Central Contra Costa Sanitary District

Protecting public health and the environment

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ELAINE R. BOEHME
Secretary of the District

December 28, 2011

Mr. Vince Christian
California Regional Water Quality Control Board
San Francisco Bay Region
1515 Clay Street, Suite 1400
Oakland, CA 94612

Dear Mr. Christian:

CENTRAL CONTRA COSTA SANITARY DISTRICT, RESPONSE TO COMMENTS ON THE TENTATIVE ORDER NO. R2-2011-XXXX, NPDES PERMIT NO. CA0037648

As you know, Central Contra Costa Sanitary District (hereafter "District") has requested renewal of its National Pollutant Discharge Elimination System (NPDES) Permit No. CA0037648 and has been actively participating in the Regional Water Board's permit renewal process.

On October 31, 2011, and November 1, 2011, the Regional Water Board received two comment letters on the proposed Tentative Order (TO) for the District's NPDES permit. The parties submitting comment letters were (1) the San Luis and Delta-Mendota Water Authority and the State Water Contractors (hereafter "Water Agencies") and (2) the San Francisco BayKeeper (hereafter "BayKeeper"). The subject comment letters contained assertions in support of requests for significant changes in the District's NPDES permit. The proposed changes by the Water Agencies would require the District to construct and operate costly new energy intensive treatment facilities. At a minimum, the requested changes by the Water Agencies and BayKeeper would require significant expenditures for research and monitoring.

On December 8, 2011, Bay Area Clean Water Agencies (BACWA) submitted a comment letter in response to the comments from the Water Agencies. The District supports the comments submitted by BACWA and has prepared this letter and its attachments to provide additional detail on some of the major assertions made in the subject comment letters. The District recognizes that the formal comment period for this TO closed on November 1, 2011, but respectfully request that these comments be entered into the record pursuant to Title 23 of California Code of Regulations, section 648.1(d).

The District understands the State and Regional Water Board's need to identify and evaluate nutrient-related problems, develop appropriate regulatory tools, and devise a long term nutrient management strategy for the San Francisco Bay Estuary. The District is supportive of the collaborative efforts that are underway with the Regional Water Board and other parties to develop a better understanding of the role of ammonium and other nutrients in the San Francisco Bay ecosystem. The District has taken a proactive and collaborative approach in working with San Francisco Estuary Institute (SFEI), the State Water Board, Regional Water Board and others on the San Francisco Bay Numeric Nutrient Endpoint (NNE) program, and also in working with various participants in the ongoing Suisun Bay study by funding aspects of the project in the 2010/2011 study season and continuing funding for the 2011/2012 second season study.

Unfortunately, the assertions made by the Water Agencies presuppose the outcomes of these ongoing efforts, rely on studies that have not been peer reviewed by Bay-Delta scientific experts, and greatly overstate the current understanding and level of certainty surrounding these issues. As a result, the District is obligated to respond to these assertions to establish a proper factual basis upon which to base permitting decisions that could cost the citizens of Contra Costa County from $70 to $150 million or more dollars in capital expenditures, based on preliminary studies conducted by our District.

This letter briefly summarizes the main assertions made in the comment letters submitted by the Water Agencies and BayKeeper, and describes the District's fundamental responses to those assertions. Detailed responses supported by expert advice from a team of scientists are contained in the attachments to this letter.

The following assertions pertaining to the District's discharge are made in the comment letter by the Water Agencies:

1. The discharge is causing or contributing to toxicity to aquatic organisms that are important to the Bay-Delta food web (page 8 #II – 1);
2. The discharge is adding ammonium loadings to Suisun Bay that are inhibiting diatom blooms and resulting in disruption of the Bay-Delta food web (page 9 # II - 2);
3. The discharge is changing nutrient ratios in the Delta, which is causing harmful effects in the Bay-Delta ecosystem (page 10 # II – 3);
4. Immediate actions to reduce nutrient loadings in the discharge would yield benefits to the ecosystem (page 10 # II – 4);
5. The proposed permit inappropriately assigns a mixing zone and dilution credit for ammonia (page 11 # III – A); and

6. The proposed permit fails to meet the requirements of the State and federal antidegradation policies (page 13 # III – B).

Assertions No. 1 through 4 are based on study results that have serious unresolved questions. In some instances, independent peer review has not been performed. In other instances, peer review has produced serious questions about the study results. In yet other instances, the study results are, in fact, untested hypotheses, which are being misrepresented as fact. In no case have these assertions been based on the use of adopted water quality objectives or water quality criteria developed or endorsed by the State of California or the USEPA.

For Assertion No. 1, the Water Agencies rely heavily on the results of a recently issued report by Dr. Swee Teh et al. to allege the existence of ammonia toxicity in Suisun Bay.[1] Serious questions exist regarding the key findings of that report, which has not been independently peer reviewed. Additionally, significant technical flaws exist in the Water Agencies' subsequent use of those findings to allege toxicity impacts in Suisun Bay. Assertions No. 2 through 4 are inconsistent with the findings of the team of highly esteemed coastal estuarine experts charged with evaluating the impacts of nutrients, including ammonium, on the San Francisco Bay Estuary as part of the development of NNEs.[2] The assertion that the District's discharge is disrupting the Delta food web by changing the nutrient balance in the estuary asserts hypothetical information as fact which has not been tested or accepted by San Francisco Bay scientific experts.

Assertion No. 5 is based on a flawed interpretation of both the San Francisco Bay Basin Plan and the detailed modeling studies performed by the District to establish a reasonable mixing zone and dilution credits. As described in the Tentative Order, the District's studies are consistent with numerous others that have been evaluated and approved by the Regional Water Board.

Assertion No. 6 is based on a legal interpretation of the antidegradation policies that is not consistent with State and Federal guidelines and policy precedents. In fact the Tentative Order is entirely consistent with the State and Federal policies.

Detailed responses to these assertions are included in the attached documents.

The following assertions and requests are made by the BayKeeper:

1. Effluent limits are needed for chlorine residual and settleable matter.

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[1] Teh, Swee; Flores, Ida; Kawaguchi, Michelle; Lesmeister, Sarah; and The Ching; *Full Life-Cycle Bioassay Approach to Assess Chronic Exposure of* Pseudodiaptomus forbesi *to Ammonia/Ammonium*, University of California at Davis; submitted to the State Water Resources Control Board pursuant to Agreement No. 06-447-300 (August 2011), (Teh et al., 2011).

[2] McKee, Lester; Sutula, Martha; Gilbreath, Alicia; Beagle, Julie; Gluchowski, David; Hunt, Jennifer; *Nutrient Numeric Endpoint Development for the San Francisco Bay Estuary: Literature Review and Data Gaps* (June 2011), (Hereinafter, McKee et al. 2011).

2. The permit should contain monitoring requirements for personal care products and should address sediment toxicity.

These suggested changes to the Tentative Order are also not appropriate, for reasons detailed in the attached documents.

In closing, it is important to recognize that no simple pollution prevention options exist for nutrient removal by POTWs. Preliminary studies of our treatment facilities indicate that removal of ammonia and other nutrients will require significant capital improvements. These studies also indicate that additional treatment can have significant environmental implications in terms of energy consumption and greenhouse gas emissions. We are continuing to fund studies to research evolving treatment technologies that may lead to less energy intensive methods of removing ammonia and nutrients in parallel with our contributions to studying the impact of ammonia and nutrients on the Suisun Bay. We continue to believe that such costly technological changes should not be undertaken without robust evidence that they are necessary and will provide benefits to the San Francisco Bay ecosystem commensurate with the economic and environmental costs.

This letter provides information that illustrates that the requested changes to the draft permit cannot be justified at this time, since the robust evidence needed to support such changes is not currently available. As such, the appropriate action by the Regional Water Board is the adoption of the draft permit as publicly noticed.

Our District mission is to protect the public health and the environment and we are committed to working with you to study the complex water ecosystem of the Suisun Bay to determine if changes in our operations or treatment technology are needed to protect it for future generations. Please contact me if you have any questions or comments regarding the content of this letter or any of the attachments.

Sincerely,

James M. Kelly

James M. Kelly, P.E.
General Manager

JMK/MPO/AEF/BTT:dp

Attachments:

1 – Responses to Comments on Tentative Order for NPDES permit for Central Contra Costa Sanitary District made by Water Agencies and San Francisco BayKeeper

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Appendix A - A Critical Review of: Full Life-Cycle Bioassay Approach to Assess Chronic Exposure of *Pseudodiaptomus forbesi* to Ammonia / Ammonium - Final Report. Dated August 31, 2011
Prepared by: Teh S, Flores I, Kawaguchi M, Lesmeister S, Teh C
Aquatic Toxicology Program, Department of Anatomy, Physiology, and Cell Biology, School of Veterinary Medicine, University of California Davis
This Critical Review Was Prepared By: Pacific EcoRisk, Inc.
2250 Cordelia Rd. Fairfield, CA 94534

Appendix B – Phytoplankton (Chlorophyll a) versus Ammonium Concentrations in Suisun Bay [1977 – 2010]

cc: CCCSD Board of Directors
Amy Chastain, Executive Director, Bay Area Clean Water Agencies
Ann E. Farrell, P.E., Deputy General Manager
Margaret P. Orr, P.E., Director of Plant Operations

Attachment 1

Responses to Comments on Tentative Order for NPDES permit for Central Contra Costa Sanitary District made by Water Agencies and San Francisco BayKeeper

December 27, 2011

On October 31, 2011 and November 1, 2011, the Regional Water Board received two comment letters on the proposed Tentative Order to renew the NPDES permit for Central Contra Costa Sanitary District (hereafter "District"). The parties submitting comment letters were (1) the San Luis and Delta Mendota Water Authority and the State Water Contractors (hereafter "Water Agencies") and (2) the San Francisco BayKeeper (hereafter "BayKeeper").

The comment letters from the Water Agencies and the BayKeeper raise a number of issues that are currently being studied and are unresolved in the scientific community. Issues are also raised regarding how certain technical and regulatory criteria, such as dilution and anti-degradation, are applied. In order to inform the dialogue on these issues, the District has prepared the following response.

Statement No. 1 –Excessive ammonium has been shown to be toxic to copepods. [10-31-11 Water Agencies letter page 8 # II -1]

Response: As detailed in the comment letter submitted by BACWA on December 8, 2011 and described further below, this statement is not fully supported by scientific data.

1. This statement relies on toxicity threshold values cited in a recent report prepared by Dr. Swee Teh et al. dated August, 2011.[1] The report summarizes research pertaining to one copepod species (*Pseudodiaptomus forbesi*) which is present in the Delta. Based on our review, this report has not been adequately peer reviewed and is not of sufficient quality to merit its use in a regulatory context. In fact, serious issues exist with the basic research, including the validity of toxicity threshold values derived from that research, the test methodology, and the reporting of methods and results. Examples of these issues are described in a memorandum prepared by

[1] Teh, Swee; Flores, Ida; Kawaguchi, Michelle; Lesmeister, Sarah; and The Ching; *Full Life-Cycle Bioassay Approach to Assess Chronic Exposure of* Pseudodiaptomus forbesi *to Ammonia/Ammonium*, University of California at Davis; submitted to the State Water Resources Control Board pursuant to Agreement No. 06-447-300 (August 2011). (Teh et al., 2011). Available at http://www.swrcb.ca.gov/rwqcb5/water_issues/delta_water_quality/ambient_ammonia_concentrations/tehetal_ammonium_exposure2011.pdf.

