California's Surface Water Ambient Monitoring Program (SWAMP): Issues of Concern

G. Fred Lee, PhD, PE, DEE & Anne Jones-Lee, PhD
G. Fred Lee & Associates
El Macero, CA
ph: 530-753-9630 fax: 530-753-9956
gfredlee@aol.com www.gfredlee.com

Need to Expand SWAMP

- California Lagged Many Other States Developing Comprehensive Water Quality Monitoring Program
- Good Water Quality Monitoring Programs Exist for Some Waterbodies
  - San Francisco Bay
  - Sacramento River
- Poor Characterization of Others
  - Sacramento/San Joaquin River Delta
  - San Joaquin River & Tributaries
- SWAMP Beginning to Fill Gap in Information on State of Water Quality in CA
- Need to Expand SWAMP to Cover
  - All Waterbodies
  - All Water Quality/Pollution Issues

Information Needed from SWAMP for Many CA Waterbodies

1. What is the overall water quality?
2. To what extent is water quality changing over time?
3. What are the problem areas and areas needing protection?
4. What level of protection is needed?
5. How effective are clean water projects and programs?

SWRCB (2005) report states:

"SWAMP was originally envisioned to provide information for all the California Water Boards' decision-making needs. It was estimated that the program would cost between $59 and $115 million per year and include 87 to 132 staff positions. The current program is funded at $3.4 million and 17 staff positions or approximately 7 percent of what is needed. Implementation of most of the strategy described in this document remains unfunded."

SWAMP Grossly Underfunded

- SWAMP Grossly Underfunded Compared to What Is Needed to Properly Implement a Comprehensive Water Quality Monitoring/ Evaluation Program in Support of SWRCB & Regional Boards' Water Quality Management Programs

Funding SWAMP

Urgent Need for All Who benefit from CA Water Resources to Immediately Begin to Fund Comprehensive Water Quality Monitoring/ Management Program in All Parts of State

Need to Expand SWAMP Activities

- Those Responsible for Developing Monitoring Program Must Be Highly Familiar with Use of Monitoring Data from Water Quality Management Programs
  - Help Ensure Data Usability
- Importance of Independent Review Panel of Individuals Knowledgeable in Developing Water Quality Monitoring Programs
  - Independent Review Essential for Reliable SWAMP

Need To Expand Aquatic Life Toxicity Testing Program

- Should Include Determination of
  - Whether or Not Water Sample is Toxic and
    - Magnitude of the Toxicity
    - Potential for Organophosphorus Pesticides to Be Cause of Toxicity
- See Guidance by Lee and Jones-Lee (2005)

Need to Expand Scope of Pollutants Measured

- Current Approach for Developing Water Quality Monitoring Program Focuses on
  - Priority Pollutants
  - A Few Other Traditional Constituents of Water Quality Concern
    - Heavy Metals
    - Selected Organics

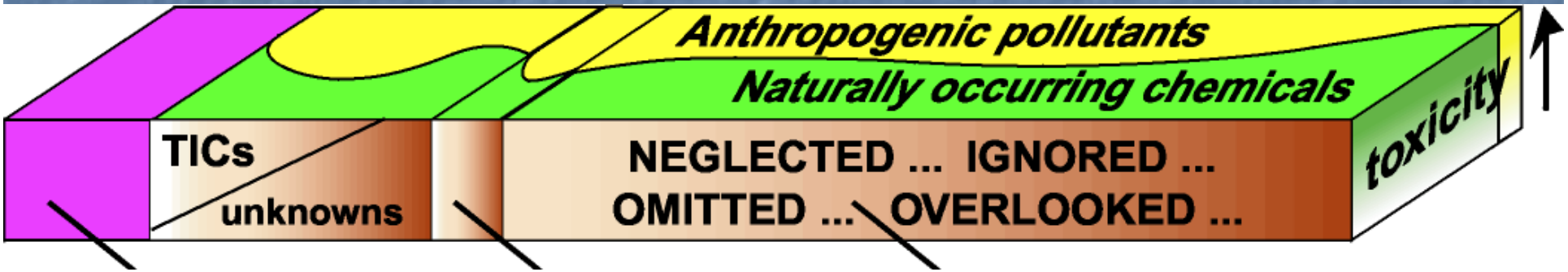
Deficiencies in Monitoring Programs

- Current Approach of Water Quality Monitoring Programs
  - Usually Only Measure Few Dozen to ~ 100 Chemicals
- Now Recognized
  - Many Thousands of Chemicals Discharged to Waterbodies from Municipal, Industrial & Agricultural Sources
    - Most Are Unregulated & Unmonitored
    - Many Have the Potential to Adversely Impact Beneficial Uses of Waterbodies

