,940 and $5,810.[33] The State Water Board is collecting

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[24] *Ibid* P. 4-6
[25] *Ibid* P. 5-1
[26] *Ibid* P. 5-41 to 5-46
[27] *Ibid*
[28] *Ibid*
[29] *Ibid* P. 5-41
[30] *Ibid* P. 6-1
[31] *Ibid*
[32] *Ibid* P. 6-1 to 6-2
[33] *Ibid* P. 6-2

data from estuaries throughout the state that are necessary to develop appropriate tools and thresholds for implementing the Plan. This data can also be used to assess compliance with the final sediment quality objectives. Thus, additional monitoring may be necessary for those waters not currently being sampled.[34]

An incremental level of control for storm water sources (e.g., to implement new practices, increase the frequency of existing practices, or install structural controls that might not be required under existing objectives) may be necessary to comply with the requirements of the proposed Plan. For any situation in which storm water sources are specifically required to control toxic pollutants to levels that are lower than what would be necessary in the absence of the Plan, potential means of compliance include: increased or additional nonstructural BMPs – institutional, education, or pollution prevention practices designed to limit generation of runoff or reduce the pollutants load of runoff, structural controls – and engineered and constructed systems designed to provide water quantity or quality control.[35] Potential cost estimates are provided in Appendix E to the report, however because SAIC concludes that there is not enough information to determine the extent of controls necessary to comply with the Plan, there are no cost estimates included in the economic analysis.[36]

There is uncertainty as to whether incremental cleanup and remediation activities will be required as a result of the Plan. In addition, as discussed in Section 6.2, for sites with ongoing or existing sources, Regional Water Boards may require source controls before considering cleanup or remediation activities. However, for any situation in which cleanup or remediation would be required that would not be conducted in the absence of the Plan, costs will depend on the technical feasibility of different strategies (e.g., capping, removal and disposal, removal and treatment and disposal), the proximity of source material (for capping) or to appropriate treatment and disposal facilities, whether disposal facilities exist or whether new facilities must be built, as well as other factors.

Section 7 of the SAIC report addresses statewide costs. It concludes that "[t]here are currently 64 segments of bays and estuaries on the State's 2006 303(d) list, including 31 listings for sediment quality, and 38 sites identified as known toxic hot spots under the State Water Board's BPTCP. These conditions require substantial resources to be spent over the next decades for monitoring, assessment, TMDL development, pollution controls, and sediment cleanup and remediation. These resources include an estimated $87.6 million to $1.03 billion for cleanup and remediation of toxic hot spots that are of high priority (SWRCB, 2003b)."[37] The incremental impacts of the proposed Plan are estimated to be between $675,900 and $1,312,400. These costs include only the necessary monitoring and assessment efforts and not any costs that might be incurred as a result of the site being classified as impaired as a result of the outcome of the monitoring and

[34] *Ibid*
[35] *Ibid* P. 6-8
[36] *Ibid* P. 6-9
[37] *Ibid* P. 7-1

assessment data.[38] The estimate for a complex TMDL is over $1million, but without the assessment and monitoring data it is not clear what the exact incremental impacts of TMDL development will be.[39]

In sum, SAIC concludes that the incremental impacts of the proposed Plan that are quantifiable at present are those related to assessment and monitoring efforts. These costs are asserted to range from $675,900 to $1,312,400. There is no indication in this report as to the expected benefits that will result from achieving the proposed sediment quality objectives. The estimates from the Consolidated Toxic Hot Spots Cleanup Plan are the only example of potential costs that are likely to occur in the event that the results of the assessment and monitoring data change the listing from unimpaired to impaired.

Proper Economic Analysis of Water Quality Objectives

Section 13000 of the California Water Code states that "activities and factors which may affect the quality of the waters of the state shall be regulated to attain the highest water quality which is reasonable, considering all demands being made and to be made on those waters and the total values involved, beneficial and detrimental, economic and social, tangible and intangible." The law further requires that water quality objectives be developed in light of the following factors: "the beneficial uses to be protected, the water quality objectives reasonably required for that purpose, other waste discharges, the need to prevent nuisance, and the provisions of Section 13241." Section 13241 in turn lists six additional "factors to be considered" including "economic considerations" and "water quality conditions that could reasonably be achieved through the coordinated control of all factors which affect water quality in the area."

This requirement for consideration of economic factors including relative costs and demands for water quality is consistent with sound public policy. It is also reflective of a long-term, nationwide movement towards economic analysis of environmental regulations. Over the last 200 years, economists have developed a rigorous methodology to assess the impacts of government actions. The approach derives from the basic principles of public finance and welfare economics and takes a holistic perspective by considering the incidence of economic impacts. Economic analysis is especially valuable for illustrating tradeoffs among policy alternatives. The economist's approach to assessing government actions combines considerations of efficiency and equity, and has been widely applied to problems of environmental regulation. At its heart, economic analysis of regulation is an accounting of the consequences of a governmental action. Such accounting is often quantitative, but many first-rate economic analyses also treat impacts qualitatively, especially for nonstandard commodities that are not traded in markets. Ideally, economic analysis will also give information on the distributional impacts of the intervention, or a description of which groups in society are affected by the action, and the extent to which they are impacted.

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[38] *Ibid* P. 7-1
[39] *Ibid* P. 7-2

A requirement to "consider economics" is not the same as a directive to adopt only those regulations that pass a cost-benefit test. Agencies can use the results of economic analysis, but not be bound by "bottom-line" numbers. Most economists would not argue that quantified costs and benefits tell the whole story, or that precise measurements of either are always possible. But when economic analysis reveals low or nonexistent benefits and high costs, it can raise a flag for those responsible of exercising their discretion in setting public policy (in this case, the State Water Resources Control Board members). Indeed, the California Legislature sought to avoid just such a socially undesirable outcome by mandating a consideration of economics when setting water quality standards.

The federal government has maintained a decades-long commitment to economic analysis of regulation. This practice began in the Nixon Administration, which initiated Quality of Life Reviews of federal regulations in 1970. The two main events in the history of economic analysis at the federal level, however, occurred in the Reagan and Clinton Administrations. President Reagan issued Executive Order 12291, perhaps the most decisive step in the cost-benefit record. This Executive Order established a set of principles for agencies to follow to the extent permitted by law, including a commitment to cost-benefit analysis. The order required Regulatory Impact Analysis of major rules, and also established a formal mechanism for OMB oversight of interventions. President Clinton issued Executive Order 12866, which reaffirmed the basic commitments to economic analysis and conferred bipartisan legitimacy.

The SAIC report fails to present the relevant economic information needed to inform the State Board and other groups in California about the impacts, positive and negative, of attaining the proposed sediment quality objectives. Notwithstanding the uncertainty about potential implementation of the Plan, it is possible to conduct an accurate and meaningful economic analysis of the proposed sediment quality objectives given the information that is currently available or discoverable through careful research.

A major shortcoming of the SAIC report is that it contains no analysis of the benefits of the proposed objectives. That is, the Board and other interested parties are left without any indication whatsoever about the importance of what the Plan proposes to achieve. Such an understanding is fundamental to the question of whether the proposed objectives are reasonable. Simply put, if the sediment quality objectives produce $1 million worth of environmental quality improvements over baseline conditions, it would not be reasonable to pursue them if they cost $1 billion to achieve.