Pacific EcoRisk, Inc., which is included as Appendix A. The findings of this memorandum are summarized as follows:

"The reviewer is troubled by the absence of any discussion by Teh et al. regarding the variability in their test response data, either between tests or within tests (i.e., inter-replicate variability). Without such acknowledgement, it is left for the non-scientist to assume that the data as presented are definitive. Moreover, it raises the question of whether the data from this study are adequate (or 'ready') for use in regulatory decision-making. However, it is important to note that this critical review is not intended to negate Teh *et al.'s* observations that ammonia is toxic to naupliar, juvenile, and /or adult *P. forbesi* at elevated concentrations and that this toxicity is strongly influenced by pH. Indeed, the primary question of 'what are the effects of ammonia on *P. forbesi'* is relevant and Teh *et al.'s* study results certainly compel a more thorough examination of this. However, the problems associated with Teh *et al.'s* experimental methodology for Subtasks 3-3 and 3-4-1 and significant questions regarding the analysis of the resulting data do indicate that the quality of the work should preclude the resulting 'critical threshold' data ….. from being used for regulatory purposes."

2. Data on abundance of copepods in Suisun Bay does not support the allegation of reduced abundance or ammonia toxicity to copepods.

Recent publications provide information that contradict the Water Agencies' comment letter regarding the impact of the District discharge on copepod abundance. For example, the Dr. Teh et al. report notes that the California Department of Fish and Game 2007 to 2009 20 mm survey for *P. forbesi* found that the abundance at station 711 (near Rio Vista) increased, despite the presence of higher levels of ammonium at this location than exist in Suisun Bay (mean ammonium concentration of 0.27 mg/L versus mean ammonium concentration 0.15 mg/L at Martinez (Station 405)).

Additionally, the Interagency Ecological Program (IEP)'s Spring 2009 newsletter reported that *P. forbesi*, an introduced species first detected in 1988, "…has declined slightly since its introduction, [but] has remained relatively abundant in summer and fall compared to other copepods."[2] The Spring 2009 newsletter further noted that "[s]ummer abundance also increased slightly from 2007 to 2008, while fall abundance increased moderately and was the highest since 2002."[3] This evidence of increasing abundance of *P. forbesi* in Suisun Bay, despite the increased ammonia loadings and the increased ammonia ambient concentrations which are acknowledged for this period, is inconsistent with the allegation that ammonium toxicity is negatively impacting the abundance of this copepod in the Bay-Delta.

[2] Interagency Ecological Program Newsletter, Vol 22., No. 2, (Spring 2009). p. 11 Available at http://www.water.ca.gov/iep/newsletters/2009/IEPNewsletterFINALSpring2009.pdf).

[3] *Id.*

3. Knowledge of the mechanistic linkages between various stressors and the Bay-Delta food web is lacking. The allegation that ammonium is an important stressor impacting the Bay-Delta food web is hypothetical; in fact, the Delta science community is well aware that ammonia is only one potential stressor out of a list of many known stressors affecting the Delta ecosystem. Much greater evidence exists that other stressors, including benthic grazing by invasive clams and changes in Delta flow regimes, have impacted the food web at a macroscopic level.

   In August, 2010, the State Water Resources Control Board (SWRCB) issued its recommendations to the State Legislature regarding the establishment of flow criteria for the Sacramento-San Joaquin Delta.[4] Those criteria called for a significant increase in Delta outflows over recent levels and, among other things, included "…flow criteria in the Delta to help protect fish from mortality in the central and southern Delta resulting from operations of the State and federal water export facilities."

   The following excerpts from the SWRCB's Delta flow criteria report highlight the importance of evaluating multiple factors when considering the health of the ecosystem:

   > "Flow is important to sustaining the ecological integrity of aquatic ecosystems, including the public trust resources that are the subject of this proceeding. Flow affects water quality, food resources, physical habitat, and biotic interactions. Alterations in the natural flow regime affect aquatic biodiversity and the structure and function of aquatic ecosystems."[pg 39]
   >
   > "The best available science suggests that current flows are not sufficient to protect public trust resources." [pg 2], and
   >
   > "The flow criteria identified in this report highlight the need…to develop an integrated set of solutions, to address ecosystem flow needs, including flow and non-flow measures….Although flow modification is an action that can be implemented in a relatively short time in order to improve the survival of desirable species and protection of public trust resources, public trust resource protection cannot be solely achieved through flows – habitat restoration is also needed." [pg 7]

   The SWRCB's Delta flow criteria report acknowledged that water quality issues, including ammonia and nutrients, should be evaluated and considered in the adaptive management of the Delta. However, both ammonia and nutrients were given lesser emphasis than flow in the SWRCB report, contrary to the content and implications of the Water Agencies comment letter.

[4] State Water Resource Control Board; *Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem*. (August 2010). Available at http://www.swrcb.ca.gov/waterrights/water_issues/programs/bay_delta/deltaflow/final_rpt.shtml

Statement No. 2 – The excess ammonium is inhibiting nitrogen uptake by diatoms and reducing diatom primary production in the Bay-Delta. [10-31-11 Water Agencies letter page 9 # II-2]

Response: The statement greatly overstates our knowledge regarding the existence and/or importance of ammonium effects on phytoplankton blooms in Suisun Bay or the Bay-Delta food web.

The importance of the inhibition effect is not well understood, particularly in the context of other factors (benthic grazing and light limitation) that are known to impact phytoplankton blooms in Suisun Bay. Numerous instances have been documented where ammonium levels below the inhibition threshold (0.056 mg/l) developed by Dr. Richard Dugdale and commonly cited by the water Agencies have not triggered phytoplankton blooms in Suisun Bay. Figures depicting these occurrences are provided in Appendix B. Research on this topic is ongoing in Suisun Bay, funded, in part, by the State and Federal water contractors and Central Contra Costa Sanitary District. Therefore, the parties making the definitive comments on the District's Tentative Order are well aware that the science is unsettled on the very points that they are alleging in the comment letter.

In the McKee et al. report prepared for the Regional Water Board by SFEI and the Southern California Coastal Water Research Project (SCCWRP), numerous statements are made which contradict the assertion that ammonium is commonly accepted as having a significant impact in San Francisco Bay. The report acknowledges the suggestion by Dr. Richard Dugdale and other researchers from the Romburg Tiburon Center that "ammonium inhibition could be one of the limiting factors that control primary productivity in the Bay."[5] However, the report goes on to state that the impacts of ammonium on diatom blooms is not well-understood, is just one of many factors known to affect productivity, and that additional work is needed to resolve this issue:

> "…the ecological importance of ammonium inhibition of spring diatom blooms is not well understood relative to factors known to control primary productivity…" [pg 147]
>
> "In SF Bay, the biomass associated with phytoplankton, measured as surface water chlorophyll *a* concentration, varies in space and time in response to nutrient availability from external loads and internal regeneration, grazing, stratification, water temperature, tidal energy, transparency, wind/wave energy, the availability of seed cysts, UV radiation effects on nitrate versus ammonium assimilation perhaps due to disruptions of enzyme pathways, differential uptake of nitrate and ammonium by larger versus smaller cells, inhibition of nitrate uptake by ammonium, predation by benthic invertebrates, and variations in the phase of the Pacific Decadal Oscillation and related changes to top down predation of benthic invertebrates."[pg 153]
>
> "…the effect of ammonium inhibition on phytoplankton productivity throughout the Bay has not been modeled vis-à-vis other contributing factors…the next logical step is to develop models

[5] *McKee et al. 2011*.

that synthesize understanding of the relative importance of ammonium and urea versus other factors controlling phytoplankton assemblages."[pg 46]

"Elevated ammonium concentrations have been suggested as a major mechanism by which spring diatom blooms appear to be suppressed in the North Bay and Lower Sacramento River…Despite this evidence, the ecological importance of ammonium inhibition of spring diatom blooms is not well understood relative to factors known to control primary productivity, particularly in other regions of the Bay where water column chlorophyll *a* appears to be increasing. Thus, *the linkage between ammonium concentrations and Bay beneficial uses is not at this time universally accepted*. San Francisco Bay Technical Advisory Team (TAT) members agree that additional data synthesis is required to better understand the role of ammonium in SF Bay."[pg 154]

It is important to note that members of the TAT responsible for scientific review of and input on the NNE document include Dr. James Cloern, a highly recognized expert in San Francisco Bay ecology and two members from the Romburg Tiburon Center, including Dr. Dugdale. The cited statements and recommendations of the NNE report should therefore be interpreted as current prevailing scientific opinion regarding the role of ammonium in Suisun Bay phytoplankton dynamics.

Statement No. 3 – Nutrient discharges into the Bay-Delta estuary are contributing to a shift in algal communities by changing the nutrient ratios to favor harmful, invasive species. [10-31-11 Water Agencies letter page 10 # II-3]

Response: This statement is largely based on two papers, funded by the State Water Contractors, that offer hypothetical arguments based on selective correlation analysis that, in part, have been rejected by the scientific community and otherwise have not been accepted as fact.

The Water Agencies allege that research by Dr. Patricia Glibert confirms that nutrient loadings from the District contribute to changes in nutrient ratios in Suisun Bay, and that those changed ratios explain adverse ecosystem changes in the Bay-Delta, including the precipitous decline of key fish species.[6] In fact, the cited work has not been accepted or endorsed by leading Bay-Delta scientists. For example, the San Francisco Bay NNE science team considered Dr. Glibert's 2010 paper, but neither endorsed it or adopted it as fact in the final McKee et al. 2011 NNE report.

It should also be noted that the work by Glibert in 2010, funded by the State Water Contractors, was criticized for its inappropriate use of statistical methods and other issues. In a peer-reviewed paper titled "Perils of Correlating CUSUM-transformed variables to infer ecological relationships (Breton et al...

[6] Glibert, Patricia; *Long-Term Changes in Nutrient Loading and Stoichiometry and Their Relationships with Changes in the Food Web and Dominant Pelagic Fish Species in the San Francisco Estuary, California*; Reviews in Fisheries Science, Vol. 18, Issue 2 (August 2010). (Glibert, 2010). Available at http://www.sfcwa.org/2011/05/20/sed-lobortis-tellus-vel-ligula-pretium-mollis/.

2006, Glibert 2010)"[7] the authors James Cloern, Alan Jassby, Jacob Carstense, William Bennett, Wim Kimmerer, Ralph MacNally, David Schoellhamer and Monika Winder stated the following:

- "Glibert (2010) concluded that recent large population declines of diatoms, copepods, and several species of fish were responses to a single factor – increased ammonium inputs from a municipal wastewater treatment plant."
- "Glibert's study…contradicts the overwhelming weight of evidence that population collapses of native fish…and their supporting food webs in the San Francisco Estuary are responses to multiple stressors including landscape change, water diversions, introductions of exotic species and changing turbidity."
- "…CUSUM transformation, as used by…Glibert (2010), violates the assumptions underlying regression techniques."
- "…CUSUM-transformed variables often have an apparent statistically significant correlation even when none exists…"
- "…Glibert (2010) inferred a strong negative association between delta smelt abundance and wastewater ammonium from regression of CUSUM-transformed time series. However, the…correlation… is not significant…"
  The Glibert 2010 work was also criticized as being incomplete for not having analyzed the importance of other factors, including export volumes, benthic grazing by invasive clams, major changes in the hydrologic regime in the Delta, and other stressors that are commonly recognized as major contributors to stress on the Delta ecosystem.

The recently released Glibert et al. 2011 paper[8]- funded in part by the State Water Contractors, the San Luis & Delta-Mendota Water Authority and Metropolitan Water District - has not yet been effectively scrutinized by the San Francisco Bay NNE science team or other Bay-Delta experts. On its face, the subject paper is not a definitive piece of work on the effect of nutrients on the Bay-Delta ecosystem. The paper instead offers ecological stoichiometric theory as a hypothetical framework for consideration and suggests that nutrient stoichiometry may be a significant driver influencing food webs in the Bay-Delta ecosystem. The paper asserts the potential validity of this theory based on extensive, albeit selective, correlation analysis. The paper relies, at least in part, on the statistical analysis from the Glibert 2010 paper that was so roundly criticized. The paper does not assert that it has developed conclusive scientific evidence for its theories applicable to the San Francisco Bay or Delta.

