Comments on CVRWQCB Staff Consultants' Draft "White Papers" on Controlling Excessive Aquatic Plants in Delta Waters

Submitted to Dr. Chris Foe, Central Valley Regional Water Quality Control Board
Rancho Cordova, CA

by

G. Fred Lee PhD, BCEES, F.ASCE and Anne Jones-Lee, PhD

G. Fred Lee & Associates
El Macero, CA
gfredlee33@gmail.com
www.gfredlee.com (530)753-9630
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The Delta Stewardship Council has required that the Central Valley Regional Water Quality Board (CVRWQB) develop a strategy for controlling the excessive growths of aquatic plants in Sacramento San Joaquin Delta (Delta) water. As part of meeting that requirement, the CVRWQCB issued contracts for the development of "white papers" on factors influencing aquatic plants in Delta water. Two draft white papers have been released:

> Berg, M. and Sutula, M., "Factors Affecting the Growth of Cyanobacteria with Special Emphasis on the Sacramento-San Joaquin Delta," Southern California Coastal Water Research Project Technical Report No. XXX, prepared for Central Valley Regional Water Quality Control Board and California Environmental Protection Agency, March (2015).
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> Boyer, K. and Sutula, M., "Factors Controlling Submersed and Floating Macrophytes in the Sacramento-San Joaquin Delta, Southern California Coastal Water Research Project Technical Report No. XXX prepared for Central Valley Regional Water Quality Control Board and California Environmental Protection Agency, April (2015).

Presented herein are our comments on the overall conclusions presented in those white papers.

The Executive Summaries of the draft white papers contained the following key "findings" to which our comments are largely directed.

In "Factors Controlling Submersed and Floating Macrophytes in the Sacramento-San Joaquin Delta":
"#3. Existing scientific literature has documented a host of environmental factors that have control over the growth of E. densa and E. crassipes worldwide. These include: 1) nutrients, 2) light, 3) temperature, 4) salinity, 5) dissolved inorganic carbon (SAV), 6) flow, turbulence and residence time, and 7) interaction with other species.

#4. Studies have documented the importance of a subset of these factors in the Delta, but

insufficient evidence exists to determine the relative importance of nutrients versus other factors in promoting the expansion of these species. Drawing on available information, we can conclude the following:

- *Conditions in the Delta, including seasonal low flow (and lack of turbulent mixing), high light, warm temperatures, and freshwater (low salinity) regime appear to favor the establishment and growth of the E. densa and E. crassipes.*
- *Aquatic plants require macronutrients (nitrogen, N and phosphorus, P) for growth. N and P are available in relatively high concentrations in the Delta, suggesting that available nutrients are not limiting growth. However, it is not possible to discern the relative influence of nutrients versus other factors. In addition, it is not clear to what degree new versus remineralized N and P (regenerated from sediment organic matter) are subsidizing this growth, making it unclear the effect that nutrient management could have on growth and persistence of these invasive aquatic plants."*

In "Factors Affecting the Growth of Cyanobacteria with Special Emphasis on the Sacramento-San Joaquin Delta":
"#2. Five principal drivers emerged as important determinant of cyanobacterial blooms in a review of the global literature on factors influencing cyanobacteria blooms and toxins production. These include: 1) Availability of N and P in non-limiting amounts; scientific consensus is lacking on the importance of N P ratios and nutrient form (e,g. ammonium) as a driver for cyanoHABs; 2) high light availability and water clarity; 3) Water temperatures; 4) Stratified water temperatures coupled with long residence times; and 5) salinity regime.

