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October 31, 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:

Re: Comments on Tentative Order No. R2-2011-XXXX (NPDES No. CA0037648) for the Central Contra Costa Sanitary District Wastewater Treatment Plant

The San Luis & Delta-Mendota Water Authority ("Authority")[1] and the State Water Contractors, Inc. ("SWC")[2] (collectively, "Public Water Agencies") respectfully submit the attached

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[1] The Authority is a joint powers authority, established under California's Joint Exercise of Powers Act. (Gov. Code, § 6500 et seq.). The Authority is comprised of 29 member agencies, 27 of which hold contractual rights to water from the federal Central Valley Project (CVP). The Authority member agencies have historically received up to 3,100,000 acre-feet annually of CVP water for the irrigation of highly productive farm land primarily along the San Joaquin Valley's Westside, for municipal and industrial uses, including within California' Silicon Valley, and for publicly and privately managed wetlands situated in the Pacific Flyway. The areas served by the Authority's member agencies span portions of seven counties encompassing about 3,300 square miles, an area roughly the size of Rhode Island and Delaware combined. The Authority's members are: Banta-Carbona Irrigation District; Broadview Water District; Byron Bethany Irrigation District (CVPSA); Central California Irrigation District; City of Tracy; Columbia Canal Company (a Friend); Del Puerto Water District; Eagle Field Water District; Firebaugh Canal Water District; Fresno Slough Water District; Grassland Water District; Henry Miller Reclamation District #2131; James Irrigation District; Laguna Water District; Mercy Springs Water District; Oro Loma Water District; Pacheco Water District; Pajaro Valley Water Management Agency; Panoche Water District; Patterson Irrigation District; Pleasant Valley Water District; Reclamation District 1606; San Benito County Water District; San Luis Water District; Santa Clara Valley Water District; Tranquillity Irrigation District; Turner Island Water District; West Side Irrigation District; West Stanislaus Irrigation District; Westlands Water District.

[2] The SWC organization is a nonprofit mutual benefit corporation that represents and protects the common interests of its 27 member public agencies in the vital water supplies provided by California's State Water Project ("SWP"). Each of the member agencies of the State Contractors holds a contract with the California Department of Water Resources ("DWR") to receive water supplies from the SWP. Collectively, the SWC members deliver water to more than 25 million residents throughout the state and more than 750,000 acres of agricultural lands. SWP water is served from the San Francisco Bay Area, to the San Joaquin Valley and the Central Coast, to Southern California. The SWC's members are: Alameda County Flood Control and Water Conservation District Zone 7; Alameda County Water District; Antelope Valley-East Kern Water Agency; Casitas Municipal Water District; Castaic Lake

comments on the National Pollutant Discharge Elimination System Tentative Permit for the Central Contra Costa Sanitary District's ("CCCSD") Wastewater Treatment Plant. The Public Water Agencies thank the San Francisco Regional Water Quality Control Board ("Regional Board") for the opportunity to present this input and our views on the Tentative Permit.

The Public Water Agencies also respectfully request designated party status for themselves and their members at the hearing regarding the Tentative Permit. For the reasons we outline in our attached comments, the Public Water Agencies are harmed by CCCSD's discharges of treated sewage into Suisun Bay, including by the impacts caused by the discharges on the ecology, aquatic life and habitat in the Bay-Delta. These impacts have contributed to severe water restrictions that have resulted in human hardship, irretrievable resource losses, and economic and environmental harms to the Public Water Agencies, our members and the communities that they serve. Accordingly, the Public Water Agencies meet the statutory requirements for designated party status and ask the Regional Board to grant our request. The Public Water Agencies have a direct interest in the Tentative Permit.

Thank you for this opportunity to participate in the CCCSD discharge proceeding. We request that further notices and correspondence concerning this proceeding be directed to the individuals identified on the attached Public Water Agencies contact list.

Sincerely,

Daniel Nelson
Executive Director
San Luis & Delta-Mendota Water Authority

Terry Erlewine
General Manager
State Water Contractors

Enclosures

Water Agency; Central Coastal Water Authority; City of Yuba City; Coachella Valley Water District; County of Kings; Crestline-Lake Arrowhead Water Agency; Desert Water Agency; Dudley Ridge Water District; Empire-West Side Irrigation District; Kern County Water Agency; Littlerock Creek Irrigation District; Metropolitan Water District of Southern California; Mojave Water Agency; Napa County Flood Control and Water Conservation District; Oak Flat Water District; Palmdale Water District; San Bernardino Valley Municipal Water District; San Gabriel Valley Municipal Water District; San Gorgonio Pass Water Agency; San Luis Obispo County Flood Control & Water Conservation District; Santa Clara Valley Water District; Solano County Water Agency; Tulare Lake Basin Water Storage District.

Public Water Agencies' Comments on the Tentative NPDES Permit Renewal for the Central Contra Costa Sanitary District Wastewater Treatment Plant
October 31, 2011

The State Water Contractors, Inc. ("SWC") and the San Luis & Delta-Mendota Water Authority ("SLDMWA" or "Authority") (collectively, "Public Water Agencies") appreciate the opportunity to comment on the tentative renewal of the National Pollutant Discharge Elimination System permit ("Tentative Permit") for the Central Contra Costa Sanitary District's ("CCCSD") Wastewater Treatment Plant ("Treatment Plant").

The CCCSD Treatment Plant collects and discharges, on average, 40 million gallons per day of treated sewage into Suisun Bay, a tidal estuary within the defined critical habitat for threatened and endangered aquatic species. Included in the daily discharge are thousands of pounds of "nutrients," in the form of ammonium (or "ammonia as nitrogen") that CCCSD does not remove or otherwise treat at its Treatment Plant.

Suisun Bay lies at the confluence of the Sacramento and San Joaquin Rivers, forming the western tip of the Sacramento-San Joaquin River Delta. To its west, Suisun Bay drains to the Carquinez Strait, which connects to San Pablo Bay, a northern extension of San Francisco Bay. The greater San Francisco Bay/Sacramento-San Joaquin River Delta estuary system is referred to as the Bay-Delta estuary, the largest estuary on the United States' pacific coast.

The Public Water Agencies have a significant interest in how the Regional Board regulates CCCSD's discharge because the members of the Public Water Agencies receive water through the California State Water Project ("SWP") and the federal Central Valley Project ("CVP"). These projects collect and store water in large reservoirs in northern California for use throughout the State. After water is released from reservoirs, the water flows to the Delta. From there, water is pumped for use by more than 2 million acres of prime farmland and some 25 million Californians living in two-thirds of the state's households.

It is well documented that water quality and aquatic resources within the Bay-Delta estuary are under stress. The estuary and many of its tributaries are listed as impaired, and the populations of both pelagic and anadromous fish have suffered serious decline in recent years. To date, regulators have largely responded to the decline by regulating the SWP and CVP and restricting the water available to the members of the Public Water Agencies. These restrictions have had a direct and severe adverse impact on the ability of the members of the Water Agencies to serve the people who depend on SWP and CVP water.

Unfortunately, while the focus on water users has resulted in great hardship, it has not led to real improvements in the delta smelt, salmon or other aquatic life of the Bay-Delta. To the Public Water Agencies, this has not been a surprise. Federal and state agencies have long recognized that nutrient loadings seriously impacts water quality and aquatic life.[3] Although it has long

[3] According to U.S. EPA: "Nutrient pollution, especially from nitrogen and phosphorus, has consistently ranked as one of the top causes of degradation in some U.S. waters for more than a decade. Excess nitrogen and phosphorus lead to significant water quality problems including harmful algal blooms, hypoxia and declines in wildlife and

been thought that the Bay Delta Estuary was not vulnerable to nutrient impacts, that is no longer the case.

Indeed, writings by Regional Board staff have acknowledged the scientific evidence that establish the nexus between nutrient discharges and impacts on aquatic life. On June 4, 2010, the Regional Board submitted a letter to the Central Valley Regional Water Quality Control Board citing published studies that document the impacts of ammonium in Suisun Bay and urging the Central Valley Regional Board to take all necessary actions to ensure beneficial uses in Suisun Bay are fully protected.[4] Further, a work plan co-authored by a Regional Board Senior Scientist, Karen Taberski, states that "there is evidence that primary productivity is inhibited in Suisun Bay, and that NH_4 [ammonium] may be causing that inhibition." *See* Taberski, Dugdale, et al., SWAMP Monitoring Plan 2011-2012, *San Francisco Bay Region Work Plan, Monitoring Spring Phytoplankton Bloom Progression in Suisun Bay* at 1 (Dec. 2010) ("Work Plan").[5] The Work Plan recognizes that a "potentially important source of NH_4 to Suisun Bay is the Central Contra Costa Wastewater Treatment Plant" and that "nutrient concentrations, including NH_4, are higher in Suisun Bay compared to other" nearby bay systems. *Id.* at 2.