"Further Truisms Regarding Environmental Monitoring"
Dr. C. Daughton of the US EPA

- *"What one finds usually depends on what one aims to search for.*
- *Only those compounds targeted for monitoring have the potential for being identified and quantified.*
- *Those compounds not targeted will elude detection.*
- *The spectrum of pollutants identified in a sample represent but a portion of those present and are of unknown overall risk significance."*

Daughton, C. C., "The Critical Role of Analytical Chemistry," July (2002)



"TARGET" ANALYTES

RECOGNIZABLE ARTIFACT

Large portion of naturally occurring and anthropogenic chemicals of varied toxicity

TICs = tentatively identified compounds

Need Pro-Active SWAMP

- SWAMP Needs to Become Pro-Active in Searching for Presence Of Unidentified, Unmonitored Pollutants Discharged to State's Waters by Municipal, Industrial & Agricultural Sources
  - Pharmaceuticals from People and Animals
  - PPCPs
  - Present in Wastewaters
  - Have Potential to Adverse to Aquatic Life at Very Low Concentrations
    - Feminization of Male Fish
    - Aquatic Life Toxicity

SWAMP Should Be

Significantly Expanded & Strengthened To Support More Comprehensive, Technically Valid Water Quality Management Programs of the State & Regional Water Quality Boards

More Detailed Discussion

Lee, G. F., and Jones-Lee, A., "Comments on 'Comprehensive Monitoring and Assessment Strategy to Protect and Restore California's Water Quality'," Submitted to California State Water Resources Control Board by G. Fred Lee & Associates, El Macero, CA, December 6 (2005).

http://www.members.aol.com/annejlee/SWAMPcomments.pdf

Further Information

Consult Website of
Drs. G. Fred Lee and Anne Jones-Lee

http://www.gfredlee.com

G. Fred Lee Experience in Water Quality Monitoring Program Development & Utilization

- PhD Environmental Engineering/Science & Aquatic Chemistry Harvard University 1960
  - Expertise in Analytical Chemistry, Aquatic Toxicology/Biology, & Engineering as Applied to Water Quality Evaluation Issues
- 30 yrs University Graduate-Level Teaching & Research on Water Quality Evaluation/Management
- 16 yrs Full-Time Consulting on Water Quality Issues
- 46 yrs Developing Large Water Quality Monitoring Programs in US & for National & International Agencies
- 46 yrs Using Data for Water Quality Evaluation & Management
- Published >100 Papers/Reports on Water Quality Monitoring Program Development & Implementation
  - Developed Evaluation Monitoring Approach for Water Quality Evaluation

Comments on
"Comprehensive Monitoring and Assessment Strategy to Protect and Restore California's Water Quality"

Comments Submitted to the California State Water Resources Control Board by
G. Fred Lee, PhD, DEE and Anne Jones-Lee, PhD
G. Fred Lee & Associates
27298 E. El Macero Drive, El Macero, CA 95618
Ph: (530)753-9630 Fx: (530)753-9956 Em: gfredlee@aol.com
www.gfredlee.com

December 6, 2005

The California State Water Resources Control Board (SWRCB) is conducting a triennial review as part of its Surface Water Ambient Monitoring Program's (SWAMP)'s ongoing programmatic review process. In response to a request for comments on the October 2005 "Comprehensive Monitoring and Assessment Strategy to Protect and Restore California's Water Quality" report (SWRCB 2005), we wish to provide the following comments.

Overall, we find that SWAMP is beginning to fill a highly significant water quality data information gap that exists in California on the current quality of California's waters. As summarized in Appendix A, the senior author (Dr. G. Fred Lee) has been involved in water quality evaluation/management in several parts of the US over the past 45 years. As a result, he has become familiar with other states' water quality monitoring programs. In 1989, when he returned to California to begin full-time consulting in the water quality management field and thereby became familiar with the current state of knowledge on the quality of California's waters, he was shocked to find that there was essentially no information available on the current state of the quality of California's waters. The SWRCB and the Regional Boards had devoted little to no resources to defining the quality of the waters of the state. While several other states, such as in the Midwest and Eastern US, had well-developed water quality monitoring programs in the 1960s, California had no statewide water quality monitoring/evaluation program in the 1990s. It became clear that the approach toward managing California's water resources was largely based on manipulating water flows and doing the minimum necessary to comply with federally imposed regulations, through the Clean Water Act (CWA). Basically, except for a few situations of extreme pollution, the quality of the waters that were being manipulated/impacted, through diversions, waste discharges, etc., was largely ignored. While California is recognized as one of the most progressive states in the nation in addressing air quality issues, California is one of the states that until recently largely ignored water quality management.