#3. Comprehensive understanding of the role of nutrients vis-à-vis other environmental factors in influencing cyanoHAB presence in the Delta is severely hampered by the lack of a routine monitoring program. Drawing on available information on the five factors influencing cyanoHABs, we can conclude the following:

- *Temperature and irradiance appear to exert key roles in the regulation of the onset of blooms. Cyanobacteria require temperatures above 20°C for growth rates to be competitive with eukaryotic phytoplankton taxa, and above 25°C for growth rates to be competitive with diatoms. In addition, they require relatively high irradiances to grow at maximal growth rates.*
- *It appears that N and P are available in non-limiting amounts in the Delta; moreover, concentrations, or ratios, do not change sufficiently from year–to–year in order to explain year–to–year variation Microcystis biomass or occurrence. Therefore the initiation of Microcystis or other cyanoHAB blooms are probably not associated with changes in nutrient concentrations or their ratios in the Delta. However, as with all phytoplankton blooms, once initiated, cyanoHABs cannot persist without an ample supply of nutrients.*

Overall Comment
The findings expressed in the draft white papers are consistent with our many years of experience investigating nutrient-related water quality, our findings in investing Delta nutrient impacts and control of excessive aquatic plants, as well as with the findings expressed in presentations made at the CWEMF Delta Nutrient Modeling Workshop discussed below.

Specific Comments

- **Basically, the water quality/beneficial use of the Delta is seriously degraded by excessive growths of aquatic plants that are caused by excessive nutrient loads to, and within, the Delta.**
- **There remains little ability to quantitatively and comparatively describe the role of nutrients (N and P) in controlling the excess fertilization of the Delta waters.**
- **There is considerable misinformation in the professional arena on the relative roles of N and P concentrations and loads, and the ratios of N to P in affecting water quality in the Delta; some of the information presented on nutrient/water quality issues is biased toward preconceived positions.**
- **Based on the results of the US and international OECD eutrophication study and our follow on studies of more than 600 waterbodies worldwide (lakes, reservoirs, estuarine systems) the planktonic chlorophyll levels in the Central Delta are well-below those that would be expected based on the phosphorus loads to the Delta. This is likely due to the role of clams' using phytoplankton as food.**
- **The relationship between nutrient loads and planktonic algal and bluegreen algal biomass in the Delta is atypical of what I have experienced for many other waterbodies. This may be due to clam's grazing the phytoplankton in the Delta. There will be need to investigate this situation as part of any studies conducted to examine the impact of algal nutrient loads to the Delta on bluegreen algal blooms in the Delta.**
- **There is a lack of understanding of the quantitative relationship between nutrient loads and fish production in the Delta.**
- **The Delta Stewardship Council's timetable for developing Delta nutrient water quality objectives by January 1, 2016, and to adopt and begin implementation of nutrient objectives, either narrative or numeric as appropriate, in the Delta by January 1, 2018 is unrealistically short.**
- **There is need for substantial well-funded, focused, and intelligently guided research on Delta nutrient water quality issues over at least a 10-yr period in order to develop the information needed to generate a technically sound and cost-effective nutrient management strategy for the Delta.**
- **As discussed in our writings, some of which are noted below, it will be especially difficult to develop technically valid and cost-effective nutrient control programs for excessive growths of macrophytes in the Delta.**

Experience/Expertise

Dr. G. Fred Lee's research and practical experience on the sources, impacts, and control of nutrients for the management of water quality/beneficial uses spans more than 50 years and includes work on several hundred waterbodies – lakes, reservoirs, estuaries, nearshore marine waters, and flowing water systems – of wide-ranging character in the US and abroad. The waterbodies investigated have ranged from ultra-oligotrophic Lake Vanda in Antarctica (that has had a permanent 12-ft ice cover for the past 2000 years) and the more than 1332-ft deep Lake Superior, to many lakes and reservoirs that experience excessive bluegreen algae blooms. He has been involved in assessing excessive aquatic plant growth in Delta waters for the past 25 years. A summary of his experience in excessive fertilization management is presented in:

Lee, G. F., "G. Fred Lee's Expertise and Experience in Investigating & Managing Excessive Fertilization in Waterbodies and Developing Nutrient Criteria," Submitted to SWRCB Nutrient Objectives Stakeholder Advisory Group (SAG), Sacramento, CA by G. Fred Lee & Associates, El Macero, CA, June (2014). http://www.gfredlee.com/exp/GFL_Nutrient_Expertise.pdf

He and Dr. Jones-Lee have developed more than 50 professional papers and reports on their studies, many of which are available on their website www.gfredlee.com in the Nutrients & Eutrophication section at http://www.gfredlee.com/pexfert2.html.