The Public Water Agencies fully support the Work Plan, which will directly assess CCCSD's relative contribution to the inhibition in primary productivity, as compared to the "dominant source of ammonium" in the Bay-Delta, the Sacramento Regional Wastewater Treatment Plant ("SRWTP"). Work Plan at 2. According to the Work Plan, the SRWTP's discharges 90 percent of the ammonium in the Bay-Delta. *Id.* Indeed, SRWTP's massive discharge is certainly the predominant source of ammonium that impairs beneficial uses in receiving waters from the Sacramento River at Freeport all the way through Suisun Bay, as the Central Valley Regional Board has found and as we have outlined in filings before the Central Valley and State Boards. Relative to the Sacramento Regional WWTP, CCCSD's discharge contributes a smaller share of the total ammonium loadings and appears, at least at this point, to primarily impact western Suisun Bay.

However, despite the clear differences between the two discharges, the CCCSD discharge of thousands of pounds per day of ammonium is significant. Hence, as detailed here and in the materials here provided for the Regional Board's review, the Public Water Agencies submit that there is already overwhelming scientific literature and research, grounded in sound science, to demonstrate that the ongoing discharge of nutrients from both Sacramento Regional *and* CCCSD are major stressors that are contributing to the decline of the food web that supports aquatic life throughout the Bay-Delta. The record is more than clear that CCCSD's ammonium discharge has the potential to exceed water quality standards and to impair designated beneficial uses of receiving waters.

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wildlife habitat. Excesses have also been linked to higher amounts of chemicals that make people sick." http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/

[4] San Francisco Bay Regional Water Quality Control Board letter from Bruce H. Wolfe, Executive Officer, to Kathy Harder, Central Valley Regional Water Quality Control Board re Comments on "Issue Paper – Aquatic Life and Wildlife Preservation Related Issues – Proposed NPDES Permit Renewal for Sacramento Regional County Sanitation District Sacramento Regional Wastewater Treatment Plant". June 4, 2010.

[5] http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/workplans/1112rb2wp.pdf

As such, the Public Water Agencies urge the Regional Board as follows:

1. The Regional Board should revise the Tentative Permit to expeditiously provide for nitrification of the discharge to remove ammonium. Further interim limits should be set that restrict the discharge while treatment is designed and built. In addition, as part of the ongoing studies, the Regional Board and CCCSD should evaluate whether denitrification should also be required.

2. In the alternative, if the Regional Board is convinced that further study is needed before requiring nutrient removal, the Water Agencies urge the Regional Board to expedite (consistent with good scientific practice) the completion of the ongoing studies, but defer issuing this Permit until that work is completed and published, so the Regional Board may consider those data and analyses.

3. Lastly, if the Regional Board determines it must proceed with a permit now, the Water Agencies urge the Regional Board to include a detailed framework in the final permit that includes (a) a schedule for promptly completing the studies, with assured funding by CCCSD, (b) a clear procedure for reconsideration of the ammonium issue, with full public participation in the process, and (c) interim limits consistent with the actual maximum concentrations of ammonium in CCCSD discharges.

I. The Tentative Permit Does Not Address the Significant Uncontrolled Discharge of Ammonia-Nitrogen From the CCCSD Wastewater Treatment Plant

The Public Water Agencies' concern with the Regional Board's Tentative Permit is grounded in one irrefutable fact well known to the Regional Board: on average the CCCSD discharges approximately 7,000 pounds of untreated ammonium in its wastewater every day. *See* Taberski, et al., *supra.*[6] This daily loading into the Bay-Delta estuary system is pouring more than *2,500,000 pounds* of untreated nutrients directly into Suisun Bay every year.[7]

Moreover, if the scope of the discharge were not enough, CCCSD discharges directly into the critical habitat of endangered and threatened species. As the Regional Board is surely aware, the Bay-Delta estuary provides critical habitat for at least five species listed under the federal Endangered Species Act, including the delta smelt[8] and spring-run Chinook salmon (threatened), the winter-run Chinook salmon (endangered), and the fall- and late fall-run Chinook salmon (species of concern).[9] Given the expansive view of federal and state agencies of the need to

[6] The actual discharge may be considerably higher, as the permitted flow rate is 53.8 million gallons per day and the 99th percentile daily effluent flow rate is 70.3 million gallons per day. Tentative Order, Attachment F at F-19.

[7] 3.5 tons x 2000 lbs. x 365 day = 2,555,000 lbs./year.

[8] The U.S. Fish and Wildlife Service listed the delta smelt as a threatened species in 1993 and designated critical habitat for the smelt in 1994. 58 Fed. Reg. 12854 (March 5, 1993); 59 Fed. Reg. 65256 (Dec. 19, 1994). A threatened species is "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." 16 U.S.C. § 1532(20). Endangered species are those which are "in danger of extinction throughout all or a significant portion of its range." 16 U.S.C. § 1532(6).

protect listed species, one would expect efforts would be made to address the ammonium in CCCSD's discharge.

Yet, the Regional Board has proposed a permit that does not limit the ammonium in the CCCSD's discharge. In contrast, many other municipal wastewater treatment plants in central California that discharge into waters that feed into the Bay-Delta estuary have stepped up and made the investments (or been required to make the investments) needed to install treatment technology that would remove ammonium. Thus, if required to bring its treatment up to date, CCCSD would not be singled out to invest in new or unproven technology. These plants are listed in Table 1.[10]

Indeed, not only is CCCSD not required to treat and remove ammonium, the Tentative Permit allows CCCSD to discharge *more* ammonium than available data indicate it has been discharging. Thus, while the Tentative Permit now places effluent limits on ammonium, the proposed limits would allow CCCSD to discharge up to 10,000 pounds per day or more. Indeed, the monthly average effluent limitation is more than *twice* the maximum effluent concentration ("MEC") that has been observed – and the daily limit is almost three times higher than the MEC. *Compare* Tentative Order, Attachment F at F-17 (MEC of 30.2 mg/L) *with* Tentative Order at 9 (effluent limitations on Total Ammonia as N – average monthly limit 65 mg/L, maximum daily 84 mg/L).

II. CCCSD's Significant Uncontrolled Discharge of Ammonium May Adversely Affect Beneficial Uses of Waters of this State and the United States

In the Tentative Permit, the Regional Board staff has not discussed the substantial available evidence linking nutrient discharges to serious impacts on aquatic life. The Public Water Agencies submit that the full body of research and scientific literature already available demonstrates that full ammonium removal should be applied to CCCSD. At a minimum, the Public Water Agencies strongly urge the Regional Board to consider carefully that evidence before deciding whether to allow the continued untreated discharge of tons of "nutrients" into Suisun Bay every day.

In fact, the overwhelming data and scientific literature demonstrate the millions of pounds of nutrients discharged by CCCSD directly to a critical habitat for threatened and endangered species is likely causing toxic effects on aquatic species and contributing to the altering of the aquatic food web—the foundation of the entire Bay Delta ecosystem. These impacts to the beneficial uses of waters of this State and the United States require a far more vigorous response by the Board than in the Tentative Permit.

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[9] *See* U.S. Fish & Wildlife Service Sacramento Fish & Wildlife Office Species Account, available at www.fws.gov/sacramento/es/animal_spp_acct/delta_smelt.pdf; Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead, available at www.nwr.noaa.gov/Publications/Biological-Status-Reviews/loader.cfm?csModule=security/getfile&pageid=21346

[10] *See also* West Yost Associates, Wastewater Control Measures Study (March 2011), available at http://www.swrcb.ca.gov/rwqcb5/water_issues/drinking_water_policy/dwp_wastewtr_cntrl_meas_stdy.pdf. This report, prepared for the Central Valley Regional Board, lists 26 treatment plants that are currently achieving nutrient removal and nine additional plants that are required by current NPDES permits to achieve this standard of treatment.

That untreated nutrients cause serious impacts on aquatic life is not a novel proposition, as detailed here and in the enclosed Technical Memorandum collecting and summarizing the recent nutrient research. *See* Water Agencies' Technical Memorandum (November 1, 2011) (Attachment 1). Indeed, among other work, the Memorandum highlights the most recent work done by Dr. Patricia Glibert, et al.[11] Dr. Glibert's latest paper analyzes comparable eco-systems and demonstrates that the fact that nutrient loadings materially impact the food web is well established by stoichiometric analysis of data from systems across the United States and around the world. Thus, while the research in the Work Plan that is now being conducted in Suisun Bay will surely advance the body of knowledge, the existing literature provides ample support for the Regional Board to take action now to restrict the discharge of nutrients.