Such a benefits assessment is well within the mainstream of environmental economics and could be performed with standard methods. A benefits assessment would begin with an accounting of the uses of water that could be impacted if levels of contaminants in sediments were to decrease. Then, it would be necessary to understand how sediment quality affects such uses of water, and develop mathematical functions describing the willingness of participants to pay for increases in sediment quality. Similarly, a proper economic analysis of benefits would account for so-called non-use values of sediment quality improvements, or values that do not relate to an actual, physical use of water. These benefits might include ecosystem impacts, aesthetics, or other impacts. Economists have performed hundreds, if not thousands of analyses to measure the value of changes in environmental quality similar to what should be done in the case of sediment quality. These applications range from the dramatic (i.e., the Exxon Valdez oil spill) to the mundane, and many of the techniques needed to perform such analyses are taught to every graduate student in environmental economics.[40]

The SAIC report also fails to present a meaningful estimation of the costs of achieving sediment quality objectives. The authors state repeatedly that there is uncertainty about how the Plan would be implemented. This may be true, but it does not excuse the authors from failing to consider scenarios to assess a likely range of costs, or from looking to other situations to understand what sediment quality improvements have cost in other instances.

The most basic requirements of an economic analysis of environmental regulation is to understand benefits and costs. Because the SAIC report is devoid of any information about benefits, and because it only considers monitoring and sampling costs instead of the far more significant costs of actually implementing the Plan, it is inadequate as a basis for decision making. The State Board should undertake a more complete economic analysis of the SQOs that sheds light on these basic impacts, and use this economic analysis to assess the reasonableness of the proposed objectives.

Errors in the Economic Analysis

Throughout the SAIC report there are several facts that do not coincide with the references cited or do not reflect the most current available information. The following section outlines the discrepancies in the report.

The Executive Summary of the SAIC report states as follows: "The number of stations needed to assess bay sediment quality will vary based on site-specific factors. Based on between 5 and 30 samples per bay, depending on area, statewide monitoring costs to assess those bays for which existing data are insufficient (a total of 119 samples representing 18,000 acres) may range from $535,000 to $810,000 (P. ES-3)." This conflicts with the calculation on P. 6-2 Exhibit 6-3 which lists the estimated cost for monitoring and assessment at $468,900 to $691,400. There is no indication as to how the numbers in the Executive summary were calculated and why they differ.

There are several apparent differences in the economic analysis versus the more recent available information with respect to the Total Maximum Daily Load (TMDL) for PCBs in San Francisco Bay. The 2004 TMDL is referenced in Exhibit 3-10 *Summary of Toxic Pollutant TMDLs for Bays and Estuaries*; however, on the San Francisco Bay Regional Water Quality Control Board website[41] the June 2007 document is the only one available to review. As one example, the differences between the two documents can be observed in the numeric targets listed for fish tissue concentration, load allocations, and sediment objectives. In the SAIC report the fish tissue target is reported at 22 ng/g, the load allocations are 30 kg/year and the sediment quality target is

[40] For a standard treatment of benefits estimation methods, see M. Freeman, *The Measurement of Environmental and Resource Values: Theory and Methods*, Baltimore: Johns Hopkins University Press, 2003.

[41] http://www.waterboards.ca.gov/sanfranciscobay/TMDL/sfbaypcbstmdl.htm

2.5 _g/kg.[42] Whereas in the 2007 TMDL the fish tissue target is 10 ng/g, the load allocations are 10 kg/year and the sediment quality target is 1 _g/kg.[43]

Exhibit 3-6 *2006 303(d) Listings for Bays in California*, includes a listing for San Leandro Bay and the chemicals of concern present in the sediment.[44] No reference is made to PCBs in San Leandro Bay in the ECSQO even though the TMDL states there are elevated concentrations in both the sediment and fish tissue in San Leandro Bay.[45] Likewise Islais Creek, is also considered to have PCB contamination in sediment according to the San Francisco Bay PCB TMDL.[46] However, in the ECSQO Exhibit 3-6 on page 3-19 there is no indication that PCBs are a contaminant of concern for Islais Creek.

Exhibit 3-9 *Summary and Actions and Costs to Address High Priority Known Toxic Hotspots*, details information from the Draft Functional Equivalent Document to the Consolidated Toxic Hot Spot Cleanup Plan August 2003 (Consolidated Plan).[47] The cost estimates are copied directly from the Consolidated Plan and are not verified to see if any of the estimated costs had been updated or whether remediation had been completed. This presents a discrepancy regarding the estimated costs that might be incurred if further action would be necessary as a result of the SQO. The difference in the estimate in Exhibit 3-9 for Peyton Slough versus the actual cost of remediation is large. According to the ECSQO the cost of remediation is estimated to be $400,000 and $1.2 million with associated costs for follow up monitoring and regional Water Board Staff ranging from $5,000 to $10,000 and $10,000 to $50,000 respectively.[48] The actual cost of the chosen remediation alternative as a result of the feasibility study was $10.8 million to $11.2 million.[49] This is nearly 10 times larger than the estimate provided in the Consolidated Plan referenced for the potential costs of the SQO.

In Exhibit 3-9 *Summary and Actions and Costs to Address High Priority Known Toxic Hotspots,* Stege Marsh is listed as a known high priority toxic hotspot. However, according to the PCB TMDL Stege Marsh has already had significant remediation activities completed.[50] The SWRCB was the lead agency for the completed remediation, but now the California Department of Toxic Substance Controls (DTSC) is the lead agency for this site.[51] While precise costs for remediation were not available over the phone an estimation of the extent of sediment remediation was available. The amount of sediment removed was 57,000 cubic yards, and there is still sediment

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[42] ECSQO (P. 3-32)
[43] SF PCB TMDL (P. 50, 59, 60)
[44] ECSQO (P. 3-19)
[45] SF PCB TMDL (P. 24)
[46] *Ibid* (P. 36)
[47] ECSQO (P. 3-26)
[48] *Ibid*
[49] http://www.swrcb.ca.gov/rwqcb2/PDFs%20-%20Peyton%20Slough%20Project/FS%20Addendum%20-%20Complete%20document/Tables/Table%202_FS_Add_Revised_Costs_Alt6&7.PDF
[50] PCB TMDL (P. 71)
[51] Personal Communication with Lynn Nakashima project lead DTSC.

requiring remediation.[52] Due to the presence of endangered species, further site assessment is necessary before remediation activities can continue.[53]

According to the SAIC report, "Exhibit 6-2 shows the minimum number of samples for different size bays, assuming that sediment conditions are relatively homogeneous. These estimates reflect a goal of providing a spatially-based measure of sediment condition with a level of precision similar to that used in regional monitoring programs throughout California. Different numbers of stations may be required for targeted or focused studies."[54] According to Exhibit 6-2 the number of samples required for assessment monitoring is 5 for up to 500 acres, 12 for between 500 and 5,000 acres and 30 for greater than 5,000 acres (P. 6-2). Moreover, "[i]f sediments fail to meet the proposed SQO, the Plan indicates that further investigation into stressor identification is necessary"[55]and that "a TIE study is one tool for such an assessment."[56] It is stated that "[t]he number of samples for a TIE study could be less than or equal to the number of samples taken for assessment monitoring."[57] However, when calculating the potential incremental impacts as a result of these assessments the sample size was significantly less than the samples taken for assessment monitoring. According to Exhibit 6-4 *Potential Number of Stressor Identification Stations* only 2 samples are required for bay sizes less than 500 acres, 3 for 500-5,000 acres, and 5 for anything greater than 5,000.[58] With cost per sample expected to be between $3,000 and $9,000 each the expected incremental impact of the TIE assessment is $207,000 to $621,000. However, if there is a potential for requiring as many TIE samples as assessment monitoring samples then the cost estimate is significantly underestimated. Using the same number of samples corresponding to the size of the bays in Exhibit 6-2, and the area of the bays in Exhibit 6-4, the cost estimate is $873,000 to $2,619,000.[59]