A summary of their comments on the CVRWQCB draft Charter Nutrient Management Strategy is:

Lee, G. F., and Jones-Lee, A., "Comments on the 'CVRWQCB Draft Charter Document – Process to Develop a Delta Nutrient Management Strategy' dated December 22, 2014," Submitted to the Central Valley Regional Water Quality Control Board, by G. Fred Lee & Associates, El Macero, CA, February 20 (2015). http://www.gfredlee.com/SJR-Delta/NutrientMgtStrategyDelta12_2014Com.pdf

That report contains references, with Internet links, to their writings on Delta nutrient management. As summarized in those comments and in reports on their website, as a member of the California Water Environmental Modeling Forum (CWEMF) steering committee Dr. Lee organized a one-day workshop devoted to CWEMF Delta Nutrient Water Quality Workshop in 2008. That workshop brought together recognized experts on various aspects of Delta nutrient-related water quality to present summaries of the state of understanding in their areas of Delta nutrient-related water quality expertise. Background information on the development of, and information provided at that workshop is available as:

Lee, G. F., and Jones-Lee, A., "Delta Nutrient Water Quality Modeling Workshop — Background Information," Report of G. Fred Lee & Associates, El Macero, CA, September (2007). http://www.gfredlee.com/Nutrients/NutrWorkshopRev4.pdf

Lee, G.F., "Overview of Delta Nutrient Water Quality Problems: Nutrient Load – Water Quality Impact Modeling," Agenda for Technical Workshop sponsored by California Water and Environmental Modeling Forum (CWEMF), Scheduled for March 25, 2008 in Sacramento, CA (2008). http://www.gfredlee.com/SJR-Delta/CWEMF_Workshop_Agenda.pdf

Lee, G. F., and Jones-Lee, A., "Synopsis of CWEMF Delta Nutrient Water Quality Modeling Workshop – March 25, 2008, Sacramento, CA," Report of G. Fred Lee & Associates, El Macero, CA, May 15 (2008). http://www.gfredlee.com/SJR-Delta/CWEMF_WS_synopsis.pdf

The power point presentations made by each of the presenters at the workshop are available as, "Overview of Delta Nutrient Water Quality Problems: Nutrient Load – Water Quality Impact Modeling," http://www.cwemf.org/workshops/NutrientLoadWrkshp.pdf

The Agenda for that workshop is appended to these comments.

OECD Eutrophication Study

Dr. Lee has been involved investigating the role of nutrients in excessive algal growth and water quality impacts since he established the Water Chemistry Program at the University of Wisconsin, Madison in 1960. A considerable component of Dr. Lee's experience in elucidating the relationship between nutrient (N and P) loads to waterbodies and their water quality response was gained in his role in the Organization for Economic Cooperation Development (OECD) international eutrophication studies in the 1970s. Those studies were coordinated by Dr. Richard Vollenweider at the Canadian Center for Inland Waters and the OECD headquarters in Paris, France. Those studies involved studies of waterbodies in 22 countries in Western Europe, North America, Japan and Australia over a five-year period at a total cost of about $50-million and was devoted to examining and quantifying the relationships between N and P loads to waterbodies and their eutrophication-related response as measured by planktonic algal chlorophyll. Dr. Lee was appointed by the US EPA to represent the US on the OECD steering committee to help plan the studies, review the results, and develop the final report for the international studies. Dr. Lee was also awarded the US EPA contract to develop a synthesis report for the approximately 100 US waterbodies included in those studies. The summary of the US findings, which were available years ahead of the international report, were published as:

> Rast, W., and Lee, G. F., "Summary Analysis of the North American (US Portion) OECD Eutrophication Project: Nutrient Loading--Lake Response Relationships and Trophic State Indices," EPA 600/3-78-008, US EPA Corvallis, OR (1978). http://www.gfredlee.com/Nutrients/Rast_Lee_OECD_Report.pdf
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> Lee, G. F., Rast, W., and Jones, R. A., "Eutrophication of Water Bodies: Insights for an Age-Old Problem," Environ. Sci. & Technol. 12:900-908 (1978). http://www.gfredlee.com/Nutrients/Eutrophication-EST.pdf