Indeed, in addition to the literature and research outlined in the Technical Memorandum, the Public Water Agencies and their members have previously provided comments in other proceedings which further detail how ammonium is harming aquatic species in the Bay-Delta estuary and altering the aquatic food web. *See* Water Agencies' Response to Discharger's Petition For Review, In the Matter of the Sacramento Regional County Sanitation District's Petition for Review SWRCB/OCC File Nos. A-2144(a) and A 2144(b) (Consolidated) (May 4 and 6, 2011); San Luis & Delta-Mendota Water Authority and State Water Contractors Comments on EPA Advanced Notice of Proposed Rulemaking Regarding Water Quality Challenges in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, Docket No. EPA-R09-OW-210-0976, 76 Federal Register 9709, February 22, 2011 (April 21, 2011); Westlands Water District's Comments on EPA Advanced Notice of Proposed Rulemaking Regarding the Water Quality Challenges in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary 76 Federal Register 9709 (February 22, 2011) Docket Number: EPA-R09-OW-2010-0976 (April 25, 2011);[12] Proposed NPDES Permit Renewal and TSO, Sacramento Regional County Sanitation District, Water Agencies' Testimony before Central Valley Regional Water Quality Control Board Meeting (December 9, 2010) (Water Agencies' Testimony); Comments of the Water Agencies on the Tentative Waste Discharge Requirements Renewal for the Sacramento Regional County Sanitation District Sacramento Regional Wastewater Treatment Plant (Oct. 8. 2010);[13] Comments of Westlands Water District (Westlands) and the San Luis & Delta-Mendota

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[11] Dr. Glibert is an aquatic ecologist and nutrient bio-geochemist with over 30 years of experience working on issues related to nutrient loading, nutrient ratios, eutrophication, changes in trophic dynamics, harmful algae, and management implications of nutrients loading all over the world. She has a Ph.D. from Harvard University and was awarded an honorary doctorate degree from Linnaeus University, Sweden earlier this year. She has studied and published widely on nutrients and food web dynamics in systems covering phytoplankton nutrient uptake and photosynthesis, nutrient excretion by zooplankton, harmful algal physiology, nutrient preferential use by phytoplankton taxa, eutrophication, and global nutrient modeling. Her field investigations span the globe – including the Chesapeake Bay, Long Island Sound, Florida Bay, Australia, Brazil, the Baltic Sea, East China Sea, Kuwait Bay, Gulf of Oman, and Hong Kong coastal waters, as well as many other sites, including San Francisco Bay Delta. She serves as the co-chair of the U.S. National HAB Committee, chair of the committee on eutrophication for the international GEOHAB Programme, and co-chair of the international SCOR/LOICZ Working Group on HABs and Eutrophication. She has consulted with the governments of Kuwait and Oman on issues related to nutrient pollution, served as an independent advisor to the Chinese Academy of Sciences on their studies of eutrophication, served on numerous panels and advisory boards related to nutrient management for the federal government and the states of Florida and Maryland.

[12] http://www.regulations.gov/#!documentDetail;D=EPA-R09-OW-2010-0976-0037

[13] http://www.swrcb.ca.gov/centralvalley/board_decisions/tentative_orders/1012/sac_regional/srcsd_com_wateragencies.pdf

Water Authority (Authority) on Tentative Waste Discharge Requirements Renewal (NPDES Permit No. CA0077682) for Sacramento Regional County Sanitation District, Sacramento Regional Wastewater Treatment Plant (Oct. 8, 2010);[14] San Luis Delta-Mendota Water Authority and State Water Contractors Comments on Draft Report Titled "Nutrient Concentrations and Biological Effects in the Sacramento-San Joaquin Delta" (June 14, 2010);[15] Water Agencies' Comments on Aquatic Life and Wildlife Preservation Issues Concerning the Sacramento Regional Wastewater Treatment Plant NPDES Permit Renewal (June 1, 2010).[16] The Public Water Agencies hereby incorporate by reference the arguments, analysis, data and scientific literature catalogued in those comments.

Among other things, the research outlines four basic scientific propositions:

1. Excessive ammonium has been shown to be toxic to copepods

Recent studies indicate that ammonium at concentrations present in the Bay-Delta estuary and Suisun Bay is acutely toxic to copepods central to the food web that supports aquatic life in the Bay-Delta estuary, including the endangered delta smelt. *See* Technical Memorandum at 7. Specifically, Dr. Swee Teh (and colleagues) at the University of California at Davis[17] have done a variety of studies of the effects of ammonium on the native *Eurytemora affinis* and *Pseudodiaptomus forbesi.*[18] Dr. Teh found ten percent mortality occurred in invertebrate species exposed to ammonia concentrations present in the Sacramento River using a 96-hour

[14] http://www.swrcb.ca.gov/centralvalley/board_decisions/tentative_orders/1012/sac_regional/srcsd_com_westlands.pdf

[15] San Luis & Delta Mendota Water Authority and State Water Contractors letter to Dr. Chris Foe, Central Valley Regional Water Quality Control Board re Comments on Draft Report Titled "Nutrient Concentrations and Biological Effects in the Sacramento-San Joaquin Delta". June 14, 2010.

[16] Water Agencies letter to Ms. Kathleen Harder, Central Valley Regional Water Quality Control Board re Comments on Aquatic Life and Wildlife Preservation Issues Concerning the Sacramento Regional Wastewater Treatment Plant NPDES Permit Renewal. June 1, 2010.

[17] Dr. Teh is a Ph.D in Comparative Pathology and a Research Toxicologist and Pathologist in the Department of Anatomy, Physiology, and Cell Biology at the University of California - Davis. He serves as the Interim Director of the Aquatic Toxicology Laboratory at the UC-Davis School of Veterinary Medicine, and is a UC-Davis Faculty Member for the Graduate Group in Ecology, the Center for Aquatic Biology and Aquaculture, the Center for Health and the Environment, and the John Muir Institute of Environment. Dr. Teh conducted his work under the auspices of the Central Valley Regional Water Quality Control Board.

[18] The relevant research and related writings include Dr. Teh's presentation at the Ammonia Summit at Central Valley Regional Water Board http://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/ambient_ammonia_concentrations/index.shtml (August 18-19, 2009) ("Teh Presentation") (also provided with these comments as an attachment to the Declaration of Dr. Swee Teh (May 4, 2011) ("Teh Decl."); Werner, et al., Pelagic Organism Decline (POD): Acute and Chronic Invertebrate and Fish Toxicity Testing in the Sacramento-San Joaquin Delta 2008-2010, Final Report Submitted to the California Department of Water Resources (July 24, 2010), (http://www.science.calwater.ca.gov/pdf/workshops/POD/Werner%20et%20al_2010_POD2008-2010_Final%20Report.pdf) (also at Teh Decl. Exhibit 3); Full Life-Cycle Bioassay Approach to Assess Chronic Exposure of P. forbesi to Ammonia/Ammonium to the Delta Pelagic Organism Decline Contaminants Work Team (July 6, 2010) Teh Decl. Exhibit 4; Letter from S. Teh to C. Foe (November 10, 2010) Teh Decl. Exhibit 5; S. Teh, et al., Final Report, Full Life-Cycle Bioassay Approach to Assess Chronic Exposure of *Pseudodiaptomus forbesi* to Ammonia/Ammonium – Submitted to C. Foe and M. Gowdy (March 4, 2011) Teh Decl. Exhibit 6.

toxicity test.[19] Dr. Teh has likewise conducted life cycle tests to assess the impacts of different concentrations of ammonium on the ability of the copepod to reproduce and thrive. Dr. Teh found that total ammonia impacted adult *P. forbesi* reproduction at concentrations greater than or equal to 0.79 mg L^{-1}, while nauplii and juveniles are affected at concentrations as low as 0.36 mg L^{-1}.[20] Dr. Teh repeated the life cycle testing and confirmed his results, which he provided to the Central Valley Regional Board.[21]

The toxic effect of total ammonia is a major stressor on aquatic life that has a pervasive impact across the Bay-Delta estuary. In fact, CCCSD's own data show that ammonium levels in the receiving water in the vicinity of the Treatment Plant discharge are at levels sufficient to be toxic to copepods 15% of the time. *See* Exhibit 1.

2. The excess ammonium is inhibiting nitrogen uptake by diatoms and reducing diatom primary production in the Bay-Delta.

In addition to toxic effects, the ammonium loadings are disrupting the food supply by inhibiting nitrogen uptake by diatoms in the Bay-Delta estuary. The phytoplankton that form the base of the food web are essential to a healthy aquatic ecosystem. Primary consumers, including copepods (such as *P. forbesi*) rely on that primary production by phytoplankton as their main source of food, which, in turn, serve as food source for other aquatic life. In recent research, Dr. Richard Dugdale and others have found that excessive ammonium from treatment plant discharges is inhibiting nitrogen uptake by diatoms and contributing to reduced diatom production in the Bay-Delta.[22] *See* Technical Memorandum at 1 and Work Plan at 1-3. Indeed, as the Work Plan acknowledges, Dr. Dugdale has found that at an ammonium concentration of 4 μmol L^{-1}, nitrate uptake is fully inhibited. Work Plan at 2.[23] This level of ammonium is exceeded a majority of the time in western Suisun Bay near Martinez. *See* Exhibit 2. In fact, the ammonium levels in the receiving water in the vicinity of the Treatment Plant discharge exceed

[19] Werner, et al., *supra;* Teh Presentation, *supra.* Dr. Teh was unfairly criticized that his initial testing did not apply a representative average pH. This criticism was not valid, as Dr. Teh's first test was within the range found in the River 20 percent of the time. Nonetheless, Dr. Teh repeated his analysis and again observed that comparable toxic effects occurred at a pH of 7.8. Teh, S. et al., August 31, 2011 Final Report to C. Foe, *supra.*

[20] Teh, S. Full Life-Cycle Bioassay Approach, *supra* (Teh Decl. Exhibit 4).