Page 7-1 of the economic analysis contains the following statement: "There are currently 64 segments of bays and estuaries on the State's 2006 303(d) list, including 31 listings for sediment quality, and 38 sites identified as known toxic hot spots under the State Water Board's BPTCP. These conditions require substantial resources to be spent over the next decades for monitoring, assessment, TMDL development, pollution controls, and sediment cleanup and remediation. These resources include an estimated $87.6 million to $1.03 billion for cleanup and remediation of toxic hot spots that are of high priority (SWRCB, 2003b)."[60] However, the source SWRCB, 2003b references the Consolidated Plan. Upon careful review there is no such range of numbers that appear in the Consolidated Plan. The ranges of estimates that are given in the Consolidated Plan in TABLE 6: *RANGE OF COSTS TO REMEDIATE TOXIC HOT SPOTS, FUNDING*

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52 *Ibid*
53 Ibid; DTSC STATUS REPORT UPDATE South Richmond Shoreline Sites, August 10, 2006
54 ECSQO (P. 6-2)
55 *Ibid* (P. 6-3)
56 *Ibid*
57 *Ibid* (P. 6-4)
58 *Ibid*
59 Total number of samples would be 291 for the body water size identified in Exhibit 6-5 and the number of samples identified in Exhibit 6-2. Thus (291*3000 = $873,000) and (291* 9000 = $2,619,000)
60 ECSQO (P. 7-1)

POTENTIALLY RECOVERABLE FROM DISCHARGERS AND UNFUNDED AMOUNT are $72,348,320 and $812,257,167.[61] Examination of the monetary figures in Table 6 in the Consolidated Plan that are purported to sum to $72,348,320 and $812,257,167 reveals a discrepancy in the reported figures. The sum of all numbers present in Table 6 in the Consolidated Plan indicate a low estimate of $156,461,488 and a high estimate of $3,105,841,535.

Again, I appreciate the opportunity to comment on the economic analysis. Please do not hesitate to contact me if you have any questions.

Sincerely,

David Sunding
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Professor, UC Berkeley

[61] Consolidated Plan (P. 47)

CURRICULUM VITAE

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July, 2007

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Emeryville, CA, 1991–1992.

Assistant Professor,
Department of Economics and School of Law,
Boston College, 1989–1992.

EDUCATION

Ph.D., UC Berkeley, 1989.
M.A., UCLA, 1986.
B.A., Claremont McKenna College, 1983.

COURSES TAUGHT

Risk, Technology and the Environment (Graduate)
Natural Resource Economics (Graduate and Undergraduate)
Economics of Public Law (Boalt Hall School of Law)
Environmental and Resource Policy (Undergraduate)
Public Finance (Graduate)
Microeconomic Theory (Graduate and Undergraduate)
Law and Economics (Boston College School of Law)

UNIVERSITY SERVICE

Co-Director, Berkeley Water Center, 2005 – Present.

Reviewer, California Policy Research Center, UC Office of the President, 2006.

Member, Forestry Search Committee, Ecosystem Sciences Division, Department of Environmental Science, Policy and Management, 2005-2006.

Member, Giannini Hall Seismic Retrofit Design Committee, 2005 – 2006.

Member, Academic Senate Committee on Amrican Cultures Requirements, 2004-2005.

Member, CNR Executive Committee, 2003-2005.

Member, CNR Committee on Directions, Opportunities and Initiatives, 2003.

Co-Director, Center for Sustainable Resource Development, College of Natural Resources, UC Berkeley, 1997 – 2004.

Faculty, Beahrs Environmental Leadership Program, 2001-2005.

Member, CNR Dean Search Committee, 2001-2002.

Chair, Specialist Search Committee, Department of Agricultural and Resource Economics, 2001-2002.

Member, CNR Advisory Board Development Committee, 2001-2002.

Member, Faculty Search Committee (International Trade), Department of Agricultural and Resource Economics, 1999-2000.

Member, CNR Dean Search Committee, 1999–2000.

Member, Workgroup Review Committee, University of California Division of Agriculture and Natural Resources, 1999–2002.

UC Berkeley Representative, Academic Assembly Council, University of California Division of Agriculture and Natural Resources, 1999–2001.

Departmental Affirmative Action Representative, 1999–2000.

Member, Faculty Search Committee (Environmental Health), Department of Agricultural and Resource Economics, 1998–2000.

PROFESSIONAL SERVICE

Member, Economic Advisory Committee on North of Delta Offstream Storage, California Department of Water Resources, 2006-2007.

Member, Panel on Illegal Competitive Advantage Economic Benefit, Science Advisory Board, U.S. Environmental Protection Agency, 2004-2005.

Mentor, American Economic Association Pipeline Project for Minority Graduate Students, 2004 – 2005.

Member, Science Advisory Board, National Center for Housing and the Environment. 2003 – 2005.

President, International Water Resource Economics Consortium, 2002-2005.

Member, Expert Panel on Cost Allocation, CalFed Bay-Delta Program, 2001-2002.

Member, National Academy of Sciences Panel on Water Conservation and Reuse, 2001-2002.

Member, Technical Advisory Committee on Water Use Efficiency, CalFed Bay-Delta Program, 1997–1998.

Referee: *Agricultural Economics, American Journal of Agricultural Economics, California Agriculture, Contemporary Economic Policy, Environmental and Resource Economics, Journal of Agricultural and Resource Economics, Journal of Business and Economic Strategy, Journal of Environmental Economics and Management, Journal of Political Economy, Journal of Public Economics, Journal of Regulatory Economics, Land Economics, Natural Resources Modeling, Resource and Energy Economics, Review of Economics and Statistics, Social Choice and Welfare, Water Resources Research.*

AWARDS

U.S. Department of Energy, "Joint Modeling of the Water and Energy Sectors." $200,000. 2006-2009.

Participant, Rosenberg International Forum in Water Policy, 2006.

Giannini Foundation. "Multimarket Impacts of Water Transfers in Areas of Origin." $18,000. 2005 – 2006.

Giannini Foundation. "Land Use Regulation and Housing Market Dynamics." $20,000. 2004-2005.

United States – Israel Binational Agricultural Research and Development Fund. "Dynamic Intraseasonal Irrigation Management Under Water Scarcity, Water Quality, Irrigation Technology and Environmental Constraints." $200,000. 2003-2004.

Giannini Foundation. "Economics of Water Conservation in Agriculture." $20,000. 2003-2004.

U.S. Environmental Protection Agency. STAR Grant. "Mechanisms for Risk Trading." $206,000. 2002-2003.

Food Systems Research Group. "Optimal Commodity Promotion in Markets with Imperfect Competition and Differentiated Products." $40,000. 2002-2003.

Outstanding Journal Article Award, AAEA, 2001.

Giannini Foundation. "Economic Benefits of Joint Management of Surface and Ground Water Storage Facilities." $17,000. 2001–2002.

Best Published Research Award Finalist, WAEA, 1998.

California Department of Food and Agriculture. "Economic Impacts of Pesticide Regulation." $1,150,000. 1994–2002.

California Department of Water Resources and U.S. Department of the Interior (CALFED Program). "Economic Valuation of Increased Water Supply Reliability and Trading Opportunities by Westside Agriculture." $80,000. 1998–2000.

California Department of Food and Agriculture. "Economic Importance of Compound 1080 in California Agriculture." $60,000. 1998–1999.

U.S. Department of Interior, Bureau of Reclamation. "Financial Incentives to Encourage Agricultural Water Conservation." $1,500,000. 1994–2000.

U.S. Environmental Protection Agency. "Economic Incentives to Reduce Nonpoint Source Loads in Nevada's Truckee River Basin." $98,500. 1995–1997.

PUBLICATIONS

F94 *Strategies to Reduce the Economic Impacts of Drought-Induced Water Shortage in the San Francisco Bay Area.* San Francisco Public Utilities Commission. April 2007.

A93 "Estimating Business and Residential Water Supply Interruption Losses from Catastrophic Events." With Nicholas Brozovic and David Zilberman. *Water Resources Research* (2007): in press.

