Stormwater Runoff Water Quality Newsletter
Devoted to Urban/Rural Stormwater Runoff
Water Quality Management Issues
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Editor: Anne Jones-Lee, PhD
Contributor to this Issue:
G. Fred Lee, PhD, PE, BCEE
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This issue of the Newsletter provides information on excessive fertilization (eutrophication)-related water quality problems in the Sacramento San Joaquin Delta (CA), and control of nutrient input from urban and agricultural sources. It serves as background to the CWEMF Delta Nutrient Water Quality Modeling Workshop that will be held on March 25, 2008 in Sacramento, CA (previously announced in Newsletter Volume 10 no. 13). Also included are references and links to sources of information on major nutrient control programs in other parts of the US.

Workshop Announcement

On March 25, 2008 the California Water and Environmental Modeling Forum (CWEMF) will hold a one-day workshop devoted to technical aspects of Sacramento San Joaquin Delta Nutrient Water Quality Issues; the workshop agenda follows these comments. This workshop will provide a unique opportunity for nutrient (nitrogen and phosphorus) dischargers, regulators, and others to become familiar with the characteristics of the water quality problems that are driving the development of nutrient control programs for point and non-point sources in the Central Valley, and to understand the relationships between nutrient discharges/sources and these problems. These issues are especially important to urban and agricultural interests in the Central Valley who will become involved in developing nutrient control programs in the Delta and its tributaries.

This March 25 workshop will present an overview of key, current algae/aquatic weed–related water quality problems in the Delta and in downstream water supply waterbodies. It will include a series of presentations on the current state of knowledge on the magnitude, location, and role of nutrients in causing water quality problems in the Delta. In keeping with the overall mission of CWEMF, attention will also be given to the current ability to reliably model (predict and assess) the changes in nutrient-related water quality characteristics in the Delta and downstream domestic water supplies that would be expected to occur as a result of various nutrient control strategies and flow management options. A summary will be presented of a conceptual model of nutrient sources for the Delta that was developed by Tetra Tech under contract with the USEPA Region 9 to support the current Central Valley Regional Water Quality Board's (CVRWQCB) development of a Drinking Water Policy. That Drinking Water Policy is aimed toward controlling the sources of pollutants such as nutrients, and organic carbon and salts, etc., that causes water quality problems for domestic water supplies that draw on Delta waters. The current Policy is available at,
http://www.swrcb.ca.gov/rwqcb5/water_issues/drinking_water_policy/index.html.

The last session of the workshop will be devoted an overview of nutrient regulatory issues. Presentations will be made on the State Water Resources Control Board's program for development of nutrient water quality criteria, the CVRWQCB's current work in developing the Drinking Water Policy, and the CVRWQCB's Irrigated Lands Ag Waiver program for developing an approach for evaluating excessive nutrient discharges from irrigated agriculture. As these programs develop, there will be increasing attention given to regulating nutrient discharges from agriculture and urban sources to address the water quality impairments caused by nutrients.

The workshop is expected to be the first of a series of more focused workshops devoted to Delta water quality characteristics that are impacted by nutrients discharged to tributaries of the Delta and within the Delta, and how these impacts and key nutrient sources can be evaluated and addressed in a technically valid, cost-effective manner. It is important for all who influence, and are influenced by, algae and aquatic weed-associated water quality problems in the Delta (including nutrient dischargers, domestic water utilities, and those who utilize the water resources of the Delta) to gain an understanding of the issues discussed in this workshop. It is anticipated that there will be an opportunity for those interested to participate in the planning of follow-up workshops.

Rationale

Excessive algae and aquatic weeds, whose growth is driven by nutrient inputs, are the cause of major water quality problems in the Delta. The workshop agenda lists the following as the current major nutrient-related water quality problems in the Delta:

- excessive growths of algae that cause severe taste and odor problems for domestic water utilities that use Delta water as a raw water source. Remedying this problem requires additional expenditures for water treatment. Other nutrient-caused water quality problems for domestic water utilities include shortened filter runs and the potential for increased trihalomethane (THM) precursors that present a potential health threat to domestic water users.
- excessive growths of hyacinth and egeria (water weeds) that impair recreational use of the Delta, degrade the aquatic food web of the Delta, and cause the CA Department of Boating and Waterways (http://www.dbw.ca.gov/aquatic.asp) to spend more than $7 million per year for treatment of Delta waters with herbicides for hyacinth control. The excessive growths of invasive aquatic plants (hyacinth and egeria) have a significant adverse impacts on the aquatic food web of importance to the aquatic resources of the Delta.
- algal populations that die and decompose, leading to low-dissolved-oxygen conditions that inhibit the homing migration of Chinook salmon in the San Joaquin River watershed, reduce fish growth, and at times, cause fish kills. More than $30 million will have to be spent to begin to control the low-DO problem in the San Joaquin River Deep Water Ship Channel near the Port of Stockton. There are also other low-DO problems especially in the South Delta channels that need to be controlled. As discussed in previous issues of this Newsletter (Volume 10 nos. 4, 5, and 6 available at http://www.gfredlee.com/newsindex.htm), by contributing indirectly to oxygen demand, nutrients added to the Delta also indirectly contribute to sediment toxicity.

Also of concern in managing nutrient-caused water quality problems is achieving a balance between minimizing water quality problems and maintaining adequate nutrients to sustain the aquatic food web and a healthy ecosystem in the Delta.

Assessing Impact of Nutrient Control on Fisheries

The assessment of the impact of altering the phosphorus concentrations in various Delta channels needs to include consideration of how those alterations impact fish production in the Delta. Lee and Jones-Lee (1991) described an empirical relationship between fish biomass in various waterbodies and the normalized phosphorus loads (normalized by morphology and hydrology); as the normalized P load increases, phytoplankton increases, increasing fish biomass. There is concern that fish production in the Delta is limited by available phytoplankton biomass. Jassby (2006) discussed this issue in a paper entitled, "Phytoplankton Biomass and Production in the Delta and Suisun Bay: Current Conditions and Trends."

Recently, newspapers including the San Francisco Chronicle (Kay, 2008) have reported on the record low numbers of salmon returning from the Pacific Ocean to spawn in Central Valley rivers. While a variety of possible reasons for the decline in the number of returning salmon were discussed in this article, Heidi Rooks, an environmental program manager in the CA Department of Water Resources said the salmon's woes are probably linked to the Pacific Ocean. According to Rooks as reported in the Kay (2008) article,

"*'Although there are environmental challenges in the Central Valley and the Delta, I'm concerned that ocean conditions, including currents and food sources, are influencing our salmon populations as well.' she said. 'We're working on habitat restoration, but it's not going to address ocean conditions.'"*

The article also stated,

"'They look at the timing of migrations and food availability,' said William Sydeman, a biologist with the Farallon Institutes for Advanced Ecosystem Research. He found that in 2005, 2006 and, to a lesser extent, in 2007, the breeding failures of the Cassin's auklet on the Farallones could be linked to the demise of krill in the marine environment at the time when the birds needed it. Salmon, too, feed on krill, anchovies and other small aquatic creatures, which are affected in abundance by ocean conditions."

The decreased food abundance in the ocean off the coast of California may be related to reduced coastal upwelling of nutrient-rich, deeper Pacific Ocean waters that serve as the base of the coastal food web.

In the 1960-70s, as part of a program to control the excessive fertilization of Lake Erie, the US and Canadian regulatory agencies established that all domestic wastewater dischargers to Lake Erie must significantly reduce the phosphorus concentrations in their effluents. Fish production in Lake Erie decreased after initiation of the domestic wastewater P control program; that decrease was of sufficient magnitude to cause some sportsfishing interests to advocate adding P back to the lake. Ludsin et al. (2003) reviewed the relationship between fish production and P reduction in Lake Erie. Similarly, reducing phosphorus input to the Delta will likely impact the fish production, and could contribute to the pelagic organism decline (POD) in the Delta. It will be important to strike a balance among phosphorus load to the Delta, desired aquatic food web characteristics, as well as the nutrient-related water quality problems of the Delta. Establishing this balance will require an extensive nutrient food web research program that is not now being undertaken.

Impact of P Control on Phytoplankton

While both nitrogen and phosphorus are nutrients important for algal growth, and scarcity of one or both may limit algal production, it has been well-established and demonstrated that under most circumstances sufficiently reducing the P input to a waterbody will effect a decrease in planktonic algae. Van Nuwenhause (2007) (for the Sacramento River Delta) and Lee and Jones-Lee and their associates (for waterbodies world-wide) [Rast et al. (1983), Lee (2001), and Lee and Jones-Lee (2002a)] have described the decreases in phytoplankton biomass that occur with reductions in phosphorus concentrations/loads. The reductions in phytoplankton biomass have occurred even where the reduced phosphorus concentrations have been well-above phytoplankton growth-rate-limiting concentrations. [The February 2008 SCOPE Newsletter (www.ceep-phosphates.org) presents a summary of the van Nuwenhause (2007) paper.] That notwithstanding, the assessment for the Delta should include consideration of how altering the loads of available nitrogen from various sources impacts phytoplankton, hyacinth, and egeria biomass.