An example of this situation is the current pelagic organism decline (POD) in the Sacramento-San Joaquin Delta, where four fish species populations have experienced significant declines over the past three years. One of the reasons that is now being proposed for this decline is the impacts of toxic chemicals on fish or fish food organisms. Beginning with the spring of 2005, a limited-scope "crash" monitoring program was initiated for aquatic life toxicity in the Delta. This program is projected to be expanded and continue for at least two more years. Lee and Jones-Lee (2005a) have recently discussed the current state of information on water quality in

the Delta relative to understanding its role in causing or contributing to the POD. In 2004, Lee and Jones-Lee (2004) presented a comprehensive report on Delta water quality issues. They summarized the known water quality problems in the Delta, which include toxicity due to currently used pesticides; excessive bioaccumulation of legacy pesticides such as DDT, as well as dioxins and PCBs; excessive bioaccumulation of mercury; low dissolved oxygen problems; potential toxicity due to heavy metals; excessive nutrients; etc. They pointed out that the manipulation of waters in the Delta, in support of the federal (US Bureau of Reclamation – USBR) Central Valley Project (CVP) and State Water Project (SWP) export projects, had been conducted without regard to how the export of up to 13,000 cfs of South Delta waters would impact the water quality impacts of the broad range of pollutants that are known to be present in Delta waters. As Lee and Jones-Lee (2005a) point out, there are a number of recognized toxic chemicals and unrecognized chemicals that could be causing/contributing to the POD.

Lee and Jones-Lee (2004) have reviewed the water quality monitoring program that currently exists in the Delta. They point out that the regulatory agencies, such as the SWRCB, Central Valley Regional Water Quality Control Board (CVRWQCB) and the Delta water exporting agencies (USBR and Department of Water Resources – DWR), have failed to implement the water quality monitoring programs that are needed to evaluate the effects of various pollutants that are discharged to the Delta and its tributaries from urban and agricultural sources. Further, while there is no doubt that the Delta water exports by the CVP and SWP are changing the location and magnitude of the impacts of pollutants in the Delta waters, a quantitative assessment of these impacts is lacking.

The lack of water quality information in the Delta is typical of many other waterbodies in the state. It is for this reason that SWAMP is urgently needed to define the following for many waterbodies in the state:

1. What is the overall water quality?
2. To what extent is water quality changing over time?
3. What are the problem areas and areas needing protection?
4. What level of protection is needed?
5. How effective are clean water projects and programs?

While the authors have not been involved with SWAMP, they are familiar with the fact that this program, in some areas of the state, is beginning to provide some water quality information. The SWRCB (2005) report states,

> *"SWAMP was originally envisioned to provide information for all the California Water Boards' decision-making needs. It was estimated that the program would cost between $59 and $115 million per year and include 87 to 132 staff positions. The current program is funded at $3. 4 million and 17 staff positions or approximately 7 percent of what is needed. Implementation of most of the strategy described in this document remains unfunded."*

SWAMP is grossly underfunded compared to the funds needed to properly implement a comprehensive water quality monitoring/evaluation program in support of the SWRCB and the

Regional Boards' water quality management programs. Basically, the state legislature has mandated that the State and Regional Boards carry out comprehensive water quality management programs, without the ability to define the magnitude of the current water quality problems and how water quality in the state is changing as a result of increased population pressures, altered agricultural practices and water pollution control efforts. **There is an urgent need for all of those who benefit from the water resources of the state to begin immediately to fund a comprehensive water quality monitoring/management program in all parts of the state.**

Use of SWAMP Data

There are several aspects of the current SWAMP that need to be addressed as part of implementing the comprehensive water quality monitoring/evaluation program. As part of attempting to use some of the SWAMP data on nutrients in the San Joaquin River, it was found that some of these data were unusable because the analytical methods used did not have adequate sensitivity to determine the nutrient chemicals at potentially significant concentrations. This raises the issue of the overall approach that is being used in SWAMP to select analytical methods for monitoring of the water quality characteristics of the state's waters. Lee and Jones-Lee (2002) developed a report, "Issues in Developing a Water Quality Monitoring Program for Evaluation of the Water Quality – Beneficial Use Impacts of Stormwater Runoff and Irrigation Water Discharges from Irrigated Agriculture in the Central Valley, CA." This report discusses how comprehensive water quality monitoring programs should be developed, implemented and utilized in water quality management programs.