In fact, excerpts from the Glibert et al. 2011 paper state that "while compelling, the ecological stoichiometric model raises many questions that need further analysis in the San Francisco Estuary…"

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[7] Cloern, J.E., A.D. Jassby, J. Carstensen, W.A. Bennett, W. Kimmerer, R. Mac Nally, D.H. Schoellhamer and M. Winder. 2011. *Perils of correlating CUSUM-transformed variables to infer ecological relationships (Breton et al. 2006, Glibert 2010)*. Limnology and Oceanography, in press.

[8] Glibert, Patricia; Fullerton, David; Burkholder, Joann; Cornwell, Jeffrey; Kana, Todd. *Ecological Stoichiometry, Biogeochemical Cycling, Invasive Species, and Aquatic Food Webs: San Francisco Estuary and Comparative Systems*. Reviews in Fisheries Science, Vol. 19, Issue 4 (October 2011). (Glibert et al., 2011).

and "…regulation of the food web by nutrient controls is directly testable…there is much that needs to be explored to test these relationships directly."[9]

In summary, the cited papers by Glibert offer theories that are strongly supported by the Water Agencies but that have not been accepted or endorsed by the Bay-Delta scientific community, the Delta Science Program or any other reputable scientific body. These theories, while interesting and perhaps worthy of further exploration, are not an appropriate basis for the imposition of very costly changes to municipal wastewater management in the San Francisco Bay region.

Statement No. 4 – Where implemented in impacted ecosystems, nutrient removal has improved the natural ecosystem and aquatic life. [10-31-11 Water Agencies letter page 10 # II-4]

Response: This statement pre-supposes the outcome of the San Francisco Bay NNE process and other efforts to address the issue of nutrient management in San Francisco Bay.

The Water Agencies allege that nutrient load reduction, as a general management action, will create various benefits to the Bay-Delta ecosystem. This overarching philosophy is offered as a rationale to support the imposition of restrictive effluent limits in the District's permit to force nitrogen load reductions. Such generalized statements are not borne out by the main body of scientific research on this topic. For instance, the following excerpts are taken from a 2010 report by Damann Anderson and Anthony Janicki[10] published by the Water Environment Research Foundation which investigates the complexity of nutrient management decision making:

> "…nutrient water quality impacts are typically waterbody specific, and thus waterbody specific assessments are necessary to develop appropriate nutrient numeric criteria…"
>
> "…determination of the causative agents for eutrophication impairment is not straightforward, but needs to be determined prior to developing management decisions…"
>
> "…all benefits and costs of available nutrient controls should be evaluated for all stakeholders prior to implementation…"

The following statement is particularly relevant to the San Francisco Bay-Delta estuary:

> "Nutrient load reductions to a waterbody that is light-limited…may show no change in resultant water quality. Hydrologic alterations affect residence time in a waterbody and can also confound the relationship between nutrient loading and water quality conditions."

The ongoing Numeric Nutrient Endpoint (NNE) development effort in the San Francisco Estuary being led by the State Water Board, Regional Water Board, the San Francisco Estuary Institute, and various

[9] *Id* at 84.

[10] Anderson, D.L and A. Janicki. 2010. *Linking Receiving Water Impacts to Sources and to Water Quality Management Decisions: Using Nutrients as an Initial Case Study*, Prepared for Water Environment Research Foundation, WERF 3C10

stakeholders is a proper scientific and policy forum for the evaluation of complex nutrient issues. McKee et al. noted that "evidence is building that the historic resilience of San Francisco Bay to the harmful effects of nutrient enrichment is weakening."[11] The NNE effort is a systematic study to address the need for future nutrient management actions. That effort is ongoing and has yet to produce definitive recommendations regarding nutrient criteria or a nutrient management plan. An important component of the NNE framework in San Francisco Bay is the development of load-response models that can simulate the ecological response of the Estuary to nutrients and other important co-factors.

The following statements are made in the McKee et al. report:

> "Estuaries within California are highly variable in how they respond to nutrient loading due to differences in physiographic setting, salinity regime, frequency and timing of freshwater flows, magnitude of tidal forcing, sediment load, stratification, residence time, denitrification, etc."[Page 8]

With regard to San Francisco Bay, specifically, the report states:

> "…San Francisco Bay has long been recognized as an estuary in which phytoplankton biomass and pelagic primary productivity is not driven by simple nutrient limitation, due to a variety of co-factors that modulate primary producer response to nutrients…" [Page 70]

It is clear that the generalized allegations and associated permit demands by the Water Agencies should not deter or distract from the ongoing NNE effort as the proper vehicle for addressing nutrient management questions in San Francisco Bay and for determining whether nutrient load reductions will provide commensurate benefits.

Statement No. 5 - The Regional Board's application of a dilution factor is flawed and should be reconsidered. [10-31-11 Water Agencies comment letter page 11 # III - A]

Response: The Regional Water Board has followed established regulatory policies and procedures in evaluating the dilution characteristics of the District's discharge and in using that information in the derivation of effluent limits for ammonia in the Tentative Order.

The six specific comments made by the Water Agencies pertaining to the proposed dilution credits for ammonia in the District's Tentative Order are addressed below, on a point-by-point basis:

> *"The Public Water Agencies are concerned that the Regional Board staff has erred in its application of a dilution factor to set effluent limits for ammonium. As the Tentative Order acknowledges, the applicable Basin plan had Water Quality Objectives for un-ionized ammonia of 0.025 mg/L (annual median) and 0.16 mg/L (maximum) upstream of the Bay Bridge. Tentative Order, Attachment F at F-23. As the un-ionized component of the total ammonia is only small fraction of the total discharges, these are then converted to total ammonia objectives of 5.0*

[11] McKee et al. 2011 at page 161.

mg/L (acute) and 1.6 mg/L (chronic). Given that the MEC for ammonium in 30.2 mg/L, there unquestionably is a reasonable potential to exceed these objectives. However, the Tentative Order then proceeds to allow a substantial dilution for total ammonia to set the effluent limits relying on the "Mixing Zone Study." Yet, this would not appear to be appropriate for several reasons:"

1. "Regional Board staff acknowledges the inability to set a mixing zone."

The language referenced by the Water Agencies and included by Regional Water Board staff in the Fact Sheet of the Tentative Order (Section IV.C.4.b.ii.(2), page F-20) addresses the difficulties in setting a mixing zone for persistent, non-bioaccumulative pollutants. The language was provided as a justification for limiting the dilution credit for copper, cyanide, and bis(2-ethylhexyl)phthalate to 10:1 even though the District's discharges achieve a much greater dilution (43:1 based on average dry weather flow rates, 33:1 based on peak flow rates). The Regional Water Board staff did not state they were unable to determine a mixing zone, just that a conservative approach is warranted for such pollutants. The referenced language does not pertain to ammonia, which is neither persistent nor bioaccumulative.

2. "Regional Board granted a mixing zone for total ammonia even though they acknowledged inability to set a mixing zone. In addition, they are applying dilution credits for control of un-ionized ammonia, not ammonium which is the more serious constituent of concern."

As mentioned in the response to Issue #1, Regional Water Board staff did not state they were unable to set a mixing zone, just that a limited dilution credit/mixing zone is appropriate for non-bioaccumulative, persistent pollutants. A mixing zone (based on initial dilution) was granted for total ammonia because it is a non-bioaccumulative, non-persistent pollutant. The Basin Plan (Section 3.3.20) includes objectives for un-ionized ammonia (which are translated to total ammonia when setting effluent limits) to "protect against the chronic toxic effects of ammonia in the receiving waters" but acknowledges "in most instances, ammonia will be diluted or degraded to a nontoxic state fairly rapidly." No chronic effects are expected from ammonia and granting a mixing zone based on initial dilution will not impact water quality. The San Francisco Bay Basin Plan[12] does not include objectives for ammonium. The Water Agencies' concerns regarding ammonium are based on recent research on copepod toxicity by Teh et al. 2011 that has not been properly peer-reviewed, and unproven theories of phytoplankton inhibition by Dr. Richard Dugdale that have not been translated into water quality criteria or surrogates for such criteria. Additional work is needed to establish meaningful water quality thresholds before they can be used in the derivation of effluent limits.

3. "The Basin Plan cautions against application of dilution credits in light of various concerns, including the difficulty in measuring the discharge in a tidal zone."

[12] California Regional Water Quality Control Board, San Francisco Bay Region; *San Francisco Bay Basin (Region 2) Water Quality Control Plan* (December 31, 2010). (Basin Plan 2010).

The section of the Basin Plan referenced by the Water Agencies (Section 4.6.1.1.) includes the rationale for limiting dilution credits and not approving mixing zones that extend outside the zone of initial dilution. Regional Water Board followed this approach when determining effluent limits for total ammonia. A "Mixing Zone Study" prepared for the District in 2011 utilized the U.S. EPA-approved CORMIX model to delineate the shape of the discharge plume. [13] CORMIX is approved for use in assessing environmental impacts of regulatory mixing zones that result from continuous point source discharges[14]. Near-field mixing processes were modeled for the District that included buoyant jet mixing (receiving water currents and merging of individual port's plumes) and boundary interactions (sediment bed, water surface, and density gradient effects). The plume shape was conservatively delineated by the surface area containing one standard deviation (i.e., 68%) of the plume in a Gaussian distribution-shaped cross-section. Initial dilution was assumed to be complete when the plume's discharge momentum and buoyancy dissipate. Although turbulent diffusion subsequently dilutes the effluent plume even more, initial dilution is commonly applied for calculating effluent limitations. The edge of the regulatory mixing zone is delineated by this near-field region, a term used in CORMIX output to describe the zone of strong initial mixing where "near-field" processes occur.

4. "The "Mixing Zone Study" indicated the plume re-stratifies and dilution does not persist beyond the zone of initial dilution."

The comment from the Water Agencies is based on a misunderstanding of the applicability of the CORMIX plume model. The model results apply to near-field mixing associated with buoyant jet mixing (the jet from each diffuser port rising due to buoyancy, spreading due to turbulence, deflecting due to receiving water current effects, and merging with neighboring port's plumes) and boundary interactions (the Bay's sediment bed and water surface, density gradients in the water column). The "plume" refers to whatever remaining portion of the initial discharge can still be distinguished from the ambient receiving water at the point of interest.

Stating that dilution "does not persist beyond the zone of initial dilution" implies an impossible physical process of the plume reconstituting or reassembling itself. Dilution of a plume only works in one direction. While the initial, momentum-induced mixing essentially ends at the edge of the mixing zone, subsequent dilution occurs through the processes of dispersion and advection. Far-field hydrodynamic modeling can be applied to predict additional dilution beyond the edge of the mixing zone.

[13] Larry Walker Associates; *Near-Field Mixing Zone and Dilution Analysis for the Central Contra Costa Sanitary District Outfall Diffuser to Suisun Bay*, (May 27, 2011). Prepared for the Central Contra Costa Sanitary District. (LWA 2011).

[14] Doneker, R.L., and G.H. Jirka; *CORMIX User Manual – A Hydrodynamic Mixing Zone Model and Decision Support System for Pollutant Discharges into Surface Waters* (2007). EPA-823-K-07-001.