The dynamics of phosphorus loads/in-Delta-Channels-concentrations and phytoplankton biomass will need to be better-understood in order to evaluate how changing the phosphorus loads to the Delta will impact desirable primary production. In recent calculations based on the van Nuwenhause (2007) IEP data, Lee and Jones-Lee (unpublished) found that the average summer planktonic algal chlorophyll in the northern and central Delta (6 µg/L) is about 7 µg/L less than expected based on the nutrient concentration–algae coupling that occurs in many other waterbodies through out the world. There are several factors that could contribute to this lower-than-expected planktonic algal biomass. Of particular concern is the grazing of phytoplankton by clams in the Delta and Suisun Bay. In a paper entitled, "Clams –Where, How, and Can We Limit the Damage?" Thompson (2007) reviewed the occurrence and potential impacts of the invasion of the Delta by the marine clam, *Corbula*, and freshwater clam, *Corbicula*. Similar impacts have been reported in Lake Erie and some of the other Great Lakes associated with the invasion of Zebra mussels (USGS, 2008). Zebra mussels have been found to harvest large amounts of phytoplankton in Lakes Erie and Huron and thereby to reduce the base of the phytoplankton food web; this has, in turn, adversely affected fish production.

Sediment Toxicity in the Delta

Lee and Jones-Lee (2007) discussed significant deficiencies in the SWRCB staff's approach for establishing sediment quality objectives for controlling toxicity in aquatic sediments. One of the most glaring deficiencies is the failure to include low-DO, ammonia, and hydrogen sulfide as toxicants in sediment, and hence the failure to consider the role of aquatic plant nutrients in indirectly causing sediment toxicity. As discussed by Lee and Jones-Lee (2007) and in Newsletters 10(4, 5, 6), it has been know for many years that nutrient/algae-caused sediment toxicity is a common and persistent problem in many waterbodies. Further, episodic DO depletion especially near the sediment/water interface associated with suspension of the sediments, enables the ferrous iron and hydrogen sulfide in the sediment to exert rapid DO demand, exacerbating the low-DO problem. This type of toxicity would not be measured in the typical laboratory toxicity tests.

In their synthesis report for the SJR DWSC low-DO study, Lee and Jones-Lee (2003) summarized the studies of Litton (2003) of the University of the Pacific on sediment oxygen demand in the DWSC. Litton found that part of the oxygen demand of the sediments was due to rapid-acting inorganic oxygen demand of the type described above. This contribution of nutrients/algae to sediment toxicity can be expected in some of the other Delta channels. A credible evaluation of the causes of sediment toxicity and its potential control in the Delta and elsewhere must include proper consideration of the role of nutrients that contribute to low-DO, ammonia, and hydrogen sulfide in the sediments that cause sediment toxicity to aquatic life.

Regulating Nutrient Discharges

Establishing wastewater and stormwater runoff discharge limits for nitrogen and phosphorus requires a different approach than is typically followed for other pollutants. For traditional pollutants such as heavy metals, pesticides, and organic compounds, a discharge limit concentration is typically established to be equivalent to the numeric water quality criterion/standard; if a mixing zone is allowed, the discharge limit concentration is applied at the edge of the mixing zone in the receiving water. For aquatic plant nutrients (nitrogen and phosphorus compounds), it is not possible to develop a numeric water quality criterion that has general applicability to lakes, reservoirs, streams, rivers, and wetlands. Each particular waterbody has its own nutrient load–water quality response relationship governed by the waterbody's morphology and hydrology. Further, because aquatic plant nutrients are an essential component of a waterbody's ecosystem, there is need to establish a balance between achieving sufficient nutrient loads/concentrations to maintain the desired productivity of the waterbody's ecosystem and preventing excessive aquatic plant growth that impairs the beneficial uses of the waterbody.