[21] Teh, S. et al., Final Report to C. Foe, *supra (*August 31, 2011 Report).

[22] *See e.g.,* Parker, A.E., A.M. Marchi, J. Drexel-Davidson, R.C. Dugdale, and F.P. Wilkerson. "Effect of ammonium and wastewater effluent on riverine phytoplankton in the Sacramento River, CA. Final Report to the State Water Resources Control Board; Wilkerson, F.P., R.C. Dugdale, V.E. Hogue and A. Marchi, 2006. Phytoplankton blooms and nitrogen productivity in San Francisco Bay, Estuaries and Coasts 29(3): 401-416. ; Dugdale, R.C., F.P. Wilkerson, V.E. Hogue and A. Marchi. 2007. The Role of ammonium and nitrate in spring bloom development in San Francisco Bay. *Estuarine, Coast and Shelf Science* 73: 17-29 ; Sommer, T., C. Armor, R. Baxter, R. Bruer, L. Brown, M. Chotkowski, S. Culberson, F. Feyrer, M. Gingras, B. Herbold, W. Kimmerer, A. Mueller-Solger, M. Nobriga and K. Souza. 2007. The Collapse of Pelagic Fishes in the Upper San Francisco Estuary, *Fisheries* 32(6):270-277; Glibert, P. 2010a. "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.* 18(2):211 – 232.

[23] Note that even below that level, Dr. Dugdale has observed inhibitory effects, as have others, *see* Technical Memorandum at 1 (researchers "describe the threshold for inhibition of nitrate uptake at ammonium levels of approximately 1 μmol L^{-1}).but that the complete inhibition has been observed at ammonium concentrations of 4 μmol L^{-1}.

the threshold level 87% of the time. *See* Exhibit 1. Further, in the receiving water in the vicinity of the discharge point, 14% of the data show ammonium concentrations of *40* μmol L^{-1} or more, *10 times* above the inhibition threshold. *See* Exhibit 1.

While the additional research by Ms. Taberski and Dr. Dugdale outlined in the Work Plan will surely provide additional useful information to supplement the body of knowledge of how ammonium inhibits productivity, the existing data amply document the effects of nutrient discharges like those from CCCSD sufficient to require nutrient removal. At a minimum, as noted, the Regional Board should consider carefully these recent studies, before deciding whether or not to allow CCCSD to continue to discharge tons of nutrients into Suisun Bay.

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.

Further, the research of Dr. Glibert and others demonstrates that excessive ammonium discharges have adversely impacted aquatic life in the Bay-Delta by increasing the ratio of nitrogen to phosphorus in the receiving water which triggers impacts to the food web on which aquatic life depends. Increasing ammonium discharges, particularly when phosphorus discharges have been declining, degrades water quality by changing the ratio between dissolved inorganic nitrogen and phosphorus, as well as the total nitrogen to total phosphorus ratio. These ratios are known to have profound influences on food webs.[24] Dr. Glibert's research strongly suggests that changes in delta smelt and several other fish species' abundance are ultimately related to changes in ammonium load from wastewater discharges. Dr. Glibert concluded that "[r]emediation of pelagic fish populations should be centered on reduction of nitrogen loads and reestablishment of balanced nutrient ratios delivered from point source discharges."[25] *See* Technical Memorandum at 3-4.

4. Where implemented in impacted ecosystems, nutrient removal has improved the natural ecosystem and aquatic life.

Requiring nitrification and denitrification of wastewater treatment plant effluent would help restore the health of the ecosystem and aquatic life in the Bay-Delta estuary. Again, the literature is clear that requiring nutrient removal on wastewater treatment plants has proven to be effective at reversing the harmful effects of previously un/undertreated discharges and restoring native eco-systems. As just one example that is discussed in Dr. Glibert's work, nutrient removal at the Blue Plains treatment plant in Washington D.C. has reduced the invasive species and begun to restore the native vegetation in the river. Once nutrient removal was implemented at Blue Plains in the 1990s, within several years, the abundance of the invasive *Hydrilla* began to decline and the abundance of native grasses increased. There are many other examples in other systems. *See* Technical Memorandum at 4-5.

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[24] Sterner, R.W. and J.J. Elser. 2002. Ecological stoichiometry: The biology of elements from molecules to the biosphere. Princeton University Press, Princeton, N.J. Sterner and Elser (2002), state that, "Stoichiometry can either constrain trophic cascades by diminishing the chances of success of key species, or be a critical aspect of spectacular trophic cascades with large shifts in primary producer species and major shifts in ecosystem nutrient cycling."

[25] Glibert, P. 2010a.

To reiterate: The Public Water Agencies submit the existing literature amply documents the effects of nutrient discharges like those from CCCSD sufficient to require treatment. At a minimum, before issuing any permit to CCCSD, the Regional Board should consider carefully these studies, as the Central Valley Regional Board did in deciding to impose full nutrient removal on the Sacramento Regional WWTP.

III. The Regional Board's Consideration of Ammonium in the Tentative Order is Incomplete and Contrary to Law

The Regional Board considers ammonium (referred to as total ammonia as N) essentially in two ways. First, the Regional Board evaluates whether the ammonium in CCCSD's discharge has the reasonable potential to exceed a water quality objective and if so, whether a water quality based effluent limit is required. Second, after setting the limits, the Regional Board determined that the anti-backsliding requirements are met, because no previous permit included any limits. Neither analysis appears to be correct.

A. The Regional Board's application of a dilution factor is flawed and should be reconsidered

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 has 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 total ammonia is only a small fraction of the total discharge, these are then converted to total ammonia objectives of 5.0 mg/L (acute) and 1.6 mg/L (chronic). Given that the MEC for ammonium is 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 by relying on the "Mixing Zone Study." Yet, this would not appear to be appropriate for several reasons:

<u>First,</u> the staff acknowledges the inability to set a Mixing Zone.

> Because of the complex hydrology of San Francisco Bay, a mixing zone has not been established. There are uncertainties in accurately determining an appropriate mixing zone. The models used to predict dilution have not considered the three dimensional nature of San Francisco Bay currents resulting from the interaction of tidal flushes and seasonal fresh water outflows. Being heavier and colder than fresh water, ocean salt water enters San Francisco Bay on a twice-daily tidal cycle, generally beneath the warmer fresh water that flows seaward. When these waters mix and interact, complex circulation patterns occur due to the varying densities of the fresh and ocean waters. ***The complex patterns occur throughout San Francisco Bay, but are most prevalent in the San Pablo, Carquinez Straight, and Suisun Bay areas.*** The locations of this mixing and interaction change, depending on the strength of

> each tide. Additionally, sediment loads from the Central Valley change on a long-term basis, affecting the depth of different parts of San Francisco Bay, resulting in alteration of flow patterns, mixing, and dilution at the outfall.

Tentative Order, Attachment F at F-20 (emphasis added). In fact, it emphasizes that the complexities are greatest in vicinity of the location of the of the CCCSD discharge. Given that, it would be wholly illogical for the Regional Board to then go ahead and apply a full dilution factor for ammonia to the CCCSD discharge and establish limits substantially greater than the maximum concentration observed.

Nonetheless, second, the staff goes on and proposes that dilution be applied to ammonia. In doing so, the staff asserts as follows:

> In granting dilution for ammonia, the Regional Water Board considered that ammonia is not a persistent pollutant and the Basin Plan states, "In most instances, ammonia will be diluted or degraded to a nontoxic state fairly rapidly." As such, there is unlikely to be cumulative toxicity effects associated with discharges containing elevated concentrations of ammonia. Therefore, granting dilution credits based on actual initial dilution is protective of water quality.

Tentative Order, Attachment F at F-20. However, the Basin Plan reference to the dilution of ammonia would appear to be referring to the "un-ionized" fraction of ammonia, not the ammonium that is the primary component of concern in the CCCSD discharge. Basin Plan, §3.3.20 at 3-7. Consistent with the general assessment that the "complex patterns" near the discharge point are not appropriate, the same approach ought to be applied to ammonium.

Third, the Basin Plan cautions *against* application of dilution in light of various concerns, including the difficulty in measuring the discharge in a tidal zone, Basin Plan §4.6.1.1 at 4-18, precisely where the CCCSD discharge is located. It further states that it would "consider inclusion of an effluent limitation greater than that calculated from water quality objectives when the increase in concentration is caused by implementation of significant water reclamation or water reuse programs at the facility; the increase in the effluent limitations does not result in an increase in the mass loading; and the water quality objectives will not be exceeded outside the zone of initial dilution." Basin Plan §4.6.1.1 at 4-18. But no such findings or analyses are done here.