The US data, as well as the data from the entire study database subsequently released, revealed a normalizing approach for phosphorus loads that resulted in strong relationships between P loads to waterbodies and their planktonic algal chlorophyll concentrations. The normalization factor was the waterbody mean depth and hydraulic residence time. Subsequent to completion of the international studies Drs. Lee and Jones-Lee continued to examine data for another approximately 500 waterbodies located in many areas of the world using the OECD modeling approach expanded to OECD data base to about 600 waterbodies, and published several reports on their findings including:

> Jones, R. A. and Lee, G. F., "Eutrophication Modeling for Water Quality Management: An Update of the Vollenweider-OECD Model," World Health Organization's Water Quality Bulletin 11:67-174, 118 (1986). http://www.gfredlee.com/Nutrients/voll_oecd.html
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> Jones, R. A., and Lee, G. F., "Recent Advances in Assessing the Impact of Phosphorus Loads on Eutrophication-Related Water Quality," Journ. Water Research 16:503-515 (1982). http://www.gfredlee.com/Nutrients/RecentAdvWaterRes.pdf

Jones, R. A. and Lee, G. F., "Use of Vollenweider-OECD Modeling to Evaluate Aquatic Ecosystem Functioning," Functional Testing of Aquatic Biota for Estimating Hazards of Chemicals, ASTM STP 988, Amer. Soc. Test. & Mat., Philadelphia, pp. 17-27 (1988). http://www.gfredlee.com/Nutrients/EcosystemFunctionOECD.pdf

Additional papers and reports on the application of the OECD eutrophication modeling approach developed by Lee, Rast, and Jones-Lee are available at www.gfredlee.com in the Nutrients & Eutrophication section at http://www.gfredlee.com/pexfert2.html. Overall it has been found that for most lakes, reservoirs, and some estuaries there is a strong relationship between normalized P load and planktonic algal chlorophyll. Furthermore, they evaluated and described the predictive capability of this modeling approach using actual data collected from waterbodies before and after nutrient load reductions had taken place, rendering this modeling approach to be essentially the only one verified by independent data. That work was published in:

Rast, W., Jones, A., and Lee, G. F., "Predictive Capability of US OECD Phosphorus Loading-Eutrophication Response Models," Journal Water Pollution Control Federation 55(7):990-1003 (1983).
http://www.gfredlee.com/Nutrients/PredictiveCapabilityOECD.pdf

Expertise and Experience in Bluegreen Algae Blooms

Dr. Lee's experience in studying bluegreen algae blooms began in 1961 when he became a Professor of Water Chemistry at the University of Wisconsin, Madison. The Water Chemistry Laboratory was located on the shore of Lake Mendota, a highly eutrophic lake, which measured 5 by 7 miles and 84 feet deep. Lake Mendota was one of the most studied lakes in the world; each summer it experienced heavy bluegreen algal blooms, each winter was ice-covered from mid-December through March. Nutrient sources were agricultural and urban runoff.

From his home and laboratory Dr. Lee observed algae blooms almost daily during the summer. During the 13 years that he held a professorship at UW he had about 50 graduate students conduct studies on Lake Mendota as part of their MS or PhD thesis and dissertations; most of those studies were focused on relationships between nutrient sources/loads/concentrations and the aquatic chemistry of nutrients and algal blooms. Many of the professional papers developed from these studies are available on www.gfredlee.com in the Nutrients & Eutrophication section at http://www.gfredlee.com/pexfert2.html.