B92 "Water Markets and Trading." With Howard Chong. *Annual Review of Environment and Resources* 31(2006): 239-264.

A91 "Price Elasticity Reconsidered: Panel Estimation of an Agricultural Water Demand Function." With Karina Schoengold and Georgina Moreno. *Water Resources Research* 42(2006): 411-421.

A90 "Consideration of Economics Under the California Porter-Cologne Act." *Hastings West-Northwest Journal of Environmental Law & Policy* (2006): in press.

A89 "Fat Taxes and Thin Subsidies: Prices, Diet and Health Outcomes." With Sean Cash and David Zilberman. *Acta Agriculturae Scand. C* 2(2006): 167-174.

F88 *A Guide to Consideration of Economics Under the California Porter-Cologne Act.* With David Zilberman. California Resource Management Institute. March 2005.

A87 "The Economics of Environmental Regulation of Housing Development." *Housing and Society* 32(2005): 23-38.

A86 "Joint Estimation of Technology Adoption and Land Allocation with Implications for the Design of Conservation Policy." With Georgina Moreno. *American Journal of Agricutural Economics* 87(2005): 1009-1019.

B85 "Response to 'Environmental Regulation and the Housing Market: A Review of the Literature' by Katherine Kiel." *Cityscapes* 8(2005): 277-282.

B84 "Water Allocation and Water Market Activity in California." With Richard Howitt. *California Agriculture: Dimensions and Trends.* Jerome Siebert, ed. Giannini Foundation, 2004.

A83 "The Economics of Climate Change in Agriculture." With Xuemei Liu, David Roland-Holst and David Zilberman. *Mitigation and Adaptation Strategies for Global Change* 9(2004): 365-382.

B82 "Economic Impacts." *The Endangered Species Act at Thirty*. M. Scott, D. Goble and F. Davis, eds. Washington, DC: Island Press, 2006.

F81 *Fiscal Costs and Economic Impacts of Recovering the Coho Salmon in California*. With Alix Peterson Zwane. California Department of Fish and Game. October 2003.

A80 "Indirect Effects of Pesticide Regulation and the Food Quality Protection Act." With Sean B. Cash, Aaron Swoboda, and David Zilberman. *Current Agriculture, Food, and Resource Issues* 4 (2003): 73-79.

A79 "Wetlands Regulation ... An Opening for Meaningful Reform?" *Regulation* 26(2003): 30-35.

F78 *Economic Impacts of Critical Habitat Designation for the Coastal California Gnatcatcher*. California Resource Management Institute. July 2003.

B77 "Factor Price Risk and the Adoption of Conservation Technology." With Georgina Moreno. *Frontiers in Water Resource Economics*. D. Berga and R. Goetz, eds. New York: Springer-Verlag, 2005.

B76 "Optimal Management of Groundwater over Space and Time." With Nicholas Brozovic and David Zilberman. *Frontiers in Water Resource Economics*. D. Berga and R. Goetz, eds. New York: Springer-Verlag, 2005.

A75 "Government Regulation of Product Quality in Markets with Differentiated Products: Looking to Economic Theory." *American Journal of Agricultural Economics* 85(2003): 720-724.

F74 *The Economic Impacts of Critical Habitat Designation: Framework and Application to the Case of California Vernal Pools*. With Aaron Swoboda and David Zilberman. California Resource Management Institute. January 2003.

A73 "Public Goods and the Value of Product Quality Regulations: The Case of Food Safety." With Stephen Hamilton and David Zilberman. *Journal of Public Economics* 87(2003): 799-817.

A72 "The Economics of Environmental Regulation by Licensing: Observations on Recent Changes to the Federal Wetland Permitting Program." With David Zilberman. *Natural Resources Journal* 42(Winter 2002): 59-90.

* Cited in U.S. Supreme Court plurality and dissenting opinions in the consolidated cases of *Rapanos v. United States* and *Carabell v. United States*.

F71 *Non-Federal and Non-Regulatory Approaches to Wetland Conservation: A Post-SWANCC Evaluation of Conservation Alternatives*. National Center for Housing and the Environment. December 2002.

A70 "Trading Patterns in an Agricultural Water Market." With Nicholas Brozovic and Janis Carey. *Water Resources Update* (2002): 3-16.

F69 *Economic Impacts of Earthquake-Induced Water Supply Shortages in the San Francisco Bay Area*. With Nicholas Brozovic and David Zilberman. Bay Area Economic Forum. October 2002.

A68 "Regulating Pollution with Endogenous Monitoring." With Katrin Millock and David Zilberman. *Journal of Environmental Economics and Management* 44(2002): 221-241.

A67 "Transactions Costs and Trading Behavior in an Immature Water Market." With Janis Carey and David Zilberman. *Environment and Development Economics* 7(2002): 733-750.

A66 "Measuring the Costs of Reallocating Water from Agriculture: A Multi-Model Approach." With David Zilberman, Richard Howitt, Ariel Dinar and Neal MacDougall. *Natural Resource Modeling* 15(Summer 2002): 201-225.

F65 Economic Impacts of Organophosphate Use in California Agriculture, Parts 1 and 2. With Mark Metcalfe, Bruce McWilliams, Brent Hueth, Robert Van Steenwyk and David Zilberman. California Department of Food and Agriculture. February 2002.

A64 "Voluntary Development Restrictions and the Cost of Habitat Preservation." With Sabrina Lovell. *Real Estate Economics* 29(March 2001): 191–206.

A63 "Emerging Markets in Water: A Comparative Institutional Analysis of the Central Valley and Colorado-Big Thompson Projects." With Janis Carey. *Natural Resources Journal* 41(2001): 283–328.

B62 "Risk Management and the Environment." With Mark Metcalfe and David Zilberman. In Richard Just and Rulon Pope (eds.). *A Comprehensive Assessment of the Role of Risk in U.S. Agriculture.* Norwell, MA: Kluwer Academic Publishers, 2002.

B61 "A Comparison of Policies to Reduce Pesticide Poisoning Combining Economic and Toxicological Data." With Joshua Zivin. In: Joe Moffitt (ed.). *Advances in the Economics of Environmental Resources: Volume 4.* Greenwich: JAI Press, 2001.

B60 "The Impact of Climate Change on Agriculture: A Global Perspective." With David Zilberman and Xuemei Liu. In: Charles Moss, Gordon Rausser, Andrew Schmitz, Tim Taylor and David Zilberman (eds.), *Agricultural Globalization, Trade, and the Environment.* New York: Kluwer, 2001.

F59 *Water Pricing and Water Use Efficiency.* U.S. Department of the Interior, Bureau of Reclamation. January 2001.

B58 "The Agricultural Innovation Process: Research and Technology Adoption in a Changing Agricultural Sector." With David Zilberman. In: Bruce Gardner and Gordon Rausser (eds.), *Handbook of Agricultural and Resource Economics.* Amsterdam: North Holland, 2001, 207-261.

F57 *Economic Impacts of Critical Habitat Designation for the California Red-Legged Frog.* Home Builders Association of Northern California. With David Zilberman. January 2001.

A56 "Insect Population Dynamics, Pesticide Use and Farmworker Health." With Joshua Zivin. *American Journal of Agricultural Economics* 82(August 2000): 527–540.

* Winner of the AAEA's Outstanding Journal Article Award in 2001.

A55 "Product Liability, Entry Incentives and Market Structure." With Stephen Hamilton. *International Review of Law and Economics* 20(September 2000): 269–283.

B54 "Climate Change Policy and the Agricultural Sector." With David Zilberman. In: R. Lal, J.M. Kimble, R.F. Follett and B.A. Stewart (eds.), *Assessment Methods for Soil Carbon.* Boca Raton, FL: CRC Press, 2000, 629–643.