In fact, the RMA-2 model was used in 2000 to determine dilution of the District's effluent away from the outfall[15] and in 2008 to estimate currents (speed and direction) at the District's diffuser.[16] RMA-2 is a generalized free surface hydrodynamic model that is used to compute two-dimensional depth-averaged velocity and water surface elevation. The RMA Bay-Delta model extends from the Golden Gate to the confluence of the American and Sacramento Rivers and to Vernalis on the San Joaquin River. A 15-minute tidal boundary time series is applied at the Golden. Time series of daily average inflow boundary conditions are applied for the Sacramento River, San Joaquin River, Yolo Bypass, San Joaquin River, Cosumnes River, Mokelumne River, miscellaneous eastside flows which include Calaveras River and other minor flows, and Napa River. Delta exports applied in the model include the State Water Project, the Central Valley Project, Contra Costa exports and North Bay Aqueduct intake at Barker Slough. The model provides a detailed spatially-varying and time-varying description of tidal directions and velocities. Dynamic boundary conditions assure accurate computation of net Delta outflows as they vary with inflow conditions and exports. Because RMA-2 is a depth-averaged model, density driven flows are not included. Estuarine conditions are otherwise well-represented.

Extreme low Delta flow conditions (average net Delta outflow of 2,300 cubic feet per seconds (cfs) occurring October 1-31, 1977) were simulated in 2000 along with the District's permitted average dry weather discharge flow rate (53.8 mgd). A conservative tracer was used to represent District's discharges. The model produced output every 15 minutes during the simulation, capturing the effects of ingoing/outgoing tides, delta and riverine flows, and discharges from wastewater treatment plants throughout the San Francisco Bay. Minimum dilution near the outfall was observed approximately 10 days after tracer release.

The 2000 tracer simulation results indicated that the District's discharge plume is highly diluted in the Bay with a minimum dilution of 200:1 near the outfall (outside the zone of initial dilution). The minimum 200:1 dilution occurs at slack after flood tide and at slack after ebb tide. The dilute plume then oscillates with the tide along the southern shore of Carquinez Strait and Suisun Bay. Results of the tracer simulation illustrate that under periods of low Delta outflow, the discharge plume may extend upstream some distance (at 500:1 dilution), but will not reach the City of Antioch. Under high Delta outflow conditions the extent of the discharge plume is much smaller and the dilution is much greater as shown in the following figure (Figure 28 excerpted from RMA 2000).

[15] Resource Management Associates, Inc; *Water Quality Impacts of Central Contra Costa Sanitary District Discharge on San Francisco Bay* (August 2000), prepared for Larry Walker Associates and Central Contra Costa Sanitary District. (RMA 2000).

[16] Resource Management Associates, Inc. *Numerical Modeling of Central Contra Costa Sanitary District Discharge in San Francisco Bay – Technical Summary Report* (June 2008), prepared for Larry Walker Associates and Central Contra Costa Sanitary District. (RMA 2008).

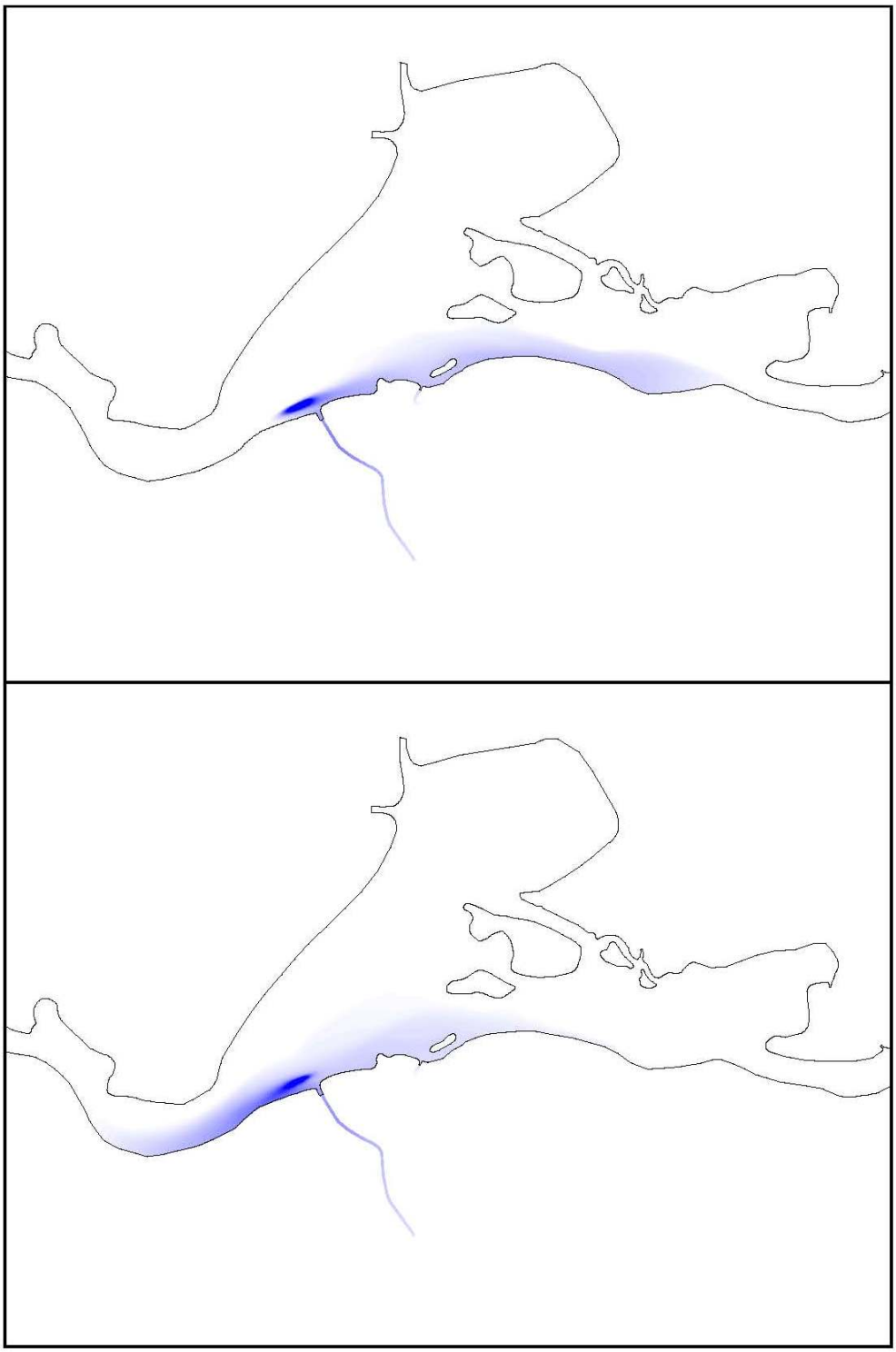

Figure 28. Color contours of tracer concentration at slack after flood tide (a), and slack after ebb tide (b). Color scale ranges from 200:1 dilution (darkest blue) to 500:1 dilution (lightest blue). (RMA 2000)

5. "The Basin Plan cautions against use of mixing zone models in estuarine environments because it is difficult to estimate the effects of re-entrainment. Also, all discharge plume models are limited because they do not account for transport due to tidal currents."

The comment from the Water Agencies is based on a misunderstanding of the applicability of CORMIX and the conservative estimation of plume dilution relative to the potential effects of re-entrainment of effluent reducing the effective dilution. As opposed to relying on a dye study which is done at one point in time, a calibrated simulation model can evaluate a broad range of conditions. Although CORMIX results delineate the effluent plume defining the edge of the mixing zone under steady-state conditions, the average of median speeds during ebb and flood tides over a simulation period representing low (10th percentile) net Delta outflows was applied.

For a sense of perspective, Figure 1 (excerpted from LWA 2011) and shown on the following page can be used to portray the spatial scales of tidal currents and the mixing zone:

- The diffuser is at an average depth of 24 feet.
- The 115-ft long diffuser is smaller than the dot in the figure identifying the diffuser's location in Suisun Bay.
- Near-field mixing is complete at a distance of 125 feet from the diffuser centerline.
- In the half-hour before or after slack tide, when currents are weakest and reversing direction, Suisun Bay water moves an average of 800 feet away from the diffuser, over six times the length of the mixing zone.
- The distance that Suisun Bay water moves away from the diffuser over a tidal cycle is typically over five miles—beyond the frame of Figure 1.

Three other lines of evidence can be used to estimate the effects of re-entrainment on dilution of the District's effluent:

- Because the tidal current does not return in exactly the opposite direction in Suisun Bay, additional dispersion of the remaining reversing plume occurs over each tidal cycle. Even during the hour surrounding slack tide, the plume's centerline typically will be offset by more than the length of the diffuser upon its return.
- A dye study[17] performed for the District in 1970 found dilutions around 200:1 in boils directly over the outfall, increasing several fold away from that point.
- The Bay-wide RMA-2 hydrodynamic model (described above in response to Issue # 4) used in 2000 to simulate extremely conservative conditions (slack tides and extreme low Delta outflow conditions) indicated dilution was greater than 200:1 near the outfall.

Re-entrainment of effluent diluted 200-fold would be a trivial factor in the dilution analysis, as confirmed by both the dye study and the hydrodynamic modeling.

[17] Brown and Caldwell Consulting Engineers; *Report on Continuous Dye Release Study Suisun Bay Outfall* (August 1970), prepared for Central Contra Costa Sanitary District.

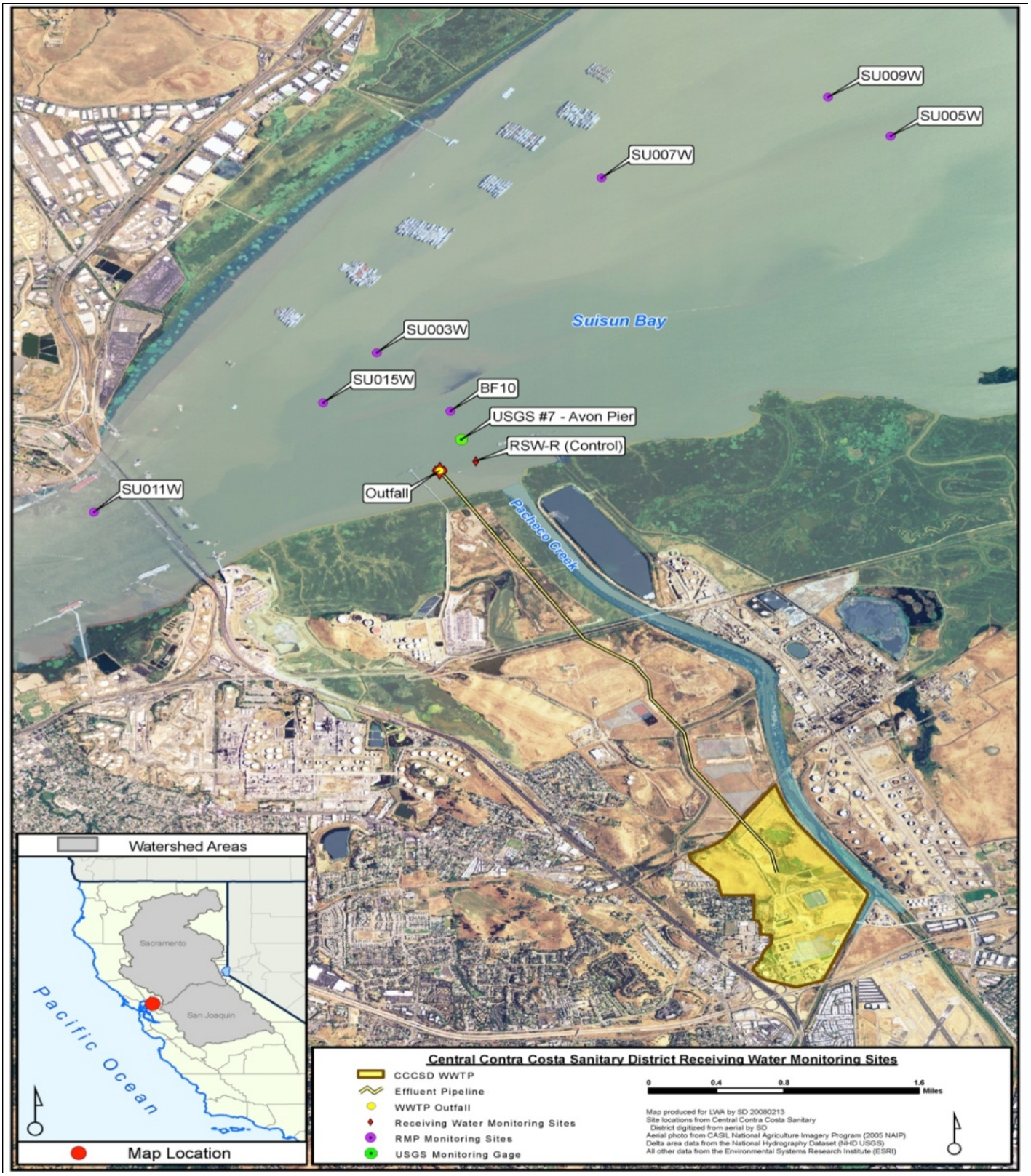

Figure 1. CCCSD outfall study area. Nearby monitoring stations are identified. (LWA 2011)

6. "The Basin Plan indicates that a conservative approach must be used when calculating effluent limits. Ignoring research on diatom inhibition and copepod toxicity due to ammonium is not a conservative approach."