Dr. Lee has had more than 40 years of experience evaluating nutrient impacts on water quality and the control of excessive fertilization of waterbodies in the US and several other countries. He has been involved in Delta nutrient-related water quality issues over the past almost 20 years. Based on that experience, Lee and Jones-Lee (2002a, 2004) discussed issues that need to be considered in establishing acceptable nutrient loads for waterbodies and appropriate nutrient discharge limitations to achieve desired eutrophication-related water quality characteristics of the waterbody. Lee and Jones-Lee stated,

"*In developing the appropriate nutrient criteria, it is suggested that the TMDL development approach is an appropriate approach to follow. This approach involves the following steps:*

- *Developing a problem statement of the excessive fertilization situation of concern.*
- *Establishing the goal of nutrient control (i.e., the desired eutrophication-related water quality).*
- *Determining nutrient sources, focusing on available forms.*
- *Establishing linkage between nutrient loads and eutrophication response (modeling).*
- *Initiating a Phase I nutrient control implementation plan to control the nutrients to the level needed to achieve the desired water quality.*
- *Monitoring the waterbody for three to five years after nutrient control is implemented to determine whether the desired water quality is being achieved.*
- *If not, initiating a Phase II where, through the monitoring results, the load-response model is improved and thereby able to more reliably predict the nutrient loads that are appropriate for the desired water quality.*

This approach is an iterative approach, where, over a period of at least five to possibly 15 years, through two or more consecutive phases, it will be possible to achieve the desired water quality and thereby establish the nutrient loads which can be translated to in-waterbody concentrations and, therefore, the nutrient criteria for the waterbody."

As discussed by Lee and Jones (1988) typical nutrient control programs focus on point sources, such as domestic wastewater discharges, which are required to control their discharges of phosphorus to a given degree, such as 90% P removal, often based on what can be readily achieved rather than the impact the action will have on receiving water quality. It is estimated that the domestic wastewaters for more than 100 million people worldwide are treated to remove a substantial amount of their phosphorus as part of efforts to control excessive fertilization (eutrophication). In situations in which domestic wastewater is the primary source of phosphorus that is causing excessive fertilization of the receiving water, the reduction of P from this source can be effective in controlling excessive fertilization. While P load reduction could be initiated for the phosphorus in domestic wastewaters from Sacramento, Stockton, and elsewhere, that are contributed to the Delta, this approach will not be effective in controlling the excessive fertilization of the Delta because much of the nutrient load is from non-point sources, primarily irrigated agriculture in the Delta watershed.

The February 2008 issue of the SCOPE Newsletter (www.ceep-phosphates.org), provides information on the costs of phosphate removal at domestic wastewater treatment plants, and cites the report by Jiang et al. (2005) entitled, "Estimation of Costs of Phosphorus Removal in Wastewater Treatment Facilities: Adaptation of Existing Facilities." That report states,
"Specifically, upgrades in performance, in a single step, from a plant working at an effluent limit of less than 2.0 mg/l phosphorus to one working with limits variously ranging between less than 1.0 mg/l to less than 0.05 mg/l phosphorus are simulated and the resulting costs of the upgrade estimated. For the most stringent upgrade, for example, to a plant generating an effluent with less than 0.05 mg/l phosphorus, these marginal costs — the cost of the additional phosphorus removed as a result of the upgrade — amount to something of the order of 150-425 $/kg P removed with the upper bound being associated with the smallest plant configuration (1 MGD)."

According to Heidel et al. (2006) the amount of domestic wastewater nitrogen and phosphorus contributed to Central Valley waterbodies varies from 1.3 to 4.2 kgN/person/yr for total nitrogen and 0.30 to 0.48 kgP/person/yr. Based on the estimated cost of P removal cited above for the additional treatment at domestic wastewater treatment plants and the amount of P typically in Central Valley domestic wastewater discharges, the cost of the additional P removal at domestic wastewater treatment plants will range from a few cents to several tens of cents per person per day for the population served by the plant depending on the degree of P removal.

Lee and Jones-Lee (2002b) reviewed key issues that are pertinent to nutrient control from agricultural sources in the Central Valley. As they discussed, highly effective nutrient control from irrigated agriculture will likely be difficult to achieve. It is anticipated that these issues will be discussed in the follow-up CWEMF Delta Nutrient workshops. Dr. M. Moore and R. Kroger of the USDA-ARS National Sedimentation Laboratory, Oxford, MS has agreed to discuss the USDA experience in nutrient control programs from agricultural sources and S. Taylor of RBF Consulting, Irvine, CA has agreed to discuss urban stormwater runoff nutrient sources and their control at a follow-up Delta Nutrient workshop. Moore, Kroger, and Taylor are nationally recognized experts in these topic areas. Also, Dr. R. Dahldren of the University of California, Davis has agreed to discuss nutrient/algal dynamics in the San Joaquin River in a follow-up workshop.