F53 *A Proposal for Management of the Confined Aquifer in the Western San Joaquin Valley.* With David Purkey. Natural Heritage Isntitute. July 2000.

A52 "Methyl Iodide as an Alternative to Methyl Bromide." With Brent Hueth, Bruce McWilliams and David Zilberman. *Review of Agricultural Economics* (Spring/Summer 2000): 43–54.

F51 *Analysis of the Army Corps of Engineers' NWP 26 Replacement Permit Proposal.* Foundation for Economic and Environmental Progress. With David Zilberman. February 2000.

A50 "Using Water Markets to Improve Environmental Quality: Two Innovative Programs in Nevada." With Sabrina Ise Lovell and Katrin Millock. *Journal of Soil and Water Conservation* 55(First Quarter 2000): 19–26.

A49 "The Price of Water...Market-Based Strategies are Needed to Cope wth Scarcity." *California Agriculture* 54(March-April 2000): 56–63.

A48 "Designing Environmental Regulations with Empirical Microparameter Distributions: The Case of Seawater Intrusion." With Gareth Green. *Resource and Energy Economics* 22(January 2000): 63–78.

F47 *Economic Valuation of Increased Water Supply Reliability and Trading Opportunities in Westside Agriculture.* With Georgina Moreno, Daniel Osgood and David Zilberman. CalFed Bay-Delta Program. December 1999.

F46 *Costs of Implementing the Food Quality Protection Act of 1996 on California Agriculture.* With Bruce McWilliams, Yuria Tanimichi and David Zilberman. September 1999.

B45 "The Economics of Inter-District Water Transfers in California." In *Proceedings of the American Society of Civil Engineers.* New York: ASCE, 1999.

F44 *Economic Impact of Restricting Use of Compound 1080 in California's Intermountain Region.* With Brent Hueth and Michelle McGregor. California Department of Pesticide Regulation. April 1999.

A43 "Returns to Public Investment in Agriculture with Imperfect Downstream Competition." With Stephen Hamilton. *American Journal of Agricultural Economics* 80(November 1998): 830–838.

F42 *Downstream Economic Impacts of Reducing Federal Water Subsidies: The Case of Alfalfa and Dairy.* With Gergina Moreno. Natural Resources Defense Councl. August 1998.

F41 *Economic Importance of Organophosphates in California Agriculture.* With Brent Hueth, Grazyna Michalska, and David Zilberman. California Department of Food and Agriculture. August 1998.

A40 "Reallocating Water from Agriculture to the Environment under a Voluntary Purchase Program." With Sabrina Ise. *Review of Agricultural Economics* 20(Summer 1998): 214–226.

E39 *An Environmentally Optimal Alternative for the San Francisco Bay-Delta*. With John Cain, David Fullerton, David Purkey and Greg Thomas. Natural Heritage Institute. July 1998.

F38 *Water Trading and Environmental Quality in the Western United States.* With David Zilberman. U.S. Environmental; Protection Agency. April 1998.

A37 "Allocating Product Liability in a Multimarket Setting." With David Zilberman. *International Review of Law and Economics* 18(March 1998): 1–11.

B36 "Resolving Trans-Boundary Water Disputes: Economists' Influence on Policy Choices in the United States." In: Richard Just and Sinaia Netanyahu (eds.), *Conflict and Cooperation on Trans-Boundary Water Resources*. Norwell: Kluwer, 1998.

F35 *Impact of Endangered Species Legislation on California Agriculture*. With David Zilberman, Jerome B. Siebert, Joshua Zivin, Sabrina Isé and Brent Hueth. California Resources Agency. January 1998.

F34 *Economics Impacts on California Agriculture of Banning Methyl Bromide Use*. With Bruce McWilliams, Brent Hueth, Lori Lynch, David Zilberman and Jerome Siebert. California Department of Food and Agriculture. January 1998.

A33 "Economics and Pesticide Regulation." With Erik Lichtenberg, Douglas Parker and David Zilberman. *Choices* (Fourth Quarter 1997): 26–29.

A32 "The Effect of Farm Supply Shifts on Concentration and Market Power in the Food Processing Sector." With Stephen Hamilton. *American Journal of Agricultural Economics* 79(May 1997): 524–531.

A31 "Land Allocation, Soil Quality and the Demand for Irrigation Technology." With Gareth Green. *Journal of Agricultural and Resource Economics* 22(November 1997): 367–375.

A30 "Water Marketing in the '90s: Entering the Electronic Age." With Janis Carey, David Zilberman and Douglas Parker. *Choices* (Third Quarter 1997): 15–19.

B29 "Modeling the Impacts of Reducing Agricultural Water Supplies: Lessons from California's Bay/Delta Problem." With David Zilberman, Neal MacDougall, Richard Howitt and Ariel Dinar. In: Doug Parker and Yacov Tsur (eds.), *Decentralization and Coordination of Water Resource Management*. New York: Kluwer, 1997.

B28 "The Changing Nature of Agricultural Markets: Implications for Privatization of Technology, Information Transfer and Land Grant Research and Extension." With David Zilberman and Madhu Khanna. In: Stephen Wolf (ed.), *Privatization of Information and Agricultural Industrialization*. Boca Raton: CRC Press, 1997.

B27 "Changes in Irrigation Technology and the Impact of Reducing Agricultural Water Supplies." With Ariel Dinar and David Zilberman. In: Darwin Hall (ed.), *Advances in the Economics of Environmental Resources: Volume 1*. Greenwich: JAI Press, 1996.

A26 "Measuring the Marginal Cost of Nonuniform Environmental Regulations." *American Journal of Agricultural Economics* 78(November 1996): 1098–1107.

A25 "Explaining Irrigation Technology Choices: A Microparameter Approach." With Gareth Green, David Zilberman and Douglas Parker. *American Journal of Agricultural Economics* 78(November 1996): 1064–1072.

A24 "How Does Water Price Affect Irrigation Technology Adoption?" With Gareth Green, David Zilberman, Douglas Parker, Cliff Trotter and Steve Collup. *California Agriculture* 50(March-April 1996): 36–40.

A23 "Strategic Participation and the Median Voter Result." *Economic Design* 1(April 1996): 355–363.

F22 *Economic Incentives for ImprovingWater Quality in Nevada's Truckee River Basin*. With Sabrina Ise and Katrin Millock. U.S. Environmental Protection Agency. October 1996.

A21 "Social Choice by Majority Rule with Rational Participation." *Social Choice and Welfare* 12(December 1995): 3–12.

A20 "Water Markets and the Cost of Improving Water Quality in the San Francisco Bay/Delta Estuary." With David Zilberman and Neal MacDougall. *Hastings West-Northwest Journal of Environmental Law & Policy* 2(Spring 1995): 159–165.

F19 *Managing Seawater Intrusion in Monterey County through Agricultural Water Conservation*. With Gareth Green and Larry Dale. Monterey County Water Resources Agency. May 1995.

A18 "Flexible Technology and the Cost of Improving Groundwater Quality." With David Zilberman, Gordon Rausser and Alan Marco. *Natural Resource Modeling* 9(April 1995): 177–192.

F17 *Conclusions and Recommendations on a Framework for Comparative Cost Effectiveness Assessment of CVP Yield Augmentation Alternatives.* With Greg Thomas. U.S. Department of the Interior, Bureau of Reclamation. December 1994.

A16 "Water for California Agriculture: Lessons from the Drought and New Water Market Reform." With David Zilberman, Richard Howitt, Ariel Dinar and Neal MacDougall. *Choices* (Fourth Quarter 1994): 25–28.

F15 *Economic Impacts of USFWS' Water Rights Acquisition Program for Lahontan Valley Wetlands.* U.S. Department of the Interior, Fish and Wildlife Service. June 1994.