See the response provided to Statements No. 1 and 2 earlier in this memo. The issues cited are currently under study and are unresolved in the scientific community.

Statement No. 6 – The Regional Board's analysis of Anti-degradation with regard to ammonia is contrary to established principles of law. [1-31-11 Water Agencies comment letter page 13 # III - B]

Response: This statement is not supported by State and federal regulations or policies, nor is it supported by the most recent State Water Board decisions or case law on this topic, all of which indicate that the Regional Water Board is not obligated to perform a new antidegradation analysis in the issuance of the Tentative Order or in the adoption of that order as a new NPDES permit.

The Tentative Order does not allow a lowering of water quality in comparison to the existing permit. The proposed permit does not increase the permitted discharge flow. The proposed permit places limits on ammonia that did not exist previously. Therefore, the permit is more restrictive than the previous permit with regard to ammonia discharges, and does not allow a lowering of water quality.

According to State Water Board guidance, where the Regional Board "has no reason to believe that existing water quality will be reduced due to the proposed action, no antidegradation analysis is required."[18] According to U.S. Environmental Protection Agency (Region 9) guidance, "The first step in an antidegradation analysis is to determine whether or not the proposed action will lower water quality…If the action will not lower water quality, no further analysis is needed and EPA considers 40 CFR 131.12 to be satisfied."[19]

The Water Agencies' arguments are based on the incorrect premise that the baseline water quality used to determine whether the Tentative Order will result in a reduction in water quality is the wastewater treatment plant's current discharge rather than the permitted discharge. While this position is supported by the State Water Board's decision in *In re Matter of the Petition of Citizens for a Better Environment et al.*, Order No. 90-5 (Oct. 4, 1990) ("Order WQ 90-5"), subsequent authorities have declined to follow the State Water Board's interpretation in Order WQ 90-5 and have concluded that the appropriate baseline is the permitted discharge. Order WQ 90-5 involved the issuance of NPDES permits to three sewage treatment plants that discharge to the San Francisco Bay south of the Dumbarton Bridge ("South Bay"). At the time the permits were issued, the South Bay had been listed as impaired for toxic pollutants but no Total Maximum Daily Loads (TMDLs) had been developed. The permits

[18] State Water Resources Control Board, *Antidegradation Policy Implementation for NPDES Permitting, Administrative Procedures Update 90-004* (July 2, 1990) at pg. 2.

[19] U.S. Environmental Protection Agency (Region 9), *Guidance on Implementing the Antidegradation Provisions of 40 CFR 131.12* (June 3, 1987) at pg. 3.

therefore contained interim performance –based effluent limits for toxic pollutants and interim mass loading limits for toxic pollutants that were 33-80% higher than actual loading. The petitioner argued that these interim limits violated state and federal antidegradation policies.

The State Board determined that issuance of the South Bay permits triggered the state and federal antidegradation policies because the permits allowed an increase in the volume of the discharges as well as an increase in the mass emissions of toxic pollutants over current levels. The Board concluded that because the interim limits for toxics were based on performance, they did not necessarily ensure protection of existing in-stream beneficial uses as required by the first part of the federal antidegradation policy. The Board further concluded that because the South Bay was impaired for toxic pollutants, the mass loading limits should be based on the dischargers' best performance since 1975 (the effective date of the federal antidegradation policy), i.e., their current performance as of 1990. The State Water Board directed the Regional Water Board to calculate the limits by "multiplying the 1989 annual mean effluent concentration by the 1985-1988 annual average flow."

However, in *Own Motion Review of the Petition of Communities for a Better Environment et al.*, Order No. 90-09 (Oct. 21, 1999) ("Order WQ 99-09"), which involved a challenge to the 1998 South Bay permits, the State Water Board used the permitted discharge, not the current discharge as the water quality baseline. The 1998 permits contained mass loading limits for copper and nickel based on the average flow data from 1985-1988 and average concentration data from 1989 as instructed by the State Board in WQ 90-5. Environmental groups asserted that the limits violated the antidegradation policies because they were much higher than the mass of copper and nickel actually discharged by the South Bay dischargers over the last five years.

The State Water Board upheld the copper and nickel mass limits in the 1998 permit despite the fact that current performance was better than in 1990. It found that the limits for nickel in the 1998 permit did not trigger antidegradation requirements because "the mass limits are unchanged from the 1993 permits. The 1998 permits do not authorize an increase in mass emissions over the 1993 permit limits."

Similarly, in *San Francisco Baykeeper v. State Water Resources Control Board,* 2003 Cal. App. Unpub. LEXIS 5290 (May 28, 2003), the court held that interim mass limits for mercury that are higher than the actual mass of mercury being discharged do not violate antidegradation policies. That case involved challenges to the City of Petaluma's and Fairfield Suisun Sanitary District's 1998 NPDES permits. When the permits were issued, the receiving waters were listed as impaired for mercury but a TMDL had not yet been developed. The permits contained interim mass limits for mercury based on treatment plant performance but higher than the actual mass of mercury being discharged due to the dischargers' reclamation programs. Environmental groups, relying on WQ Order 90-5, argued that the limits violate antidegradation policies because they exceed actual loading. The Court rejected the plaintiffs' arguments, concluding

> "State Board's interpretation of Tier 1 of the antidegradation policy evolved in the years following Order WQ 90-5, and we accord greater weight to its more recent construction of federal policy [Order WQ 99-09]. There is no contention

here that the 1998 Petaluma and FSSD permits authorize an increase in the mass of mercury over mass allowed by the 1990 permits. We conclude that Regional Board was not obliged to set mass limits at the current mercury loading levels."

The State Water Board Guidance is consistent with the conclusions in Order WQ 99-09 and *San Francisco Baykeeper* that the appropriate baseline is the permitted discharge not the current discharge. The State Water Board Guidance states that baseline water quality is

> "…the best quality of the receiving water that has existed since 1968 when considering Resolution No. 68-16 [state antidegradation policy], or since 1975 under the federal policy, unless subsequent lowering was due to regulatory action consistent with State and federal antidegradation policies. If poorer water quality was permitted, *the most recent water quality resulting from the permitted action is the baseline water quality* to be considered in any antidegradation analysis. State Board Guidance at p. 4 (emphasis added)."

Third, the Tentative Order will not result in a reduction of water quality as compared to its current permit. The Tentative Order does not authorize an increase in the volume of the discharge. Both the current permit and the Tentative Order permit the District to discharge up to 53.8 mgd. The Regional Water Board approved an increase in the volume of the District's discharge from 45 mgd to 53.8 mgd without conditions ten years ago after the District conducted an antidegradation study, which concluded that such an increase was consistent with state and federal antidegradation studies. Nor does the Tentative Order authorize a substantial increase in the mass emission of a pollutant. To the contrary, the Tentative Order is more restrictive than the current permit with respect to ammonia. The District's current permit does not contain any limits on ammonia while the Tentative Order imposes effluent limitations on total ammonia. While the Water Agencies assert that the Tentative Order will reduce water quality because it will permit the District to discharge more ammonia than the District is currently discharging, as discussed above, current performance is not the correct baseline. Therefore, because the Tentative Order does not authorize an increase in the volume of the discharge or an increase in the mass emissions of a pollutant as compared to the current permit, the antidegradation policies are not triggered and the Regional Water Board was not required to conduct an antidegradation analysis or make any antidegradation findings.

Statement No. 7 – The Draft Permit Must Include Effluent Limitations for Residual Chlorine and Settleable Matter. [11-1-11 San Francisco BayKeeper comment letter page 1 # 1].

Response: Effluent limits for settleable matter and chlorine residual should not be included in the District's NPDES permit.

Effluent produced at the District's wastewater treatment plant and discharged to Suisun Bay receives primary and secondary treatment and is disinfected with ultraviolet light. There is no chlorine used and no chlorine residual produced with ultraviolet (UV) disinfection, so effluent limitations for chlorine residual at the District's facility are unnecessary.

The Regional Water Board adopted a Basin Plan Amendment on January 21, 2004 to update water quality objectives and NPDES permit implementation provisions.[20] The amendment clarified that effluent limitations for settleable matter do not apply to either secondary or advanced sewage treatment facilities and should not be included in future permits for those facilities. As stated in the staff report that accompanied the subject Basin Plan amendment,[21] "For secondary and advanced treatment systems, the equivalent limitation is suspended solids, pursuant to 40 CFR 133.102. Application of both suspended solids and settleable matter effluent limitations to secondary and advanced sewage treatment facilities is not only redundant, but also does not afford better protection of beneficial uses. Settleable matter is not a relevant indicator of adverse effects of secondary and advanced treated sewage on receiving waters. It is a technology-based effluent limit for only primary treatment and was mistakenly applied to secondary and advanced treatment plants." The NPDES permit issued to the District includes effluent limitations for total suspended solids as required to monitor performance of secondary treatment facilities.

Statement No. 8 – The Draft Permit Must Conduct a Complete Reasonable Potential Analysis that Fully Addresses Pharmaceuticals, Chemicals from Personal Care Products, and Sediment Toxicity. [11-1-11 San Francisco BayKeeper comment letter page 1 # 2].

Response: Information does not exist to allow the performance of a reasonable potential analysis for the parameters in question.

Pharmaceuticals and Personal Care Products

As prescribed in the SIP, the RPA process is applicable only to priority pollutant criteria and objectives established by the U.S. EPA and the State of California.[22] Under the RPA process, water quality based effluent limits must be implemented if effluent quality exceeds the criteria/objectives (Trigger 1) or the ambient receiving water quality exceeds the criteria/objectives and the pollutant was detected in the effluent (Trigger 2). Utilization of Trigger 3 (sometimes referred to as best professional judgment) to establish effluent limits must be supported by scientific facts (e.g., presence in effluent and receiving waters) and evidence of impacts to beneficial uses. However, because no criteria or objectives have been adopted for pharmaceuticals and personal care products (PPCPs), none of these evaluations can be conducted. Trigger 3 has not been utilized for PPCPs because water quality thresholds have not been established, there is no process for determining if these constituents are impacting beneficial uses at ambient levels, and no monitoring has been completed to link levels in effluent to levels of concern in the ecosystem.

[20] Order No. R2-2004-0003.

[21] San Francisco Bay Regional Water Quality Control Board, *Staff Report – Proposed Amendment to the Water Quality Control Plan for the San Francisco Bay Basin (Basin Plan) Updating Water Quality Objectives and Implementation Language* (December 19, 2003), page 32.

[22] SWRCB (2005), page 3.