In 1973 Dr. Lee was appointed Professor of Engineering at the University of Texas, Dallas and Director of Environmental Studies. He conducted several detailed studies of waterbodies in the North Texas area including Lake Ray Hubbard a water supply reservoir for the City of Dallas. That lake experienced severe bluegreen algal blooms which resulted in strong taste and odor problems. His studies investigated the impact of controlling the phosphorus loads from domestic wastewater sources on the magnitude of the bluegreen algal blooms, and are discussed in:

Archibald, E. M. and Lee, G. F., "Application of the OECD Eutrophication Modeling Approach to Lake Ray Hubbard, Texas," J. Am. Water Works Assoc. 73:590-599 (1981)
http://www.gfredlee.com/Nutrients/OECDLakeRayHub.pdf

Lee, G. F. and Meckel, E., "Estimated Impact of Diversion of Garland-Rowlett

Wastewater Treatment Plant Effluent on Water Quality in Lake Ray Hubbard," Occasional Paper No. 30, Department of Civil & Environmental Engineering, New Jersey Institute of Technology, Newark, NJ, March (1978).

Lee, G. F., Abdul-Rahman, M. and Meckel, E., "A Study of Eutrophication, Lake Ray Hubbard, Dallas, Texas," Occasional Paper No. 15, Department of Civil & Environmental Engineering, New Jersey Institute of Technology, Newark, NJ, September (1978).

In the 1980s Dr. Lee held the position of Professor of Environmental Engineering at Colorado State University. In that position he conducted studies of the impact of Fort Collins CO domestic wastewater discharges on local water reservoirs including:

Lee, G. F. and Jones, R. A., "Impact of Fort Collins, CO Domestic Wastewater Discharges on Water Quality in Fossil Creek and Timnath Reservoirs," Report to Fort Collins, CO Department of Public Works, G. Fred Lee and Associates - EnviroQual, Maplewood, NJ, February (1982).

Those reservoirs experienced strong bluegreen algal blooms as a result of the phosphorus loads from domestic wastewaters. Drs. Lee and Jones worked with the Rawhide Electric Generating Station to evaluate the water quality that would result in a cooling lake/reservoir whose water source was domestic wastewaters from Fort Collins, CO. Using the OECD Vollenweider modeling approach and the database they developed, they predicted that the Rawhide Electric Generation Station cooling lake would experience heavy bluegreen algae blooms due to the high levels of phosphorus and nitrogen in the wastewater inputs relative to the morphologic and hydrologic characteristics of the reservoir. Their findings are described in:

Lee, G. F. and Jones, R. A., "Water Quality Management Program for Rawhide Electric Generating Station Cooling Impoundment," Report to Platte River Power Authority, Report of G. Fred Lee & Associates El Macero, CA September (1980). NTIS PB 82-111980.

Jones, R. A. and Lee, G. F., "Development of Water Quality Management Program for the Rawhide Electric Generating Station Cooling Impoundment: A Domestic Wastewater Reuse Project," In: Water Reuse in the Future, Proc. AWWA Denver, CO, pp 1945-1978 (1982).
http://www.gfredlee.com/ReclaimWW/Rawhide_Wastewater_Reuse.pdf

They also examined the impact of treating the Danbury, CT domestic wastewaters to remove phosphorus on water quality in receiving waters of Lake Lillinonah:

Jones, R.A. and Lee, G. F., "Evaluation of the Impact of Phosphorus Removal at the Danbury, Connecticut Sewage Treatment Plant on Water Quality in," Occasional Paper No. 31, Department of Civil & Environmental Engineering, New Jersey Institute of Technology, Newark, NJ, April (1978).

Similar evaluations were made concerning the impact of reuse of domestic wastewaters as a water source for recreational lakes in Lubbock, TX:

Lee, G. F., and Jones-Lee, A., "Indirect Reuse of Domestic Wastewater for Recreational Lakes: Evaluation of the Sanitary Quality of the Yellowhouse Canyon Lakes, Lubbock, Texas," Proc. AWRA Symposium: Water Supply and Water Reuse: 1991 and Beyond, American Water Resources Association, pp. 435-449, June (1991).
http://www.gfredlee.com/ReclaimWW/Water_Reuse_Yellowhouse.pdf

For several years in the late-1960s–early 1970s, Dr. Lee served as member of the International Joint Commission for the Great Lakes (IJC) Water Quality Management Committee. He and his graduate students conducted studies on the impacts of altering the phosphorus loads to the Great Lakes Superior, Michigan, Erie, and Ontario on algal-related water quality. The Lake Ontario studies focused on excessive growths of *Cladaphora* in the nearshore waters.