In fact, fourth, the "Mixing Zone" study on which the staff rely recognizes that while there is initial dilution above the diffuser, that dilution *does not persist* beyond the zone of initial dilution. According to the study: "Under both chronic and acute conditions, the plume becomes vertically fully mixed over the diffuser, ***but re-stratifies later and is not mixed in the far field***." *See* Near-field Mixing Zone and Dilution Analysis for the Central Contra Costa Sanitary District Outfall Diffuser to San Pablo Bay at 12 (Nov. 10, 2010) ("Mixing Zone Study"). Indeed, the Tentative Order expressly recognizes that the study only "presents the findings regarding the initial dilution of the discharge at the outfall." Attachment F at F-18. It makes no determination, as the Basin Plan directs, that "the water quality objectives will not be exceeded outside the zone of initial dilution." Attachment F at F-18.

Further, fifth, the Basin Plan also cautions against relying on modeling when evaluating a discharge in an estuarine environment because models are limited to the initial dilution analysis. This include EPA models, like the one used by CCCSD's consultant. Mixing Zone Study (uses EPA approved CORMIX model). Specifically, "the direction of waste transport varies over the course of the tidal cycle, so it is difficult to determine the fraction of new water versus recirculated water mixing with the discharge. U.S. EPA has developed several models of initial dilution for discharge plumes, ***but none takes into account transport due to tidal currents."*** Basin Plan §4.6.1.1 at 4-18.

Finally, sixth, regardless, the analysis of ammonia and dilution are entirely divorced from the overwhelming body of literature and data outlined in and provided with these comments. In fact, as outlined, the data demonstrate that the concentration of ammonium (or total ammonia as N) is consistently exceeding both the toxicity level for copepods and the inhibitory threshold for primary productivity. That suggests the proposed dilution is not the "conservative approach to calculating effluent limitations" required by the Basin Plan. Basin Plan §4.6.1.1 at 4-18 Instead, those data must be considered carefully and fully by the Regional Board before deciding that the tons of "nutrients" poured into the critical habitat for endangered and threatened species will simply be "diluted" away.

B. The Regional Board's analysis of Anti-degradation with regard to ammonia is contrary to established principles of law

California's Antidegradation Policy is summarized by a 1990 Administrative Procedures Update ("APU") from the State Board, which was meant to "provide guidance for the Regional Boards for implementing State Board Resolution No. 68-16 . . . and the Federal Antidegradation Policy, as set forth in 40 C.F.R. § 131.12." (APU 90-04, (July 1, 1990) at p. 1.) As such, the APU is designed to help the Regional Boards implement both federal policy (40 C.F.R. § 131.12) and the State Board's Antidegradation Policy (Resolution No. 68-16).

For high quality waters, Resolution 68-16 mandates that the water quality must be maintained—unless the Discharger can prove that lowering the water quality: (1) will provide "maximum benefit" to the state; (2) will not impair present or anticipated beneficial uses of the receiving water; and (3) will not violated water quality objectives. Additionally, discharges which increase the volume or concentration of waste in high quality waters must comply with discharge limits based on the "best practicable treatment or control" ("BPTC") which ensures that no pollution or nuisance will occur and that the highest water quality will be maintained.

If approved, the Tentative Permit would violate state and federal Antidegradation Policy by allowing degradation of receiving waters due to ammonium discharge. The Tentative Permit provides an ammonia discharge limit that is higher than the existing and historic ammonia discharge and which allows increased concentration of ammonia in the discharge. And the CCCSD is asking the Regional Board to issue a final discharge permit allowing the Treatment Plant to physically increase its discharge of secondarily treated sewage to up to 53.8 mgd, up nearly 34 percent from the existing baseline discharge of approximately 40 mgd. As a result, if the CCCSD's requested Permit were granted, CCCSD would physically increase the discharge of pollutants, like total ammonia nitrogen, into the Bay-Delta estuary—critical habitat for listed fish species and the largest single source of fresh water supply in all California.

Before the Regional Board can issue, reissue, amend, or revise such a discharge permit, however, federal and state Antidegradation Policy require the Regional Board to determine that permit conditions result in BPTC and to determine whether any water quality degradation that will result is permissible when balanced against the benefit to the public from issuing the permit. Here, the Tentative Permit makes no findings with respect to BPTC and the balancing of water quality degradation against any public benefit from allowing degradation. The Tentative Permit discloses zero analysis connecting facts in the record to any express conclusion that allowing the ongoing and increased discharge of ammonium and other pollutants complies with Antidegradation Policy.

To the extent that CCCSD might contend that some aspect of the required Antidegradation Policy analysis is addressed in some unspecified, prior California Environmental Quality Act ("CEQA") documentation, it is important to understand that substantially changed circumstances and significant new information prevent reliance on any prior CEQA review to support the Tentative Permit. The pelagic organism decline and scientific evidence that ammonia discharges harm the Bay-Delta foodweb would prevent reliance on any prior CEQA document to help support the Antidegradation Policy analysis and compliance determination that is required before CCCSD's new discharge permit may be approved.

The Regional Board must work with CCCSD to complete a legally adequate Antidgradation Policy analysis, and findings, and then circulate a revised Tentative Permit whose terms and Fact Sheet demonstrate Antidegradation Policy compliance, including ammonium effluent limits that achieve BPTC. Failure to do so will result in approval of an unlawful permit that degrades receiving water quality, violates water quality objectives, impairs designated beneficial uses—all in violation of state and federal water quality protection law.

IV. The Regional Board Should Take Affirmative Steps to Address the Ammonium in the CCCSD Discharge

A. The Regional Board should require CCCSD to install nitrification treatment

In view of the scientific evidence, the Regional Board should require CCCSD to reduce the nutrients in its discharge to acceptable levels. The Regional Board should set final effluent limits that are achievable with full nitrification treatment, as well as a reasonable schedule for designing and building the treatment system. Further, daily and monthly interim effluent limits on ammonium (ammonia as N) should be set that reflect the real maximum concentrations that have been observed in the discharge, with a modest margin for compliance.

There are well established technologies available to CCCSD to remove nutrients, as evidenced by the many other municipalities in California and across the country that have implemented ammonium removal through the "nitrification" of the wastewater. *See* discussion, *supra.*

Unquestionably, this is a feasible technology that has previously been determined to satisfy BPTC under California law.[26]

B. The Regional Board should defer issuing the Tentative Permit until pending studies on the effects of nutrients in CCCSD's discharge are completed

In the alternative, if the Regional Board remains convinced that further study must be completed before addressing nutrients in CCCSD's discharge, the Public Water Agencies urge the Regional Board to expedite (consistent with good scientific practice) the ongoing Work Plan, but defer issuing a final permit until that work is completed and published. In that way, the Regional Board may consider those data and analyses before issuing a new permit.

Given the stated focus of the Work Plan and the recognized concerns about the CCCSD discharge on the productivity in the Bay Delta estuary, proceeding to finalize the permit without the benefit of the latest data is unreasonable. Specifically, among other objectives, the study is designed to further assess whether "high NH_4 concentrations in Suisun Bay correlate with low primary production." Work Plan, Attachment at 2. It would be prudent to complete this work before granting CCCSD another five years to discharge millions of tons of nutrients into a critical habitat for threatened and endangered species. Indeed, part of the study is focused directly on CCCSD's contribution. As the Work Plan acknowledges, the data gathered to date has found that "an additional NH_4 signal was detected in the western part of Suisun that may play a role in controlling phytoplankton blooms in Suisun Bay." Work Plan at 4. One of the objectives of the research, therefore, is to determine if the CCCSD and its discharge of "7,000 lbs/day of ammonia to western Suisun Bay" are the source of that observed ammonium – as logically is currently "presumed to be" the case. *Id.; see also* Work Plan, Attachment at 2-9 (defining "Monitoring Objectives and Questions").

C. Alternatively, if the Regional Board is intent on finalizing a permit, the final permit should at a minimum be revised to address ammonium more effectively

Lastly, if the Regional Board determines it must proceed with a permit now and is not prepared to require full nitrification, then the Public Water Agencies urge the Regional Board to include a detailed framework in the final permit to address ammonium. The framework should include three components:

First: The Regional Board should make specific findings in the permit regarding its concern that the ammonium in CCCSD's discharge may be contributing to impacts in Suisun Bay and that therefore it is in the process of implementing studies to evaluate those concerns. The permit should then include a schedule for promptly completing the Surface Water Ambient Monitoring Program sampling and associated studies outlined in the Work Plan, with assured funding of that work by CCCSD as a condition for receiving the new permit.

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[26] A number of municipal sanitations districts have also been required to install "denitrification" treatment which follows nitrification to further treat the wastewater by removing the nitrates from the discharge. In the case of Sacramento Regional, the Water Agencies believe the evidence strongly supported the Central Valley Board's decision to require that additional treatment given the available data concerning that discharge. Here, as the Regional Board develops additional data regarding CCCSD's discharge, it should consider whether denitrification should also be included.