The most recent recommendations for PPCP monitoring were developed by a Blue Ribbon Panel of scientific advisors convened by the State Water Resources Control Board in 2009. The panel was convened by the State Water Board to "provide guidance for developing monitoring programs that assess potential Constituents of Emerging Concern (CEC) threats from various water recycling practices, including indirect potable reuse via surface spreading; indirect potable reuse via subsurface injection into a drinking water aquifer; and urban landscape irrigation." [23] The panel's monitoring recommendations were released in 2010 and included a discrete list of surrogate compounds and performance based indicators related to human health exposures during recycled water applications. Additional research was suggested by the panel to develop and validate analytical methods for those compounds, prioritize compounds for monitoring, and determine environmental impacts under different exposures to recycled water or wastewater. At this point in time, there is no process or thresholds for identifying constituents of concern or for assessing impacts to aquatic ecosystems.

Sediment Toxicity

A Statewide plan for assessing sediment toxicity and its impacts on water quality was adopted by the State Water Resources Control Board in 2008.[24] The U.S. Environmental Protection Agency approved the plan on August 25, 2009, allowing full implementation in California. Part 1 of the Water Quality Control Plan pertains only to sub-tidal, surficial sediments of enclosed bays and estuaries. Applied to the San Francisco Bay Estuary, the assessment procedures are clearly defined only for polyhaline conditions (i.e., Central San Francisco Bay, portions of San Pablo Bay), not for the mesohaline (moderately saline, South Bay/Suisun Bay) or oligohaline (freshwater) areas.

Part 1 establishes narrative sediment quality objectives (SQOs) to protect aquatic life and human health in sediments. The approved plan includes only the process for evaluating compliance with the aquatic life SQO (Phase I). The aquatic life SQO is implemented using a Multiple Lines of Evidence Approach (MLOE) that integrates three types of measurement/assessment tools. The lines of evidence include (1) sediment toxicity (laboratory exposure of invertebrates to surficial sediments), (2) benthic community condition (measure of composition, abundance, diversity of aquatic species inhabiting the surficial sediments), and (3) sediment chemistry (measurement of the concentration of chemicals of concern in surficial sediments). The human health SQO is currently implemented on a case-by-case basis by the Regional Water Boards, based on monitoring and assessments performed by various state agencies.

Integrating lines of evidence following the SQO approach will yield an assessment level that may range from "unimpacted" to "clearly impacted" for each monitored site. A finding of "unimpacted" and "likely unimpacted" will be considered in compliance with receiving water limits. The findings of "likely impacted" or "clearly impacted" will be considered degraded when evaluating waters for placement on

[23] *Recommendations of a Science Advisory Panel, Monitoring for Chemicals of Emerging Concern (CECs) in Recycled Water* (June 25, 2010). Panel convened by the State Water Resources Control Board.

[24] State Water Resources Control Board, *Water Quality Control Plan for Enclosed Bays and Estuaries - Part 1 Sediment Quality* (September 16, 2008). Adopted as Resolution No. 2008-0070.

the Section 303(d) list and evaluating compliance with the aquatic life SQO. A finding of "possibly impacted" requires additional study to determine if a site is truly degraded.

Part I was amended in April 2011 to add a narrative SQO that protects resident finfish and wildlife from the detrimental effects caused by exposure to pollutants in sediments, a process for implementing the narrative objectives, new definitions in the glossary in support of the proposed narrative objectives, and corrections for omissions and typographical errors. State Water Board staff is currently drafting policy to implement Phase II amendments. Phase II will address the methodologies needed to interpret and implement SQOs to protect benthic communities from direct exposure in mesohaline areas of San Francisco Bay and the freshwater Delta, and protect human health from consumption of fish and shellfish.

If a Regional Water Board determines that a discharge of toxic pollutants has the potential to cause or contribute to an exceedance of the SQOs, the objectives may be applied as receiving water limits in NPDES permits. Effluent limits will only be developed if specific pollutant(s) causing degradation have been identified, if a discharge is clearly linked to those identified pollutants, and if an estimated reduction in pollutant loading from the discharge in question will improve sediment quality. In the San Francisco Bay Area, the Regional Water Board is in the process of compiling information on sediment quality and the health of sediment biota. As a result, wastewater dischargers are required to participate in the Regional Monitoring Program (RMP) to obtain further information on sediment quality and benthic populations. As this information is acquired and assessed, the Regional Water Board will decide if receiving water limits are needed in NPDES permits or if the RMP should conduct stressor identifications in specific areas of the Bay. Stressor identifications involve tests to confirm pollutant related impacts, identify specific pollutants, and (as needed) identify the pollutant sources. Sites designated as "clearly impacted" or "likely impacted" are the highest priority for stressor identification studies in accordance with the policy adopted by the State Water Board.

The requirements and findings in the District's Tentative Order are consistent with the SQO policy and the current state of the science in San Francisco Bay. The multiple lines of evidence approach for assessing compliance with SQOs was first applied to samples collected in 2008. However, these results have not yet been peer-reviewed or released for regulatory decision-making. In addition, and as mentioned above, the SQO techniques are to-date applicable only to polyhaline conditions, not the mesohaline conditions that exist in Suisun Bay. Until SQO assessments are conducted on samples collected in Suisun Bay and it is determined if sediments are impacted, specific monitoring by a discharger is not required. Continued participation by the District in the RMP is the appropriate approach for determining SQO compliance and addressing concerns regarding sediment toxicity in Suisun Bay.

Appendices:

Appendix A: A Critical Review of "Full Life-Cycle Bioassay Approach to Assess Chronic Exposure of *Pseudodiaptomus forbesi* to Ammonia/Ammonium - Final Report. Teh et al., August 31, 2011." Prepared by Pacific Ecorisk, Inc., December, 2011.

Appendix B: Phytoplankton (chlorophyll a) versus ammonium concentrations in Suisun Bay (1977-2010).

Appendix A

FINDINGS REPORT

From A Critical Review of:

Full Life-Cycle Bioassay Approach to Assess Chronic Exposure of *Pseudodiaptomus forbesi* to Ammonia/Ammonium - Final Report

Dated August 31, 2011

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Submittal Date:
December 26, 2011

1. INTRODUCTION

On behalf of the Central Contra Costa Sanitary District (CCCSD), Larry Walker Associates has contracted Pacific EcoRisk, Inc. (PER) to perform a critical review of the "Final Report: *Full Life-Cycle Bioassay Approach to Assess Chronic Exposure of Pseudodiaptomus forbesi to Ammonia/Ammonium*" authored by Teh S, Flores I, Kawaguchi M, Lesmeister S, and Teh C (dated August 31, 2011).). As requested by CCCSD, the primary focus of this review were the experiments described as Subtasks 3-3 and 3-4-1 in the Teh *et al*. report. Additional comments on study methodology and data analysis were developed and can be provided to interested parties on request as evidence that additional study is needed.

2. COMMENTS ON SUB-TASK 3-3 (CHRONIC [31-DAY] LIFE CYCLE TOXICITY TESTING)

Comment #1. Teh *et al*.'s analysis of the number of nauplii and number of juveniles produced during the chronic (31-day) exposure is believed to be flawed at a very fundamental level. It is apparent in Teh et al.'s derivation of 'mean number of nauplii, juveniles, and adult *P. forbesi* produced per female' (in Teh *et al*.'s Table 11) and in the 'sum total number of nauplii, juvenile, and adult *P. forbesi* produced' (in Teh *et al*.'s Appendix III table) that they summed the counts of nauplii and juveniles that were counted on the progressive 2-3 day intervals (the raw data for these counts were provided in Teh *et al*.'s Appendix I) as if each new progressive count was of new individuals that had not been counted on the previous count day. So when 17 nauplii were counted in Control replicate A on Day 5 of the test, and 20 nauplii were counted on Day 7, and 17 were counted on Day 10, and so on, Teh *et al*. summed these up as if they were different nauplii that had been produced during the progressive 'count days'.

This would be correct had the nauplii and juveniles that were counted on each 'count day' been removed from the original replicate container and transferred to a new replicate container such that any nauplii or juveniles observed and counted in the original replicate containers on subsequent days would have been new organisms separate and distinct from the organisms that had been counted during the previous count day(s). Note that this approach would have created a logistical challenge, with a doubling of the number of experimental replicate beakers on Day 3 of the test (going from the original n=20 to n=40), a tripling of the beakers on Day 5 (n=60), a quadrupling of beakers on Day 7 (n=80), and so on and so on. This would then be compounded as nauplii that had transformed into juveniles would again need to be transferred to new replicates so as to allow observation of new juveniles produced by the remaining nauplii. The number of necessary beakers rapidly becomes logistically improbable.

However, it is not believed that this is what happened. Unfortunately, their report's inadequate description of test methodology is not explicit on this. However, it can be deduced from the nature of the study that the neonates were left in place in each replicate, as these were the source of the subsequent juveniles, which were similarly left in place to serve as the source for the

subsequent adults. This was confirmed by inquiry made with one of the other authors of the report (M Kawaguchi, pers. comm.). As a result, when 20 nauplii were counted in Control replicate A on Day 7, some (if not most) of these organism were the very same organisms that had been counted on the earlier Day 5 count, and the nauplii that were counted on Day 10 were some of the same as had been counted on Days 7 and Day 5.

This conclusion is also supported by the following observations made for closely-related congener *Pseudodiaptomus annandalei* (Golez et al. 2004):

1. hatching of the first brood of nauplii occurs within 24-hrs of spawning;
2. females produced new ovisacs at ~ 1 day intervals, again with hatching occurring within that 24-hrs;
3. "females that were isolated from males produced only two clutches of viable eggs". Additional ovisacs were produced (making it appear that the female is reproductive), but the "succeeding clutches of eggs were aborted or shed off within 48 hrs and never hatched out".

Of course, the reproductive biology of *P. forbesi* may differ from that of the congener *P. annandalei*; however, in the absence of contradictory empirical evidence, Occam's razor would dictate otherwise.

We are left to conclude that **Teh *et al*.'s reported results for 'total number' and 'mean number per female' for the nauplii and juveniles are incorrect, and that their analyses of that data are similarly incorrect**.

Interestingly, in Teh *et al*.'s analyses of the 'total number' and 'mean number per female' of adults produced during the study, the number of adults counted on each progressive 'count day' were **NOT** summed in similar fashion, with Teh *et al*. instead evaluating on the count data from a single 'count day' (Day 31).

Comment #2. While it is believed that Teh *et al*.'s count data are incorrect, let us assume for a moment that they are in fact correct. The organism counts using Teh *et al*.'s summation method are summarized in Table 1 below. When their juvenile count data are analyzed using CETIS (a statistical software specifically designed to analyze aquatic toxicity data), the NOEC and LOEC are shown to be 0.79 mg/L TAN and 1.62 mg/L TAN (Table 2 below), NOT the lower concentrations reported by Teh *et al*.

It should noted that CETIS is the statistical software most commonly used by toxicity testing labs to analyze toxicity test data, and is believed to be the statistical software used at the UC Davis Aquatic Toxicology Lab; indeed, Teh *et al*. used CETIS to analyze their Subtask 3-4-1 and Subtask 3-4-2 experimental data as evidenced in Appendices IV and V of their report.

It should also be noted that our assessment of problems with Teh *et al*.'s statistical analyses should not be interpreted as indicating that there was no effect resulting from the ammonia, but

simply that the experimental data do not support any differences that were observed as being statistically significant.