Cowen, W. F., Sirisinha, K. and Lee, G. F., "Nitrogen and Phosphorus in Lake Ontario Tributary Waters," Water, Air, Soil Pollut. 10:343-350 (1978).

As discussed in Lee and Jones-Lee writings on eutrophication management they have found that the OECD Vollenweider modeling can be used to evaluate the impact of altering phosphorus loads to a waterbody on the planktonic algal chlorophyll in the waterbody. The following paper discussed the technical foundation for such evaluation:

Rast, W., Jones, A., and Lee, G. F., "Predictive Capability of US OECD Phosphorus Loading-Eutrophication Response Models," Journ. Water Pollut. Control Fed. 55(7):990-1003 (1983).
http://www.gfredlee.com/Nutrients/PredictiveCapabilityOECD.pdf

Overall, as discussed and referenced herein Drs. Lee and Jones-Lee have extensive experience in investing nutrient-related water quality problems in a wide variety of waterbodies and within the Delta. Their experience supports the conclusions reported in the Executive Summaries of the draft CVRWQCB white papers – Namely there is very limited understanding of the role of aquatic plant nutrients N and P in contributing to the nutrient-related water quality problems in the Delta.

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Technical Workshop on
Overview of Delta Nutrient Water Quality Problems:
Nutrient Load – Water Quality Impact Modeling
[http://www.cwemf.org/workshops/NutrientLoadWrkshp.pdf]

Tuesday, March 25, 2008
8:30 a.m. to 4:30 p.m.
Secretary of State Building Auditorium, 1500 11th Street, Sacramento, CA.

Objective

The objective of this workshop is to present an overview of the Delta's water quality impairment issues that are associated with aquatic plant nutrients (N and P). The focus will be the current state of information available, and still needed, to model and manage excessive fertilization in the Delta. If there is interest, this overview workshop will be followed at a later date by limited-scope workshops devoted to specific topics such as domestic water supply water-quality concerns, agricultural nutrient sources and their control, and modeling nutrient load–chlorophyll response in the Delta.

Agenda

8:30 a.m. Welcome and Introduction – Rich Satkowski (California Water and Environmental Modeling Forum)

Overview of Delta Nutrient Water Quality Problems Nutrient Load – Water Quality Impact Modeling – Dr. G. Fred Lee (G. Fred Lee & Associates)

The Problems and Relationships to Nutrient Concentrations/Loads

8:45 a.m. Overview of Delta Transport: How Inflows, Diversions, and Exports Affect Flow Patterns and Transport Processes – Tara Smith (Department of Water Resources)

9:15 a.m. Delta Nutrient Drinking Water Quality Issues Delta and Aqueduct Tastes & Odors and Bluegreen Algal (Cyanobacterial) Toxins – Dr. Jeff Janik (California Department of Water Resources)

Taste & Odor Problems in Southern Water Supplies – Dr. Richard Losee (Metropolitan Water District of Southern California), Dr. Bill Taylor (Metropolitan Water District of Southern California)

Delta & Aqueduct Taste & Odor Precursors: Modeling Status – Dr. Paul Hutton (Metropolitan Water District of Southern California)

10:45 a.m. Nutrient Sources for Growth of Exotic Aquatic Plants in the Sacramento San Joaquin Delta – Dr. Lars W.J. Anderson (USDA-Agricultural Research Service), Marcia Carlock (California Department of Boating and Waterways)

1:00 p.m. Low DO Problems in the SJR Deep Water Ship Channel – Mark Gowdy (State Water Resources Control Board)

Modeling Agricultural Nutrient Loads, Algal Biomass, and Low DO in the SJR Deep Water Ship Channel – Dr. Carl Chen and Joel Herr (Systech Engineering, Inc.)