Second: The Regional Board should set a clear procedure for reconsideration of the ammonium issue, with full public participation in the process, after the studies are completed and the data are published. The Regional Board should include deadlines to ensure the ammonium limits are reconsidered no later than 12 months after the Regional Board issues a final permit.

Third: As outlined for the recommended interim limits, the Regional Board should set effluent limits consistent with the actual maximum concentrations of ammonium in the CCCSD discharge, with a modest margin for compliance. With the maximum observed concentration of ammonium according to the Regional Board in the range of 30 mg/L, there is no rational basis in the record to set limits of 65 mg/L (monthly) and 84 mg/L (daily maximum).

Table 1. Treatment Requirements for Select Wastewater Treatment Plants That Discharge Directly or Indirectly to the Bay-Delta Estuary.

Discharger	Permitted Average Dry Weather Flow (mgd)	Treatment Requirements
		Nitrification or Nitrification + Denitrification
Sacramento Regional WWTP	181	Yes
Stockton	55	Yes
Central Contra Costa Sanitary District	*53.8*	*No*
Fairfield	17.5	Yes
Manteca	17.5	Yes
Delta Diablo	16.5	No
Tracy	16	Yes
Vallejo	15.5	No
Vacaville Easterly WWTP	15	Yes
Woodland	10.4	Yes
Lodi	8.5	Yes
Davis	7.5	Yes
Mountain House	5.4	Yes
Benicia	4.5	No
Galt	4.5	Yes

Technical Memorandum

Summary of Nutrient Impacts

There is a large body of literature documenting the significant impacts of increased loading and changing forms, concentrations, and ratios of nitrogen and phosphorus both within the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta) and globally to the food web form and function. The form of nutrients matters. Wilkerson, *et al.* (2006) and Dugdale, *et al.* (2007) show that "bloom levels of chlorophyll are evident only when nitrate uptake occurs and that nitrate uptake only takes place at lower ambient ammonium concentrations." They conclude that ammonium concentrations greater than 4 μmol L^{-1} inhibit nitrate uptake by diatoms and thus suppress bloom formation. This level of ammonium is exceeded a majority of the time in the Sacramento River and Suisun Bay.

In enclosure experiments with samples from Central Bay, Suisun Bay and the Sacramento River at Rio Vista, Wilkerson *et al.* (in preparation) observed "a gradient of decreasing phytoplankton physiological rates in the upstream direction as far as Rio Vista." Algal biomass accumulation was delayed in enclosures from Suisun Bay and was not observed within 96 hours in enclosures from Rio Vista. Also supporting this finding, Parker, *et al.* (in review) observed a 55% decline in primary production in the Sacramento River below the Sacramento Regional Wastewater Treatment Plant compared to production above the Treatment Plant's outfall. Parker, *et al.* (in review) conclude that "[t]he quantitative reduction in primary productivity and nitrogen uptake at various points in the river was predictable and strongly related with NH_4 concentrations."

These observations of ammonium suppression are not new or unique to the Bay-Delta. There is a large body of scientific research describing ammonium suppression of algae productivity, which was first observed as far back as the 1930s (Ludwig, 1938; Harvey, 1953). Some of the early field demonstrations of this phenomenon were by MacIsaac and Dugdale (1969, 1972), followed by research in the Chesapeake Bay by McCarthy, *et al.* (1975). Lomas and Glibert (1999a) describe the threshold for inhibition of nitrate uptake at ammonium levels of approximately 1 μmol L^{-1}. Ammonium suppression of nitrate uptake when both nutrients are in ample supply should not be confused with the preferential use of ammonium by phytoplankton when nitrogen is limiting. Under the latter conditions, phytoplankton will use ammonium preferentially because it requires less energy than nitrate. Under the former conditions, the cells must cope with an excess; and in doing so, their metabolism is altered away from an ability to assimilate nitrate. Total primary productivity is suppressed as a result. This is particularly problematic for the Bay-Delta as it is already a comparatively low producing estuary (Jassby *et al.,* 2002). Laboratory experiments suggest that Delta-wide chl-a levels are now low enough to limit zooplankton abundance (Müller -Solger *et al.*, 2002).

Nutrient form also affects phytoplankton species composition. Cyanobacteria have been shown to preferentially use chemically reduced forms of nitrogen over nitrate in many studies.

Chemically reduced nitrogen not only includes ammonium, but also urea and dissolved organic nitrogen. This evidence comes from:

- Measurements of enzyme activities in the cells – enzymes that process these forms of nitrogen. Cyanobacteria have been shown to have some of the highest measured rates of urease, for example, relative to all phytoplankton species tested, and among cyanobacteria, *Microcystis* rates are the highest (Solomon et al., 2010).

- Directly determined rates of nitrogen uptake using isotope tracer techniques. These rates show that cyanobacteria use reduced nitrogen forms and, in many cases, avoid the chemically oxidized forms (Glibert *et al.,* 2004).

- Direct growth studies. These studies based on growth measurements in the laboratory demonstrate that growth rates of *Microcystis* can be significantly higher on urea than on nitrate (Berman and Chava, 1999). Meyer, *et al.* (2009) state: "Compared to NO_3- and N_2 (via fixation) as N sources, NH_4+ produces the highest growth and primary production rates for *Microcystis aeruginosa* and other cyanobacteria (*Aphanizomenon flos-aquae* and *Anabaena flos-aquae*) in laboratory studies [citations removed]" (Meyer *et al.,* 2009).

Moreover, retrospective analysis of the data in the Bay-Delta system further demonstrates that at very high ammonium concentrations (*i.e.*, > 200 $\mu g\ L^{-1}$), phytoplankton functional groups such as flagellates, cryptophytes and diatoms are outcompeted by cyanobacteria (Glibert, P., Univ. of Maryland. Personal communication). Thus, even though *Microcystis* may have a broad capability for using different forms of nitrogen to support their physiological demands for nitrogen, they have a greater capacity to take up and metabolize reduced forms of nitrogen compared to other functional groups and may have higher growth rates under reduced nitrogen compared to nitrate and thus may outcompete other phytoplankton groups at very high ammonium levels. Lehman et al. (2010) concedes: "Recent increases in ammonium concentration in the western delta may give a competitive advantage to *Microcystis* which rapidly assimilates ammonium over nitrate."

The physiological literature strongly supports the concept that different algal communities use different forms of nitrogen. Diatoms generally have a preference for nitrate; dinoflagellates and cyanobacteria generally prefer more chemically reduced forms of nitrogen (ammonium, urea, organic nitrogen) (Berg, *et al.*, 2001; Glibert, et al., 2004, 2006; Brown, 2009). It has long been recognized that diatoms may have a nutritional requirement for, and under some circumstances even a preference for, nitrate (Lomas and Glibert, 1999a; 1999b). Moreover, diatoms often show no evidence of nitrate uptake saturation under very high nitrate conditions (Collos et al. 1992, 1997), in contrast to the generally accepted saturating uptake kinetic relationships that are used to describe the relationship between nutrients and uptake rate. Thus, cyanobacteria may grow particularly well on ammonium while their competitors, such as diatoms, do not.

The shift in algal community composition in the Bay-Delta has been far more extensive than just the recent increase in annual blooms of *Microcystis.* The Delta's algal species composition has shifted from diatoms to smaller and lower quality food species such as flagellates, cryptophytes and cyanobacteria (Lehman, 2000; Lehman *et al.*, 2005; Lehman et al., 2010; Jassby *et al.*, 2002; Sommer *et al.*, 2007; Glibert, 2010; Glibert et al., 2011; Winder and Jassby, 2010) and to invasive macrophytes such as *Egeria densa* (Sommer, *et al.*, 2007; Nobriga et al., 2005; Glibert et al., 2011). Jassby (2008) states:

> *A decrease in percentage of diatom biovolume occurred during 1975–1989, caused by both a decrease in diatoms and an increase in green algae, cyanobacteria, and flagellate species biovolume (Kimmerer 2005; Lehman 1996), i.e., probably in the direction of declining nutritional value per unit biomass. In principle, the total nutritional value of a community could decrease even as its biomass increases. Moreover, changes in size, shape, and motility of species comprising the phytoplankton community could also affect their availability as food particles for crustacean zooplankton and other consumers.*

In addition, the ratios of nitrogen to phosphorus are known to have profound influences on food webs. Sterner and Elser (2002) state: "[s]toichiometry can either constrain trophic cascades by diminishing the chances of success of key species, or be a critical aspect of spectacular trophic cascades with large shifts in primary producer species and major shifts in ecosystem nutrient cycling."