Table 1. Production on *Pseudodiaptomus forbesi* nauplii, juveniles, and adults (from Appendix I in Teh *et al*. report)

Test Treatment (mg/L TAN)	Test Replicate	Total # of *Pseudodiaptomus forbesi* Life Stage Counted			
		Nauplii[A]	Juveniles[A]	Adults[A] (counts made only on Day 31)	Adults[B] (counts made as for nauplii & juveniles)
Control	A	86	38	11	93
	B	100	73	26	178
	C	68	45	7	122
	D	75	52	3	52
0.36	A	60	27	0	1
	B	62	57	3	36
	C	83	79	18	167
	D	71	43	7	77
0.79	A	24	48	10	77
	B	64	31	4	45
	C	41	17	1	17
	D	52	22	8	77
1.62	A	47	1	0	0
	B	32	0	0	0
	C	46	14	5	28
	D	54	23	19	108
3.23	A	15	1	1	4
	B	39	1	1	6
	C	42	18	13	83
	D	30	13	5	34

A - For the nauplii and juveniles, Teh et al. summed the progressive counts on successive days as separate individuals; as explained in our review, this is believed to be erroneous, and is inconsistent with the counts of the "produced" adults which consist of the number of adults that were alive on Day 31 of the test.

B - Counts of "produced" adults using the summation of the progressive counts on successive days as separate individuals (as used by Teh et al. for the nauplii and juveniles); as explained in our review, this is believed to be erroneous.

Table 2. Comparative analyses of juvenile and adult production in the 31-day test (from CETIS analysis of juvenile data using Teh et al. summation method)

Statistical Endpoint	Juveniles		Adults	
	Teh et al. Analyses	CETIS Analyses	Teh et al. Analyses	CETIS Analyses
NOEC =	0.36 mg/L TAN	0.79 mg/L TAN	**<0.36 mg/L TAN**	**3.23 mg/L TAN**
LOEC =	0.79 mg/L TAN	1.62 mg/L TAN	**0.36 mg/L TAN**	**>3.23 mg/L TAN**
Chronic Value =	1.13 mg/L TAN	1.13 mg/L TAN	<0.36 mg/L TAN	>3.23 mg/L TAN

Chronic Value = geometric mean of NOEC and LOEC.

Comment #3. Teh *et al*.'s apparently erroneous statistical analysis of the adult data is even more significant (Table 2). Teh *et al*. reported that the NOEC and LOEC for adults were <0.36 mg/L TAN and 0.36 mg/L TAN, respectively. However, their inter-replicate variability for that endpoint is so high (CVs ranged from 70% to 150%) that even qualitative evaluation suggests otherwise. CETIS analysis indicates that the NOEC and LOEC are 3.23 mg/L TAN and >3.23 mg/L TAN.

Again, it should be noted that our assessment of problems with Teh *et al*.'s statistical analyses should not be interpreted as indicating that there was no effect resulting from the ammonia, but simply that the experimental data do not support any differences that were observed as being statistically significant. Certainly, the NOECs and LOECs resulting from this experiment should not be considered suitable for use in a regulatory framework.

3. COMMENTS ON SUBTASK 3-4-1 (EFFECTS OF AMMONIA ON NAUPLII PRODUCTION OVER 3 DAYS)

Comment #4. In this test, Teh *et al*. exposed individual gravid female copepods to TAN concentrations of 0 (control treatment), 0.38, and 0.79 mg/L for 3 days after which the number of nauplii produced were counted. The results of this test have been summarized in the Table 3 below.

From data reported in Teh et al.'s Table 12 and Appendix V:

Table 3. Effects of ammonia on *P. forbesi* production of nauplii over 3 days (Teh *et al*. Subtask 3-4-1).

TAN Concentration (mg/L)	Mean # of Nauplii per Female
Control	7.6
0.38	5.5
0.79	5.4

The results from this test are somewhat troubling in that, while technically monotonically increasing as the ammonia concentration increases, no apparent concentration-response relationship is observed between the 0.38 mg/L treatment and the 0.79 mg/L treatment. One would expect that as the TAN concentration increases from 0.38 mg/L (a presumably toxic concentration) to 0.79 mg/L (a two-fold greater concentration), there should be an increase in the toxic response – this is a fundamental paradigm of toxicology.
We have already seen in the data evaluations presented above that there is variability in toxic responses made by these organisms. Indeed, in some cases, the variability has been so extreme as to preclude a meaningful statistical analysis (as in the case of the adult data from the 31-day test). The absence of the expected concentration-response in the current test (Table 3) suggests that variability in organism response is occurring (the CV was 48% in the 0.38 mg/L treatment) such that the treatment means may be deviating from the true population mean (in statistical terms, this is referred to as a "false positive" or a "false negative").

In the present case, it is impossible to determine which of the two test responses is deviating most from the true population mean response. However, it is worth noting that:

1. there were two replicates at the 0.38 mg/L treatment that had 10 nauplii (the highest number observed in ANY replicate) whereas there was only one replicate at the control treatment that had 10 nauplii, and
2. the CV at the 0.38 mg/L treatment was 48%, which was markedly higher than at the Control or 0.78 mg/L treatment.

This is suggestive that the variability at the 0.38 mg/L treatment was elevated and may have resulted in a false positive, such that the observed mean response of 5.5 nauplii per female was lower than the true population mean. If correct, then the conclusion(s) drawn from the test data may not reflect true conditions, and the true LOEC could be 0.79 mg/L, and not 0.38 mg/L. At a

minimum, the absence of the expected concentration-response should cast enough uncertainty on the test results as to make them inappropriate for regulatory decision-making.

Comment #5. It is fortunate that multiple sets of test data from the study allow comparison of results between tests; for instance, the results of Subtask 3-4-1 can be compared to those generated in the earlier Subtask 3-3 (31-day) test in which gravid females were exposed to varying concentrations of TAN and counts of nauplii produced after 3 days were counted, but were also counted after 5 days and 7 days (recall that counts made on progressive count days are not believed to be all new organisms). The Subtask 3-3 data are summarized in Table 4 below, along with the data from Task 3-4-1.

If one were to "cherry-pick" the Day 3 data and exclude the additional data, then Teh *et al.*'s conclusion for the Subtask 3-4-1 might stand. However, by extending the observation period beyond 3 days, it becomes evident that not only is there no reduction in nauplii production at 0.36 mg/L TAN, but nauplii production actually appears to be *increased* relative to the control treatment (the maximum mean # of nauplii on Day 5 at the 0.36 mg/L TAN treatment is **31% greater** than the highest mean # of nauplii produced in the Control treatment on any of the count days). Furthermore, CETIS analysis indicates that there were no statistically significant reductions in nauplii production at the 0.36 mg/L (Table 5). Even if we use the count summation used by Teh et al., by extending the counts beyond 3 days, it becomes apparent that there is no statistically significant difference between the response at 0.36 mg/L TAN and the Control treatment. This certainly creates a very significant uncertainty over the results of the Subtask 3-4-1 test of the effects of ammonia on nauplii production over 3 days.

It could be argued that this phenomenon is the result of ammonia having caused a delay in egg hatching, and the 31-day data are certainly suggestive of that. However, the only way to address that would have been to have some information from the scientific literature on the egg gestation period for this species, coupled with testing being performed under the current test conditions using females with egg sacs of the same age.

Table 4. Effects of ammonia on *P. forbesi* nauplii produced over 3 and 5 days.

Teh *et al.* Study Task	TAN Treatment (mg/L)	Mean Number of Nauplii per Female		
		Day 3	Day 5	Sum through Day 5 (Day 3 + Day 5)[A]
Subtask 3-4-1	Control	**7.6**	not counted	not counted
	0.38	**5.5**	not counted	not counted
	0.79	**5.4**	not counted	not counted
Subtask 3-3	Control-A	5.67	6.67	12.33
	Control-B	6.67	6.67	13.33
	Control-C	5	5	10
	Control-D	5	5	10
	treatment mean	**5.6**	**5.8**	**11.4**
	0.36-A	3	5	8
	0.36-B	2.33	8.33	10.67
	0.36-C	3.33	8.33	11.67
	0.36-D	3.33	3.33	6.67
	treatment mean	**3.0**	**6.3**	**9.3**
	0.79-A	0.33	1.67	2
	0.79-B	6.67	3.33	10
	0.79-C	2.67	2.67	5.33
	0.79-D	6.67	4	10.67
	treatment mean	**4.1**	**2.9**	**7.0**

A – These counts are made using method of Teh *et al.*, which assumes that the progressive counts on successive days are separate individuals; as explained in our review, this is believed to be erroneous.

Table 5. Comparison of nauplii production test results (all results expressed as mg/L TAN) (from CETIS analysis of data)

Statistical Endpoint	**Subtask 3-4-1**	**Subtask 3-3**				
	Day 3	Day 3	Day 5	Day 3 + Day 5[A]	Total (31 days)[A]	Total (31 days)[B]
NOEC =	<0.38	3.23	0.36	0.36	0.36	0.79
LOEC =	0.38	>3.23	0.79	0.79	0.79	1.62
Chronic Value =	<0.38	>3.23	0.53	0.53	0.53	1.13

Chronic Value = geometric mean of NOEC and LOEC.

A – These counts are made using method of Teh *et al.*, which assumes that the progressive counts on successive days are separate individuals; as explained in PER's review, this is believed to be erroneous.

B – These counts are made using what is believed to be the best remaining method: identifying the maximum number of nauplii observed on any given day for each replicate (this assumes that the individuals were left in the replicate beakers and were counted again and again on progressive days [i.e. repeated measures]).

4. FINAL COMMENT

The reviewer is troubled by the absence of any discussion by Teh et al. regarding the variability in their test response data, either between tests or within tests (i.e., inter-replicate variability). Without such acknowledgement, it is left for the non-scientist to assume that the data as presented are definitive. Moreover, it raises the question of whether the data from this study are adequate (or 'ready') for use in regulatory decision-making. However, it is important to note that this critical review is not intended to negate Teh *et al*.'s general observations that ammonia is toxic to naupliar, juvenile, and/or adult *P. forbesi* at elevated concentrations and that this toxicity is strongly influenced by pH. Indeed, the primary question of 'what are the effects of ammonia on *P. forbesi*' is relevant and Teh *et al*.'s study results certainly compel a more thorough examination of this. However, the problems associated with Teh et al.'s experimental methodology for Subtasks 3-3 and 3-4-1 and significant questions regarding the analysis of the resulting data do indicate that the quality of the work should preclude the resulting 'critical threshold' data (i.e., NOECs, LOECs, and point estimates [e.g., ECx, LCx, and ICx values]) from being used for regulatory purposes.

References Cited:

Golez MSN, Takahashi T, Ishimaru T, Ohnoa A (2004) Post-embryonic development and reproduction of *Diaptomus annandalei* (Copepoda: Calanoida). Plankton Biology & Ecology 51(1):15-25.