A14 "Methyl Bromide Regulation...All Crops Should Not Be Treated Equally." With Cherisa Yarkin, David Zilberman and Jerry Siebert. *California Agriculture* 48(May-June 1994): 10–15.

A13 "Cancelling Methyl Bromide for Postharvest Use to Trigger Mixed Economic Results." With Cherisa Yarkin, David Zilberman and Jerry Siebert. *California Agriculture* 48(May-June 1994): 16–21.

F12 *Market Implementation of Bay/Delta Water Quality Standards.* U.S. Environmental Protection Agency. March 1994.

F11 *Economic Impacts of Mevinphos Cancellation in California.* California Department of Pesticide Regulation. March 1994.

B10 "Who Makes Pesticide Use Decisions? Implications for Policymakers." With David Zilberman, Michael Dobler, Mark Campbell and Andrew Manale. In: Walter Armbruster (ed.), *Pesticide Use and Product Quality.* Glenbrook: Farm Foundation, 1994.

B9 "Managing Groundwater Quality under Uncertainty." With David Zilberman and Gordon Rausser. In: Michelle Marra (ed.), *Quantifying Long-Run Agricultural Risks.* Orono: University of Maine, 1993.

F8 *Economic Impacts of Federal Worker Protection Standards.* With Cheryl Brown, Valerie Brown and Bob Chavez. California Department of Food and Agriculture. October 1993.

F7 *Water Quality Regulation in the San Francisco Bay and Delta.* With David Zilberman, Richard Howitt, Neal MacDougall and Linda Fernandez. U.S. Environmental Protection Agency. May 1993.

F6 *The Economic Consequences of Enforcing the Delaney Clause.* With Alan Marco. U.S. Environmental Protection Agency. March 1993.

B5 "Natural Resource Cartels." With David Teece and Elaine Mosakowski. In: Allen Kneese and James Sweeney (eds.), *Handbook of Natural Resource and Energy Economics*, Volume III. Amsterdam: Elsevier, 1993.

F4 *Economic Impacts of Cancelling Methyl Bromide in California*. With Cherisa Yarkin, David Zilberman, Jerome Siebert and Alan Marco. California Department of Food and Agriculture. February 1993.

F3 *Economic Impact of the Silverleaf Whitefly*. With Jerome Siebert, David Zilberman and Michael Roberts. California Department of Food and Agriculture. January 1993.

B2 "Joan Robinson as a Development Economist." With Irma Adelman. In: George Feiwel (ed.), *Joan Robinson and Modern Economic Theory*. London: Basil Blackwell, 1988.

A1 "Economic Policy and Income Distribution in China." With Irma Adelman. *Journal of Comparative Economics* 11(September 1987): 444–461. Reprinted in Bruce Reynolds (ed.), *China's Economic Development: How Far, How Fast?* New York: Academic Press, 1989. Reprinted in Joseph C. H. Chai (ed.), The Economic Development of Modern China. London: Edward Elgar, 1999.

UNDER REVIEW

"Valuing Investments in Water Supply Reliability." With Georgina Moreno, Daniel Osgood and David Zilberman. Submitted to *American Journal of Agricultural Economics*.

"The Nature of the Groundwater Pumping Externality." With Nicholas Brozovic and David Zilberman. Submitted to *American Journal of Agricultural Economics*.

"Community Composition and the Provision of Local Public Goods: Evidence from the Immigration Reform and Control Act." With Alix Zwane. Submitted to *American Journal of Agricultural Economics*.

"Prices Vs. Quantities Revisited." With Nicholas Brozovic and David Zilberman. Submitted to *Journal of Environmental Economics and Management*.

"Federal Land Use Controls and the Planning Anticommons." With Aaron Swoboda and Jonathan ter Horst. Submitted to *Journal of Law & Economics*.

"Regulation and the Shadow Price of New Housing." With Aaron Swoboda. Submitted to *Regional Science and Urban Economics*.

"Housing and Habitat: Strategies for Implementing the Endangered Species Act in Urbanizing Areas." With Haley Jones and Jonathan ter Horst. Submitted to *Journal of Urban Economics*.

WORKING PAPERS

"Environmental Regulation by Licensing." With Aaron Swoboda and David Zilberman.

"Water Savings from Adoption of Precision Technology." With Karina Schoengold and Georgina Moreno.

"Managing a Coastal Aquifer under Multiple Uncertainty." With David Zilberman.

"Relicensing and the Cost of Minimum Streamflow Requirements." With Karina Schoengold.

"Regional Management of Wastewater Discharges from the Food Processing Industry." With David Zilberman.

"Environmental Regulation of the Food Proecssing Industry." With Steve Hamilton.

"How do Federal Agencies Select Lands for Habitat Conservation?" With Haley Jones and Jonathan ter Horst.

INVITED PRESENTATIONS

"Evaluating Investments in Groundwater: Hard Science or Black Art?" Groundwater Resource Association. San Francisco, CA. June 2007.

"Delta Futures and California's Water Economy." Public Policy Institute of California. San Francisco, CA. February 2007.

"California's Water Infrastructure Needs." Bay Area Economic Forum. San Francisco, CA. February 2007.

"Management of a Coastal Aquifer under Multiple Uncertainty." Association of Environmental and Resource Economists. Chicago, IL. January 2007.

"Growth, Environment & Efficiency: California's Water Future." UC Berkeley Homecoming. Berkeley, CA. October 2006.

"Water Supply and the Bay Area Economy." League of Women Voters Know Your Bay Area Day. San Francisco, CA. September 2006.

"Economics of Water Quality Regulation." International Agricultural Economics Association Pre-Conference Workshop on Water Resources. Brisbane, Australia. August 2006.

"Measuring the Groundwater Pumping Externality." American Agricultural Economics Association. Long Beach, CA. July 2006.

"Costs and Benefits of Wetland Regulation." American Law Institute – American Bar Association Wetlands Conference. Washington, DC. June 2006.

"Economics of Water Resource Management in California." University-Industry Consortium. Oakland, CA. May 2006.

"Regulating Water Quality in California." University of California Water Resources Center Continuing Conference. Davis, CA. May 2006.

"Natural Disasters and the Resilience of the Urban Economy." Symposium on Real Estate, Catastrophic Risk and Public Policy. Berkeley, CA. March 2006.

"Economics and the Endangered Species Act: The Role of Critical Habitat." Annual Conference on the Endangered Species Act and Habitat Conservation Planning. San Francisco, CA. December 2005.

"Economics of Groundwater Management." Groundwater Resources Association. Pasadena, CA. September 2005.

"The Economics of Waer Quality Regulation." Central Valley Clean Water Association. Sacramento, CA. May 2005.

"Economics of Technology Adoption and Diffusion." Conference on Sustainable Energy Futures. Berkeley, CA. April 2005.

"Consideration of Economics Under Porter-Cologne." Urban Water Institute. Newport Beach, CA. April 2005.

"Tools for a New Era of Sustainable Water Management." Barcelona, Spain. March 2005.

"Bad Neighbors: The Economics of Conflict Over New Housing." Conference on Urban Policy. Berkeley, CA. January 2005.

"Economic Analysis of Water Quality Regulations: When is It Worth the Trouble?" Industrial Environmental Association. San Diego, CA. November, 2004.

"Measuring the Cost of Conservation by Permitting." Association of Environmental and Resource Economists. Denver, CO. August 2004.

"Panel Estimation of Agricultural Water Demand Based on an Episode of Rate Reform." American Agricultural Economics Association. Denver, CO. August 2004.

"Local Public Goods and Ethnic Diversity." American Agricultural Economics Association. Denver, CO. August 2004.

"Prices vs. Quantities Revisited." American Agricultural Economics Association. Denver, CO. August 2004.