The N:P ratio has long been shown to influence phytoplankton community composition and the presence - or absence - of native species and vegetation, as extensive studies have repeatedly demonstrated in systems around the world including: Hong Kong, Tunisia, Germany, Florida, Spain, Korea, Japan, and Washington D.C. (Chesapeake Bay), to name just a few. The Potomac River (Chesapeake Bay) was invaded by submerged aquatic vegetation, *Hydrilla,* and clams, *Corbicula*, when the N:P ratio of effluent from the large Blue Plains sewage treatment facility increased after phosphorus was reduced in the 1980s (Ruhl and Rybicki 2010). In Spain's Ebro River estuary, *Hydrilla* and *Corbicula* invaded shortly after phosphorus was removed from effluent (Ibanez *et al.* 2008). In Tolo Harbor, Hong Kong, nutrient loading, particularly phosphorus loading, increased due to population increases in the late 1980's. The result was that a distinct shift from diatoms to dinoflagellates was observed in the harbor, coincident with a decrease in the N:P ratio (Hodgkiss and Ho 1997; Hodgkiss 2001). Once the phosphorous was removed from the sewage effluent that was being discharged into the harbor and stoichiometric proportions were re-established, there was a resurgence of diatoms and a decrease in dinoflagellates (Lam and Ho 1989). In Tunisian aquaculture lagoons, dinoflagellates have been shown to develop seasonally when N:P ratios decrease (Romdhane, et al. 1998). Comparable results have been observed in systems in Germany (Radach *et al.*, 1990) and along the coast of Florida (Glibert *et al.*, 2004; Heil *et al.*, 2007).

N:P ratios have also been shown to influence zooplankton community composition. Norwegian studies monitored lakes for many years and found that different zooplankton tend to dominate under different N:P ratios, due to the different phosphorus content of different species found in the lake (Hessen 1997). Hessen (1997), for example, showed that a shift from calanoid copepods to *Daphnia* tracked N:P; calanoid copepods retain proportionately more N, while *Daphnia* are proportionately more P rich. Studies from experimental whole lake ecosystems found that zooplankton size, composition and growth rates changed as the N:P ratio varied (*e.g.*, Schindler 1974, Sterner and Elser 2002).

There has been a measureable change in the N:P ratio in the Bay-Delta, an increase in total N loading, a decrease in total P loading, and a change in the dominant form of nitrogen from nitrate to ammonium (Glibert, 2010). In a retrospective analysis of 30 years of data from the Bay Delta, Glibert (2010; Glibert et al., 2011) found that the variation in these nutrient concentrations and ratios is highly correlated to variations in the base of the food web, primarily the composition of phytoplankton, to variations in the composition of zooplankton, to variations in the abundance of invasive clams, and to variations in the abundance of several fish species.

Winder and Jassby (2010) provide additional documentation of the shift that has occurred in the phytoplankton and zooplankton community.

The shift in the phytoplankton community has ripple effects through the food web. Cloern and Dufford (2005) state, "[t]he efficiency of energy transfer from phytoplankton to consumers and ultimate production at upper trophic levels vary with algal species composition: diatom-dominated marine upwelling systems sustain 50 times more fish biomass per unit of phytoplankton biomass than cyanobacteria-dominated lakes [citations removed]." Slaughter and Kimmerer (2010) provide further support. They observed lower reproductive rates and lower growth rates of the copepod, *Acartia* sp. in the low salinity zone compared to taxa in other areas of the estuary and conclude that "[t]he combination of low primary production, and the long and inefficient food web have likely contributed to the declines of pelagic fish."

There is also a growing body of literature documenting improvements in ecosystem functions in systems where nutrient loading is reduced. Reducing nutrient loading in the Chesapeake Bay, Tampa Bay, and coastal areas of Denmark has proven to be effective at reversing the harmful effects of previously undertreated discharges and restoring the native systems. For example, within several years of increasing nutrient removal at the Blue Plains treatment plant in Washington DC, N:P ratios in the Potomac River declined, the abundance of the invasive *Hydrilla verticillata* and *Corbicula fluminea* began to decline (Figure 1), and the abundance of native grasses increased (Ruhl and Rybicki 2010).

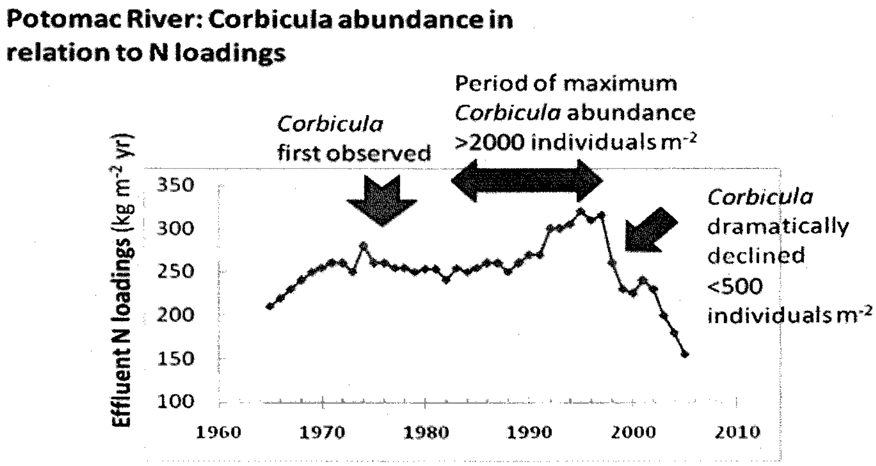

Figure 1. Comparative relationships for the Potomac River showing the change in effluent N loading and the relative abundance of the invasive clam, *Corbicula fluminea* clams. Data derived from Dresler and Cory (1980), Jaworski *et al.* (2007), and Cummins *et al.* (2010).

Tampa Bay provides another important example. Eutrophication problems in the Bay were severe in the 1970s, with N loads approximating 24 tons per day, about half of which was due to point source effluent (Greening and Janicki 2006). Several years after nitrogen and phosphorus reductions were achieved, native seagrass began to increase. Lower nutrient discharges also had positive effects on the coastal waters around the island of Funen, Denmark (Rask *et al.* 1999). Since the mid 1980s, there has been a roughly 50% reduction in the loading of N and P in the region due to point source reductions. Again, native grasses returned and low oxygen problems were reversed.

Moreover, there is recent evidence that diatom blooms can be restored in the Bay-Delta if ammonium loading were reduced. In Suisun Bay a diatom bloom reached chlorophyll concentrations of 30 $\mu g\ L^{-1}$ during spring 2000 when ammonium concentrations declined to 1.9 $\mu mol\ L^{-1}$ (Wilkerson *et al.* 2006). Similarly, chlorophyll concentrations in Suisun Bay reached 35 $\mu g\ L^{-1}$ during spring 2010 when ammonium concentrations declined to 0.5 $\mu mol\ L^{-1}$ (Dugdale *et al.*, 2011). These blooms are comparable to spring chlorophyll levels from 1969-1977 (Ball and Arthur, 1979) when ammonium concentrations were 1.8 $\mu mol\ L^{-1}$ during summer and 4.0 $\mu mol\ L^{-1}$ during winter (Cloern and Cheng, 1981). If clam abundance declines, as has occurred in San Pablo Bay and South San Francisco Bay (Cloern *et al.*, 2007), chlorophyll levels may also be restored during summer in Suisun Bay if ammonium loading were reduced.

Additionally, as Glibert (2010) reported, "[s]upporting the idea that correct balance of nutrients is important for restoration of delta smelt and other pelagic fish, there is a small but apparently successful subpopulation of delta smelt in a restored habitat, Liberty Island. Liberty Island is outside the immediate influence of Sacramento River nutrients. It has abundant diatoms among a mixed phytoplankton assemblage, as well as lower NH_4 levels and higher ratios of NO_3:NH_4 than the main Sacramento River [citations removed]."

The recent increase in *Microcystis* bloom frequency and size can also be explained by changes in Delta nutrients. Based on stable isotope analyses of particulate organic matter and nitrate, Kendall (2010) observed that ammonium, not nitrate, is the dominant source of nitrogen utilized by *Microcystis* at the Antioch and Mildred Island sites in the summer 2007 and 2008.

Nutrients affect more than *Microcystis* growth; nutrients may also affect its production of toxins. In Daechung Reservoir, Korea, researchers found that toxicity was related not only to an increase in N in the water, but to the cellular N content as well (Oh, *et al.* 2000). A very recent report by van de Waal (2010) demonstrated in chemostat experiments that under high CO_2 and high N conditions, microcystin production was enhanced in *Microcystis*. Similar relationships were reported for a field survey of the Hirosawa-no-ike fish pond in Kyoto, Japan, where the strongest correlations with microcystin were high concentrations of NO_3 and NH_4 and the seasonal peaks in *Microcystis* blooms were associated with extremely high N:P ratios (Ha *et al.* 2009). Thus, not only is *Microcystis* abundance enhanced under high N:P, but its toxicity is as well (Oh, *et al.* 2000).