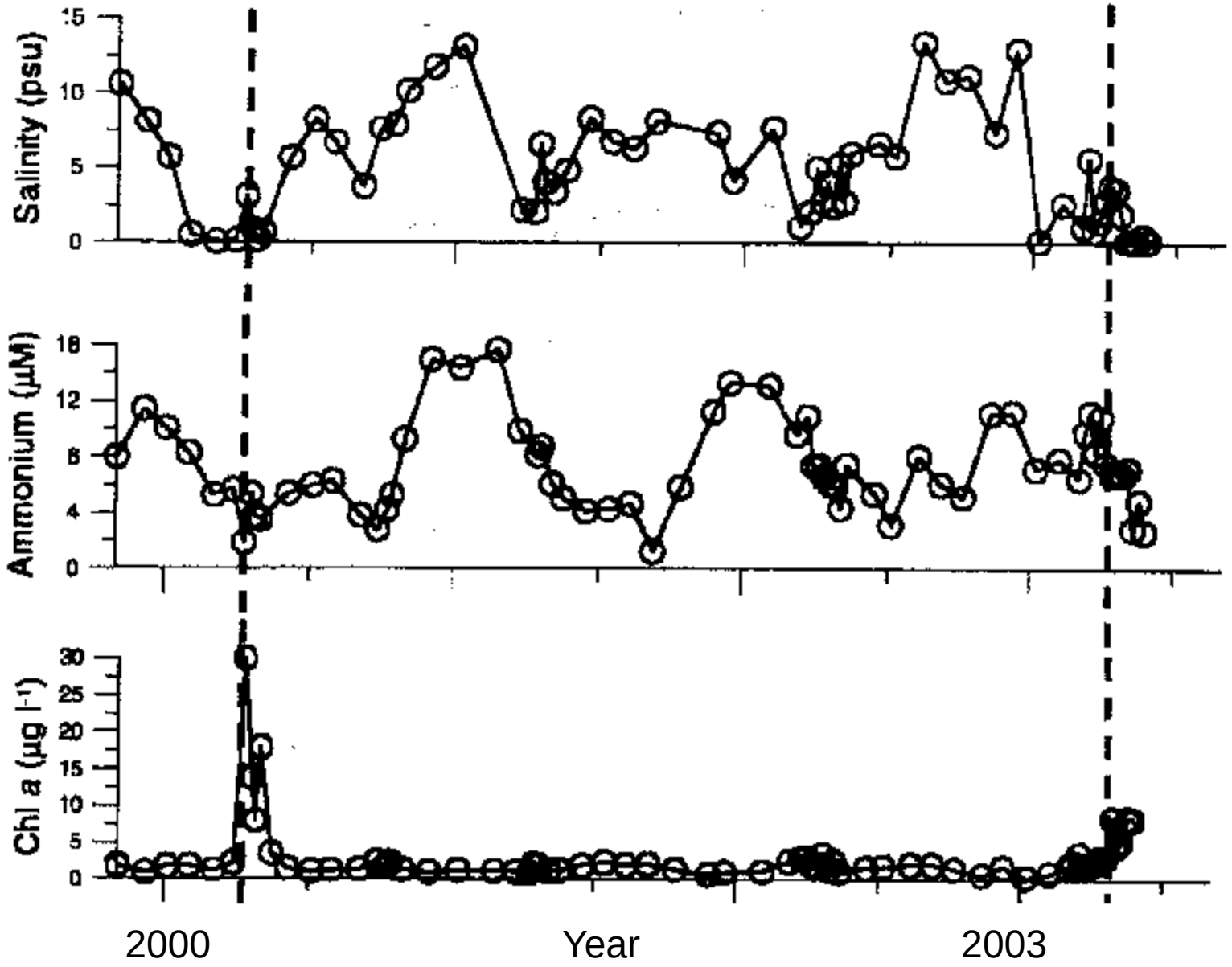
Appendix B

Phytoplankton (Chlorophyll a) versus Ammonium Concentrations

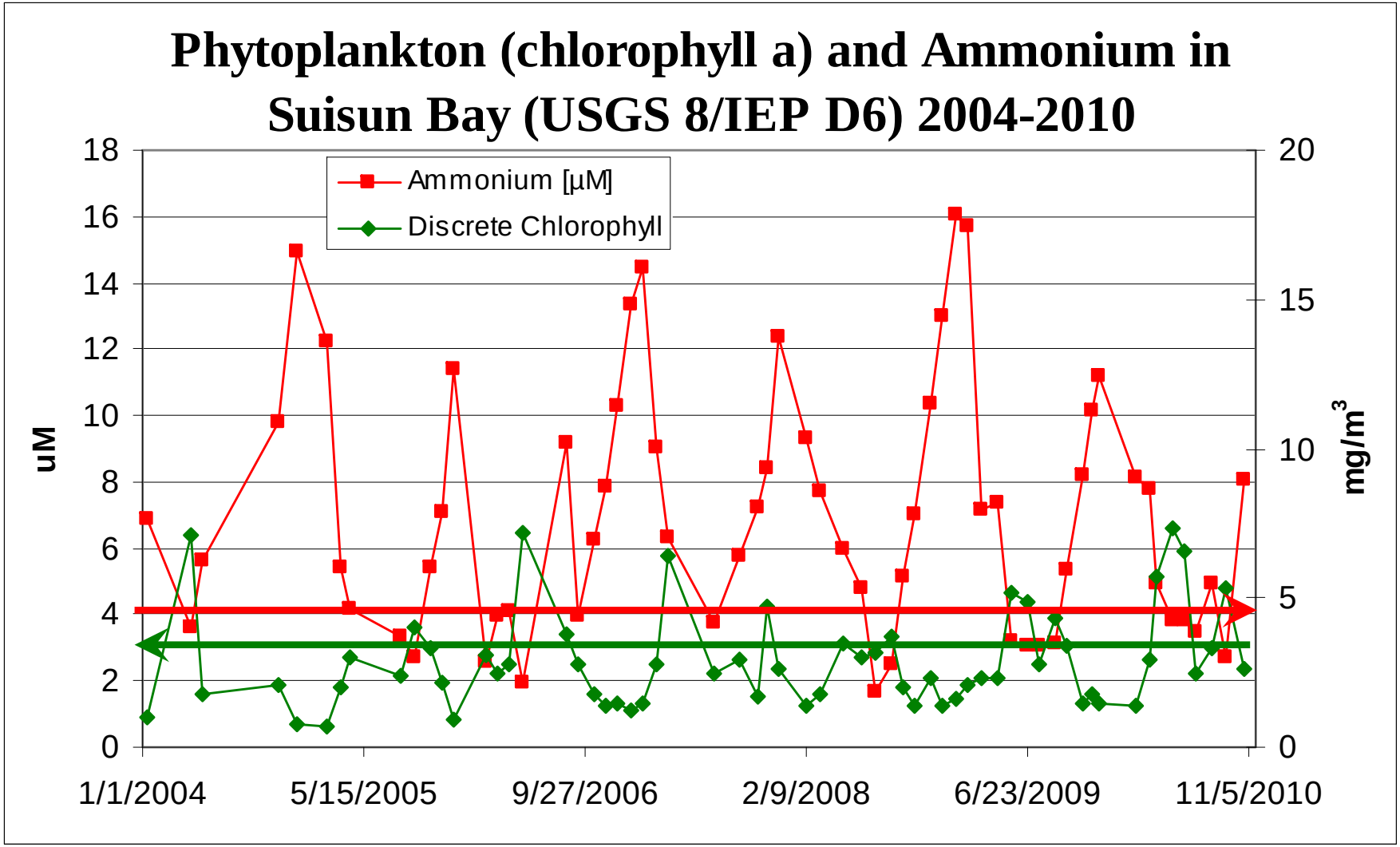
in Suisun Bay [1977-2010]

Dr. Dugdale et al., hypothesis that ammonia-N has to drop below 4 µ moles for phytoplankton bloom to occur is not fully supported by ambient data.

(1) In four years of monthly monitoring in Suisun Bay (November 1999–August 2003) by Dr. Dugdale et al., ammonia-N dropped below 4 µ moles 5 times, yet bloom occurred only one time.

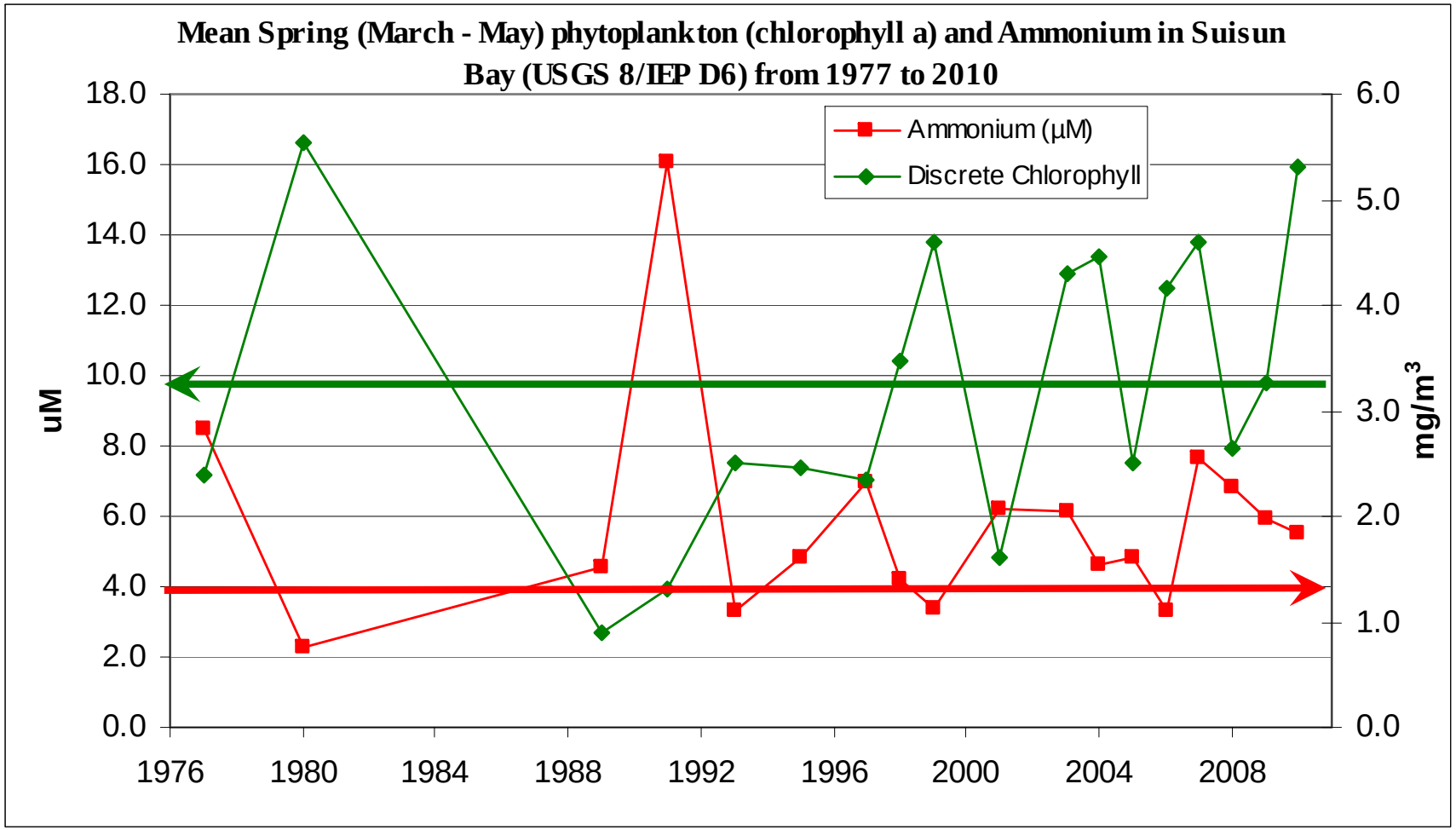

Salinity (psu)
15
10
5
0
Ammonium (µM)
16
12
8
4
0
Chl a (µg l-1)
30
25
20
15
10
5
0
2000
Year
2003

(2) From 2004 to 2010 ammonia dropped below 4 µ moles 20 times, yet there were only 5 blooms.


Phytoplankton (chlorophyll a) and Ammonium in Suisun Bay (USGS 8/IEP D6) 2004-2010
Ammonium [µM]
Discrete Chlorophyll
uM
mg/m3
18
16
14
12
10
8
6
4
2
0
20
15
10
5
0
1/1/2004
5/15/2005
9/27/2006
2/9/2008
6/23/2009
11/5/2010

(3) From 1977 to 2010, the spring mean chlorophyll reached above average only 3 out of 9 times (33%) when ammonia was below 4 µ moles.

This suggests that there are other factors more important than ammonia for increased chlorophyll production.


Mean Spring (March - May) phytoplankton (chlorophyll a) and Ammonium in Suisun Bay (USGS 8/IEP D6) from 1977 to 2010
Ammonium (µM)
Discrete Chlorophyll
uM
mg/m3
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1976
1980
1984
1988
1992
1996
2000
2004
2008