"Managing Groundwater with Localized Externalities." American Agricultural Economics Association. Denver, CO. August 2004.

"Fat Taxes and Thin Subsidies." American Agricultural Economics Association. Denver, CO. August 2004.

"Environmental Regulation and California Agriculture: Focus on ESA and the Clean Water Act." Western Growers' Association. Sacramento, CA. June 2004.

"Endangered Species Regulation and California Agriculture." Giannini Foundation Conference on the Future of California Agriculture. Sacramento, CA. May 2004.

"Environmental Regulation and Housing Affordability." U.S. Department of Housing and Urban Development Conference on Regulatory Barriers to Housing Affordability. Washington, DC. April 2004.

"Economic Analysis of Evironmental Regulation." Clean Water Act Summit Meeting. Irvine, CA. March 2004.

"Economic Impacts of Endangered Species Regulation: A Project-Level Perspective Focusing on the Housing Industry." Conference on the Endangered Species Act at 30. Santa Barbara, CA. November 2003.

"Whither Reclamation Reform? Looking to the Next 100 Years of Reclamation Law." Berkeley Conference on Water Policy Reform. San Francisco, CA. September 2003.

"Simultaneous Estimation of Technology Choice and Land Allocation." American Agricultural Economics Association. Montreal, Canada. July 2003.

"Advertising in Markets with Product Differentiation and Imperfect Competition." Food Systems Research Group, University of Wisconsin. June 2003.

"Wetlands Protection Beyond Section 404." American Law Institute – American Bar Association Wetlands Conference. Washington, DC. May 2003.

"Prioritizing Habitat Conservation." Conference on the Endangered Species Act. Land Use Research Foundation of Hawaii and the Hawaii State Bar Association Section on Real Property and Finance. May 2003.

"Government Regulation of Product Quality in Markets with Differentiated Products: Looking to Economic Theory." Allied Social Science Association. Washington, DC. January 2003.

"Non-Regulatory and Non-Federal Approaches to Wetland Protection." National Association of Home Builders. Las Vegas, NV. January 2003.

"Agricultural Water Use and the Role of Prices." Joint Meeting of the U.S. and Iranian Academies of Sciences. Tunis, Tunisia. December 2002.

"Economic Megatrends and Water Use in the United States." National Academy of Sciences. Washington, DC. September 2002.

"Pesticide Regulation and Changes in Human Health." World Congress of Environmental Economics. Monterey, CA. June 2002.

"Mechanisms for Risk Trading." World Congress of Environmental Economics. Monterey, CA. June 2002.

"Economic Damage from Water Supply Disruptions Following an Earthquake in the San Francisco Bay Area." Bay Area Water Users' Association. Foster City, CA. June 2002.

"Economic Perspectives on Federal Wetland Regulation." American Law Institute – American Bar Association. Washington, DC. May 2002.

"Reconciling Competing Interests in the West Side." CSRD Conference on the Future of the West Side. Parlier, CA. March 2002.

"Protecting Public Interests on Private Land." Center for Sustainable Resource Development, UC Berkeley. February 2002.

"Cost-Shifting and Environmental Quality." POWER Annual Conference. Los Angeles, CA. December 2001.

"Factor Price Risk and the Diffusion of Conservation Technology." California Conference on Environmental and Resource Economics. UC Santa Barbara. November 2001.

"Valuation of Water Supply Reliability." American Agricultural Economics Association. Chicago, IL. August 2001.

"Allocating Water by Markets." American Society of Horticultural Sciences. Sacramento, CA. July 2001.

"The Farm Bill and Resource Conservation: Success Stories." CSRD Conference on Agriculture and the Environment. Washington, DC. June 2001.

"Does Factor Price Risk Encourage Conservation?" International Water Resource Economics Consortium. Girona, Spain. June 2001.

"Optimal Control of Groundwater Over Space and Time." International Water Resource Economics Consortium. Girona, Spain. June 2001.

"Trading Behavior in an Informal Market." International Water Resource Economics Consortium. Girona, Spain. June 2001.

"Economics of Pesticide Cancellation: The Food Quality Protection Act of 1986." University of California Agricultural Economics and Management Workgroup. UC Davis. May 2001.

"Economic Aspects of Biological Control." University of California Conference on Urban Pest Management. UC Riverside. October 2000.

"Price Volatility and Resource Conservation." American Agricultural Economics Association. Tampa, FL. July 2000.

"Economics of Water Trading in California." UC Berkeley Water Working Group. Berkeley, CA. March 2000.

"Reforming Public Lands Policy." Painting the White House Green: Economics and Environmental Policy-Making in the Clinton Administration. Laramie, WY. September 1999.

"Transaction Costs and Trading Behavior in a Permit Market." American Agricultural Economics Association. Nashville, TN. August 1999.

"Facilitating Water Transfers with the *WaterLink* System." American Society of Civil Engineers. Seattle, WA. August 1999.

"Valuing Agricultural Water Supply Reliability." International Water Resource Economics Consortium. Waikoloa, HI. July 1999.

"Economics of Inter-District Water Transfers." Western Economics Association. San Diego, CA. June 1999.

"The Value of Water Supply Reliability in Westside Agriculture." CalFed Economics Workgroup. Sacramento, CA. June 1999.

"Economic Impacts of Pesticide Regulation." Center for Sustainable Resource Development Conference on Pest Management. UC Berkeley. May 1999.

"Water Marketing within Irrigated Agriculture." American Agricultural Economics Association. Salt Lake City, UT. August 1998.

"Welfare Impacts of Climate Change: Focus on Pest Problems and Water Resources." American Agricultural Economics Association. Salt Lake City, UT. August 1998.

"Water Trading and the Costs of Bay/Delta Protection." Water Education Foundation. San Diego, CA. July 1998.

"Federal Public Land Policy: Litmus Test Issues." Berkeley Commons Club. Berkeley, CA. June 1998.

"Recent Developments in American Agricultural Policy." Commonwealth Club. San Francisco, CA. October 1997.

"Performance of a Voluntary Water Purchase Program." Western Regional Water Economics Conference. Lihue, HI. October 1997.

"Water Marketing for the Environment: The Clinton Administration's Perspective." Conference on Regional Water Markets. Berkeley, CA. July 1997.

"Returns to Public Investment in Agriculture with Imperfect Downstream Competition." American Agricultural Economics Association. Toronto, Canada. July 1997.

"Markets for Crop Germplasm." Invited Paper, American Agricultural Economics Association. Toronto, Canada. July 1997.

"Land Allocation, Soil Quality and Irrigation Technology Choice." Western Agricultural Economics Association. Reno, NV. July 1997.

"Product Liability and Entry Incentives." Western Agricultural Economics Association. Reno, NV. July 1997.

"Agricultural Policy in the Post-1996 Farm Act World." Signature Lecture, USDA Economic Research Service. Washington, DC. May 1997.

"Federal Water Policy in the United States." International Conference on Coordination and Decentralization in Water Resources Management. Annapolis, MD. April 1997.

"Non-Uniform Regulation of Groundwater Quality." American Agricultural Economics Association. San Antonio, TX. July 1996.

"The Effect of Farm Supply Shifts on Concentration and Market Power in the Food Processing Industry." American Agricultural Economics Association. San Antonio, TX. July 1996.

"Differential Property Tax Assessment, Land Allocation and Land Values at the Urban Fringe." American Agricultural Economics Association. San Antonio, TX. July 1996.

"Efficient Strategies for Acquiring Agricultural Water Rights." Invited Paper, Australian Agricultural and Resource Economics Society. Melbourne, Australia. February 1996.

"Strategies for Agricultural Water Conservation." U.S. Bureau of Reclamation Water Users Conference. Concord, CA. January 1996.