Nutrient Sources, Concentrations/Loads
2:00 p.m. Impact of Sacramento River Input of Phosphorus to the Delta on Algal Growth in the Delta – Dr. Erwin Van Nieuwenhuyse (Bureau of Reclamation) [Summary of his recent paper describing the response of average summer chlorophyll concentration in the Delta to an abrupt and sustained reduction in phosphorus discharge from the Sacramento County Regional Sanitation District wastewater treatment facility.]

3:00 p.m. Conceptual Model of Nutrient Sources in the Central Valley and Delta – Dr. Sujoy B. Roy (Tetra Tech, Inc.)

Regulatory Issues
3:30 p.m. Development of Nutrient Criteria – Steve Camacho (State Water Resources Control Board)

CVRWQCB Drinking Water Policy – Karen Larsen (Central Valley Regional Water Quality Control Board)

CVRWQCB Irrigated Lands Agricultural Conditional Waiver Water Quality Nutrient Monitoring Program – Margie Read (Central Valley Regional Water Quality Control Board)

4:25 p.m. Final Comments
4:30 p.m. Adjourn

CWEMF Delta Nutrient Water Quality Modeling Workshop March 25, 2008
Workshop Speakers

Dr. Lars W. J. Anderson, Lead Scientist/Plant Physiologist, USDA Agricultural Research Service Exotic and Invasive Weed Research, Davis, CA (lwanderson@ucdavis.edu)

Steve Camacho, Environmental Scientist, Planning, Standards, and Implementation Unit, State Water Resources Control Board, Sacramento, CA (scamacho@waterboards.ca.gov)

Marcia Carlock, Aquatic Weed Control Program Manager, California Department of Boating and Waterways, Sacramento, CA (MCARLOCK@dbw.ca.gov)

Dr. Carl W. Chen, President, Systech Engineering, Inc., San Ramon, CA (carl@systechengineering.com)

Mark Gowdy, Water Resources Engineer, Division of Water Rights, State Water Resources Control Board, Sacramento, CA (mgowdy@waterboards.ca.gov)

Joel W. Herr, Vice President and Chief Engineer, Systech Engineering, Inc., San Ramon, CA (joel@systechengineering.com)

Dr. Paul Hutton, Senior Engineer, Water Resources Management Group, Metropolitan Water District of Southern California, Sacramento, CA (phutton@mwdh2o.com)

Dr. Jeff Janik, Limnologist, California Department of Water Resources, Sacramento, CA (jjanik@water.ca.gov)

Karen Larsen, Senior Environmental Scientist, Central Valley Regional Water Quality Control Board, Rancho Cordova, CA (klarsen@waterboards.ca.gov)

Dr. G. Fred Lee, President, G. Fred Lee & Associates, El Macero, CA (gfredlee@aol.com)

Dr. Richard Losee, Water Quality Laboratory, Metropolitan Water District of Southern California, LaVerne, CA (rlosee@mwdh2o.com)

Margie Read, REAII, Chief, Monitoring and Assessment Unit, Irrigated Lands Conditional Waiver Program, Central Valley Regional Water Quality Control Board, Rancho Cordova, CA (mread@waterboards.ca.gov)

Dr. Sujoy B. Roy, Principal Engineer, Tetra Tech, Inc., Lafayette, CA (Sujoy.Roy@tetratech.com)

Rich Satkowski, Executive Director, California Water and Environmental Modeling Forum Sacramento, CA (cwemf@cwemf.org)

Tara Smith, Chief, Delta Modeling, Bay-Delta Office, CA Department of Water Resources Sacramento, CA (tara@water.ca.gov)

Dr. Bill Taylor, Limnologist, Reservoir Team Manager, Water Quality Section, Water Systems Operations, Metropolitan Water District of Southern California, LaVerne, CA (wtaylor@mwdh2o.com)

Dr. Erwin van Nieuwenhuyse, Fisheries Biologist, Division of Environmental Affairs, US Bureau Reclamation, Sacramento, CA (evannieuwenhuyse@mp.usbr.gov)

If there are questions about any of the presentation please contact the presenter. If you have questions about the overall workshop contact G. Fred Lee

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