Glibert *et al.* (2011) provides further support for the hypothesis that nutrient form and ratio is driving food web composition in the Delta. Using several different statistical approaches, Glibert *et al.* (2011) evaluated the relationships between approximately thirty different aquatic species and various nutrient ratios and found significant correlations for a majority of them. After comparing trends in the Bay-Delta estuary to those in Lake Washington, Potomac River, Hudson River and several European lakes and estuaries, they state,

> *Moreover, the physiology of the resident organisms and biogeochemical pathways lends support to the premise that similar trophic structure, including the appearance of* Microcystis, *in many of these systems has resulted from similar nutrient dynamics, biogeochemistry and food web interactions that resulted, in turn, from changes in stoichiometry and the relative abilities of different types of organisms to either sequester nutrients and/or to tolerate nutrients that are in excess (e.g., NH_4^+).*

They suggest that, "[r]eductions in N (especially NH_4^+) will allow organisms, from diatoms to fish, that cannot withstand high NH_4^+ (and/or that are outcompeted by NH_4^+ -tolerant organisms, such as various harmful dinoflagellates and cyanobacteria), to compete."

Glibert *et al.* (2011) found, "[f]or all organisms, with the exception of *Acartia*, for which strong correlations were observed with X2 (Table 9), *i.e.*, *Eurytemora*, *Pseudodiaptomus*, *Daphnia*, *Bosmina*, *Corbula*, *Crangon*, longfin smelt, splittail, striped bass, starry founder, crappie, sunfish and largemouth bass, equal or more significant correlations were observed with nutrients or nutrient ratios." This analysis determined pairwise relationships between biological parameters and nutrients and/or nutrient ratios using both the original data and data that were adjusted for autocorrelation. Glibert *et al.* (2011) also found that total phosphorus "explained at least as much of the variability in delta smelt as did the [Feyrer *et al.*, 2010] habitat index (Table 4), and dinoflagellate abundance explained even more (Table 6)." Unlike the X2 relationships whose mechanisms of effect are largely unknown, the nutrient relationships have a strong mechanistic explanation in ecological stoichiometry and stable state principles.

Ammonia Toxicity

Studies have been conducted by scientists at UC Davis investigating the effects of ammonia to the calanoid copepod *Pseudodiaptomus forbesi* using a full-life cycle bioassay approach. *P. forbesi* is an important food organism for the young of many fish species in the Bay-Delta including delta smelt and longfin smelt, two State listed species. Evidence of the toxic effects of ammonia on *P. forbesi* comes from life cycle tests conducted by Teh *et al.* (2011). Teh *et al.* (2011) found that total ammonia nitrogen at 0.36 ± 0.01 mg L^{-1} significantly affects the recruitment of new adult copepods and total ammonia nitrogen at 0.38 ± 0.01 mg L^{-1} significantly affects the number of newborn nauplii surviving to 3 days old.

Clam Invasion

There is no denying that the overbite clam has had a significant impact on the ecosystem since it took hold in the mid-1980s. Kimmerer (2002) and Kimmerer *et al.* (2009) found that many of the relationships between spring X2 and abundance changed in the mid-1980s, presumably due to the invasion by the overbite clam, *Corbula amurensis.* Phytoplankton biomass also declined significantly due to grazing pressure from the invasive clams. There is some scientific debate regarding the ability, or lack thereof, to manage clam populations by increasing freshwater outflows. However, this strategy fails to account for the potential consequences of an increased distribution in the freshwater clam, *Corbicula fluminea*, if freshwater flow is used to try to push the distribution of the brackish water clams further west of the Delta.

In addition, Glibert *et al.* (2011) found that "the change after 1987 also corresponds with the change in nutrient loading. X2 is strongly correlated with PO_4^{3-}, TP and NH_4^{+}." Glibert (2010) suggested that changes in nutrients created the environment in which these clams could dominate. Glibert (2010) found a strong correlation between the CUSUM trends in clam abundance and ammonium concentration and in the ratio of inorganic nitrogen to inorganic phosphorus (DIN:DIP).

Glibert *et al.* (2011) provides further support for nutrient effects on clam abundance as well as on the abundance of other invasive organisms such as non-native centrarchids and non-native invasive weeds. Using several statistical approaches, Glibert *et al.* (2011) found "a strong long-term correlation between water-column DIN:TP ratios (and DIN:PO_4^{3-} ratios) and abundance of the clam, *Corbula*…there is also a strong long-term positive relationship between pH and *Corbula* abundance." They explain,

> *Changes in external nutrient loads can drive changes in internal ecosystem biogeochemistry and, in turn, trophodynamics. This analysis suggests that increasing*

> *dominance over time of macrophytes, clams, and* Microcystis *along with more omnivorous fish that are fueled by a benthic food web, are not a result of stochastic events (random invasions) but, rather, are related to a cascade of changes in biogeochemistry resulting from changes in nutrient loading over time as a major driver. This analysis supports the premise that reductions in P loading from external sources drive aquatic systems toward increased importance of sediment dynamics, and toward the sediments as a major source of P. The food webs that are supported are different from those supported when the water column is the major source of P; they are benthic-dominated. Macrophytes such as* Egeria *and phytoplankton such as* Microcystis *are physiologically well adapted to these altered nutrient and pH regimes. The communities of bivalves and fish change accordingly.* (Glibert *et al.*, 2011, pp. 389-399)

As discussed previously, and in more detail in Glibert *et al.* (2011), numerous examples exist where nutrient reductions in other ecosystems has led to the restoration of native sea grasses and to declines in invasive bivalve populations.

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Exhibit 1. This exhibit presents an evaluation of Central Contra Costa Sanitary District (CCCSD) receiving water data in the vicinity of the CCCSD wastewater treatment plant discharge for the 2006-2010 time period. The frequency of observations of receiving water ammonium concentrations in specified ranges is presented in Figure A. An evaluation of the percent of receiving water samples that exceed ammonium concentrations known to cause impacts to diatoms and zooplankton are presented in Table A.

Figure A

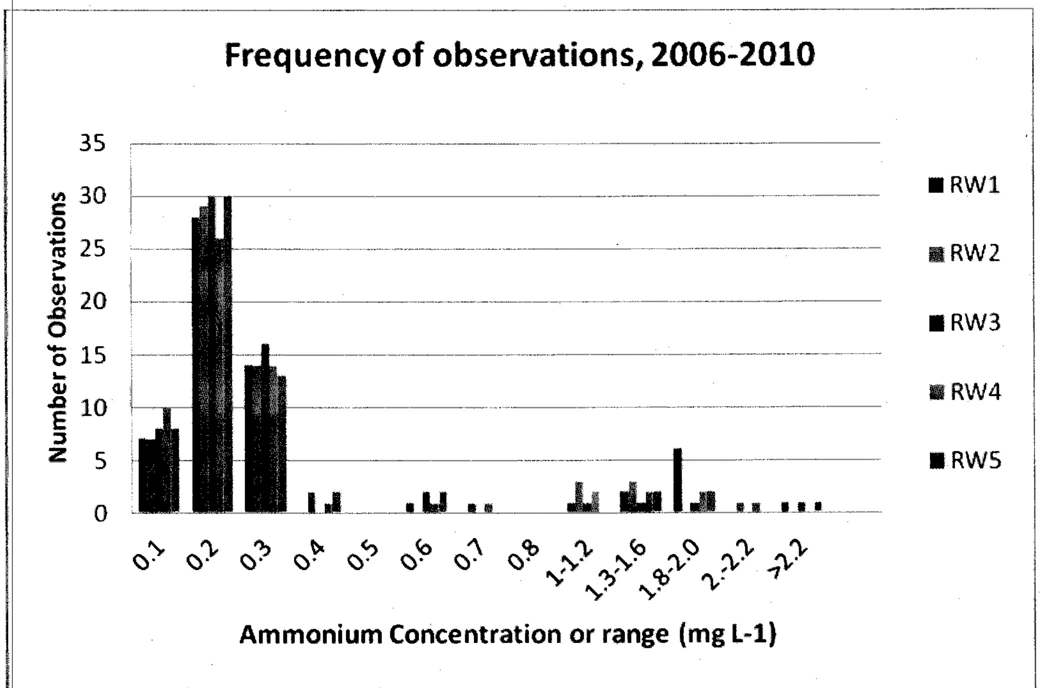

Table A

Criterion	Ammonium level	Percent of samples that exceeded this level from 2006-2010 in CCCSD Receiving Water samples
Dugdale inhibition of diatoms	0.06 mg L-1 or 4 μMol-N	87%
Swee Teh toxicity to zooplankton	0.36 mg L-1 or 25.7 μMol-N	15%
10-x greater than the Dugdale inhibition level	0.6 mg L-1 or 40 μMol-N	14%

Exhibit 2. This exhibit presents historical ammonium concentration data collected from 1975 to 2010 by the Environmental Monitoring Program of the Interagency Ecological Program for the Bay-Delta Estuary at a monitoring location in western Suisun Bay near Martinez (monitoring Station D6). The ammonium concentration of 0.056 mg L^{-1} (equivalent to 4μmol L^{-1}) is indicated on the graph. This ammonium concentration has been found to inhibit nitrogen uptake by diatoms and contribute to reduced diatom production in the Bay-Delta estuary.