"Voting on Environmental Health Risks." American Agricultural Economics Association. Indianapolis, IN. August 1995.

"Explaining Irrigation Technology Choice: A Microparameter Approach." American Agricultural Economics Association. Indianapolis, IN. August 1995.

"The Economics of United States Environmental Laws." Symposium at Far Eastern State University. Vladivostok, Russia. March-April 1995.

"The Endangered Species Act: Impact on California Agriculture and Policy Options." University of California Executive Seminar on Agricultural Issues. Sacramento, CA. December 1994.

"Economics of Tort Liability Rules for Pesticide Damage." Second Occasional California Conference on Environmental and Resource Economics. Santa Barbara, CA. October 1994.

"Water Law as a Regulating Mechanism." International Conference on Coordination and Decentralization in Water Resources Management. Rehovot, Israel. September 1994.

"Contaminant Dynamics and the Cost of Groundwater Quality Regulations." Conference on Pesticide Economics and Policy in Memory of Carolyn Harper. Amherst, MA. April 1994.

"Water Markets and Water Quality." University of California Conference on Regional Water Constraints. Berkeley, CA. October 1993.

"Irreversibility, Contaminant Dynamics and the Cost of Groundwater Quality Regulations." American Agricultural Economics Association. Orlando, FL. August 1993.

"Methodological Issues in Pesticide Regulation." First Occasional California Conference on Environmental and Resource Economics. Santa Barbara, CA. May 1993.

"Economic Impacts of the Central Valley Project Improvement Act." First Occasional California Conference on Environmental and Resource Economics. Santa Barbara, CA. May 1993.

"Majority Rule with Rational Abstention is Globally Transitive." Sixth World Congress of the Econometric Society. Barcelona, Spain. August 1990.

GOVERNMENT BRIEFINGS

"System Integration and California Water Management." California Assembly and Senate Members and Staff. Sacramento, CA. August 2006.

"The Endangered Species Act at 30: Lessons for Reform." Organized with U.S. Senate Committee on Energy and Natural Resources. Washington, DC. December 2004.

"Non-Federal and Non-Regulatory Approaches to Wetland Conservation." House Transportation and Infrastructure Committee Staff. Washington, DC. February 2003.

"Removing Barriers to Water Marketing." California Senate Committee on Agriculture and Water and the California Foundation for Environment and Economy. Berkeley, CA. January 2003.

"Agricultural Water Pricing and Water Use Efficiency." U.S. Bureau of Reclamation. Sacramento, CA. May 2002.

"Assessing Recent Changes to the Wetlands Permitting Process." Congressional Real Estate Caucus. Washington, DC. September 2000.

"Water Markets in California." California Assembly and Senate Staff. Sacramento, CA. May 2000.

"Economic Analysis of Proposed Changes in Wetlands Permitting Policies." U.S. House of Representatives and Senate Staff. Washington, DC. March 2000.

"Groundwater Implications of Water Trading." California Assembly Water Parks and Wildlife Committee and Senate Agriculture and Water Committee. Sacramento, CA. November 1999.

"Economic Aspects of the 1996 Food Quality Protection Act." Office of Policy, U.S. Environmental Protection Agency. Washington, DC. October 1998.

"Innovative Approaches to Water Conservation: The Westside Case." Joint U.S. Bureau of Reclamation and the California Department of Water Resources Water Conservation Information Committee. San Diego, CA. August 1998.

"Climate Variability and U.S. Agriculture: Mitigating the Impacts." U.S. Environmental Protection Agency. Washington, DC. May 1998.

"New Approaches to Agricultural Water Conservation." Congressional Water Caucus. Washington, DC. February 1996.

LEGISLATIVE AND ADMINISTRATIVE TESTIMONY

"Economic Impacts of Drought-Induced Water Shortage in the San Francisco Bay Area." San Francisco Public Utilities Commission. June 2007.

"Economic Considerations Relating to the Designation of Critical Habitat." Committee on Resources, U.S. House of Representatives, April 2004.

"Fiscal and Socioeconomic Impacts of of Implementing the California Coho Salmon Recovery Plan." California Fish and Game Commission, February 2004.

"Economic Impacts of Critical Habitat Designation." Subcommittee on Fisheries, Wildlife and Water, Committee on Environment and Public Works, U.S. Senate, April 2003.

"Performance of the Federal Wetlands Permitting Program." Subcommittee on Water and Wetlands, Committee on Transportation and Infrastructure, U.S. House of Representatives. September 2001.

"Economic Observations on Water Infrastructure Investment in California." Subcommittee on Water and Power, Committee on Transportation and Infrastructure, U.S. House of Representatives. July 2001.

"Economic Impacts of Reduced Water Supplies on Westside Agriculture." Bay-Delta Advisory Committee. June 1998.

"Economic Impacts of the Central Valley Project Improvement Act." Subcommittee on Water and Power, Committee on Transportation and Infrastructure, U.S. House of Representatives. April 1998.

"Forest Service Losses on Below-Cost Timber Sales." Committee on Energy and Natural Resources, U.S. Senate. February 1997.

"Benefits and Costs of Enhanced Flood Protection in the American River Valley." Committee on Transportation and Infrastructure, U.S. House of Representatives. February 1996.

Berrenda Mesa Water Storage District, Bakersfield, CA.
J.G. Boswell Company, Los Angeles, CA.
Building Industry Association of Southern California, Diamond Bar, CA.
Chino Basin Watermaster, Ontario, CA.
City of Bakersfield, CA.
Dow Chemical, Midland, MI.
El Dorado County Water Agency, Shingle Springs, CA.
Enron, Houston, TX.
Environmental Defense, Oakland, CA.
Fairplex, Los Angeles, CA.
Fannie Mae, Washington, DC.
General Electric, New York, NY.
Hilmar Cheese, Hilmar, CA.
Home Builders Association of Northern California, San Leandro, CA.
Hughes Aircraft, Los Angeles, CA.
Idaho Power, Boise, ID.
Intel, Santa Clara, CA.
Intercontinental Hotels, New York, NY.
The Irvine Company, Irvine, CA.
Kern County Water Agency, Bakersfield, CA.
Los Angeles International Airport, Los Angeles, CA.
The Maple Companies, Dallas, TX.
Metropolitan Water District of Southern California, Los Angeles, CA.
Monterey Peninsula Water Management District, Monterey, CA.
National Association of Counties, Washington, DC.
National Association of Home Builders, Washington, DC.
Natural Resources Defense Council, San Francisco, CA.
The Nature Conservancy, Boulder, CO.
Occidental Chemical, Dallas, TX.
PacifiCorp, Portland, OR.
Pacific Gas & Electric, San Francisco, CA.
Phelps Dodge, Phoenix, AZ.
Plum Creeek Timber, Seattle, WA.
Prudential Insurance, New York, NY.
San Diego County Water Authority, San Diego, CA.
San Francisco Public Utilities Commission, San Francisco, CA.
Semitropic Water Storage District, Bakersfield, CA.
Shell Chemical, Houston, TX.
Shell Oil, New York, NY.
Sierra Club Legal Defense Fund, Honolulu, HI.
Suez/ONDEO, Paris, France.
SunCal Companies, Irvine, CA.
Teledyne, Los Angeles, CA.
Toro, Minneapolis, MN.
Transportation Corridor Agencies, Irvine, CA.
U.S. Department of the Interior, Washington, DC.

U.S. Department of Justice, Washington, DC.
U.S. Environmental Protection Agency, Washington, DC.
Western States Petroleum Association, Sacramento, CA.
Wheeler Ridge – Maricopa Water Storage District, Bakersfield, CA.

PROFESSIONAL ASSOCIATIONS

American Agricultural Economics Association
American Economic Association
American Law and Economics Association
Association of Environmental and Resource Economists
Econometric Society