There have been several unsuccessful attempts to control nutrients in agricultural runoff in other parts of the country. As discussed by Lee and Jones-Lee (2002b), programs to control nutrients from agricultural sources have not been effective in the watershed of either Lake Erie (Logan, 2000) or Chesapeake Bay (Sharpley, 2000). The Chesapeake Bay Commission (CBC, 2003, 2004) has issued reports that project that the cost of controlling nutrient (40% reduction) and sediment inputs to the Bay will be about $11 billion.

In November 2007, the US EPA, through the Gulf Hypoxia Task Force, issued a draft plan to reduce nutrient inputs from 31 states in the Mississippi River watershed as part of trying to control the extent of hypoxia (low-DO waters) that occurs in the nearshore waters of the Gulf of Mexico due to algal growth and death. That draft plan is available at http://www.epa.gov/msbasin. Newsletter NL-9-10 presented information on this issue. There is considerable uncertainty about the ability of the proposed plan to achieve the nutrient control needed to alleviate the low-DO problem in the Gulf of Mexico.

Conclusion

Based on the extent of development of nutrient control programs in various parts of the US, it is likely that before long a nutrient control plan will be developed to address the excessive fertilization problems of the Sacramento San Joaquin Delta. All nutrient dischargers and those concerned about the impacts of nutrients in the Delta need to involve themselves in the nutrient regulatory process to ensure, to the extent possible, that whatever approach is developed for controlling excessive fertilization is technically sound and cost-effective.

The March 25, 2008 CWEMF Delta Nutrient Water Quality Modeling Workshop, and the anticipated follow-up workshops, will provide an introduction to several key issues that will need to be considered in developing programs to control excessive fertilization of the Delta while adequately considering the impact of nutrient control on the Delta aquatic resources.

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About the Workshop Organizer

Dr. G. Fred Lee, conference organizer, has been active in the research, evaluation, and cost-effective management of nutrient-caused water quality problems since the early 1960s and has worked with Dr. Anne Jones-Lee on these issues since the mid-1970s. They have published extensively on approaches for developing technically valid, cost-effective evaluation and management plans for excessive fertilization. More recently they have commented on the approaches and problems with nutrient criteria development and nutrient control programs in the following issues of their Stormwater Runoff Water Quality Newsletters: 1-2, 1-3, 1-5, 4-3/4, 5-1, 6-1, 6-2, 7-6/7, 9-1/2, 9-7, 9-8, 9-10, 10-1, 10-2, 10-4, 10-5, 10-6, 10-7, 10-13 (available at www.gfredlee.com).

If there are questions on the March 25, 2008 workshop and potential follow up workshops please contact G. Fred Lee at gfredlee@aol.com.

Technical Workshop†

Overview of Delta Nutrient Water Quality Problems: Nutrient Load – Water Quality Impact Modeling

Tuesday, March 25, 2008
8:30 a.m. to 4:30 p.m.
Secretary of State Building Auditorium, 1500 11th Street, Sacramento, CA.
(Corner of 11th and "O" Streets, First Floor. Please show your ID.)

No-charge for CWEMF members*; $50 for non-members; $10 for student non-members**
Fee payable at the door or by mailing cash or check.
Space is limited. To register, please email your name and affiliation to technicalworkshop@cwemf.org.

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 work-shops 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)
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)

† Workshop organized by Drs. G. Fred Lee and Anne Jones-Lee of G. Fred Lee & Associates, El Macero, California (gfredlee.@aol.com, www.gfredlee.com)

* The following have current CWEMF organizational memberships: CH2M Hill, CCWD, EBMUD, MWDSC, CDWR, SWRCB, USBR, USCOE, USFWS and USGS.

** The workshop fee also provides CWEMF membership until the Annual Meeting in February 2009.

10:30 a.m. **Break**

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)

12:00 p.m. **Lunch**

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 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.*

2:45 p.m. **Break**

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

Regulatory Issues

3:45 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 Reed (Central Valley Regional Water Quality Control Board)

4:20 p.m. **Discussion of Issues Pertinent to Development of Site-Specific Nutrient Criteria for the Delta**
Dr. G. Fred Lee (G. Fred Lee & Associates)

4:30 p.m. **Adjourn** (Please turn in your evaluations)

List of 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)