One of the key components of a credible water quality monitoring program is that it is based on measurements with adequate sensitivity and reliability to determine the concentrations of potential pollutants – i.e., those substances that impair the beneficial uses of waterbodies. In order to develop this type of approach, those responsible for developing the monitoring program must be highly familiar with the use of the monitoring data in water quality management programs. Far too often, there is a disconnect between those who develop water quality monitoring programs, and those who must use the data in an evaluation and management program. SWAMP needs to establish an independent review panel of individuals who are knowledgeable in developing water quality monitoring programs and, most importantly, the use of the data generated from such programs in water quality management programs. Adoption of such an approach would eliminate the kinds of problems the authors found with some of the nutrient data that have been developed by SWAMP for the San Joaquin River.

Lee and Jones-Lee (2005b) have developed guidance on the issues that need to be considered in developing a nutrient management program to manage excessive fertilization of Central Valley waterbodies. This program is designed to provide the kinds of information needed to implement the CVRWQCB's water quality objectives for *biostimulatory substances*. It relies on the guidance developed by Lee and Jones-Lee (2002) for developing water quality monitoring programs for nonpoint source pollutants in the Central Valley. Basically, it focuses on first determining what kinds of data are needed to determine if there is a nutrient-caused water quality problem in a waterbody. It then defines the analytical program needed to develop these data. The approach outlined for developing adequate and reliable nutrient data needs to be followed for essentially all of the constituents that are monitored in SWAMP, where an expert panel

reviews the utility of the data being generated with respect to their use in water quality evaluation and management programs.

Aquatic Life Toxicity Testing

As additional funds become available to support SWAMP, there is need to expand the aquatic life toxicity testing program. During the mid- to late 1990s, the authors developed, implemented and reported on a comprehensive aquatic life toxicity monitoring program for tributaries of Upper Newport Bay in Orange County, California (Lee and Taylor 2001). This total effort amounted to about half a million dollars. As part of that effort, they utilized an aquatic life toxicity testing approach that had been developed by CVRWQCB staff and the University of California, Davis, Aquatic Toxicology Laboratory. This program included not only determining if a water sample was toxic, but also the magnitude of the toxicity and the potential for organophosphorus pesticides to be the cause of the toxicity. Recently, Lee and Jones-Lee (2005c) have written up this approach as part of providing guidance to the CVRWQCB Ag Waiver water quality monitoring program in implementing the aquatic life toxicity testing that is being conducted under this program. This monitoring approach is the approach that should be used in SWAMP to implement aquatic life toxicity testing. It will require additional funding beyond that currently available for aquatic life toxicity testing.

Proactive Approach for Finding Unidentified Pollutants

The current approach for developing a water quality monitoring program focuses on the Priority Pollutants and a few other traditional constituents of water quality concern (such as heavy metals, selected organics, etc.). This approach leads to a water quality monitoring program that may only measure a few dozen to a hundred or so chemicals. It is being recognized that there are many thousands of chemicals discharged to waterbodies from municipal, industrial and agricultural sources, which are unregulated and unmonitored, and which have the potential to impact the beneficial uses of waterbodies.

Presented below is a summary of the current situation for monitoring potentially toxic chemicals nationally, that was developed by Dr. Christian Daughton, Chief of the Environmental Chemistry Branch (ECB), Environmental Sciences Division, US Environmental Protection Agency. Daughton (2002) discussed the fact that the current approach for monitoring pollutants associated with domestic wastewaters and landfill leachate measures only a very small number of the many thousands of chemicals commonly present in homes that are a threat to human health and wildlife in the environment. Daughton (2004a, b) highlighted the growing concern about unrecognized, unregulated pollutants, indicating that there are over 22 million organic and inorganic substances, with nearly 6 million commercially available. The current water quality regulatory approach addresses fewer than 200 of these chemicals. There could readily be yet-to-be-recognized, unregulated chemicals in the many thousands of chemicals that are discharged to and occur within the state's waters that are contributing to impairment of beneficial uses.

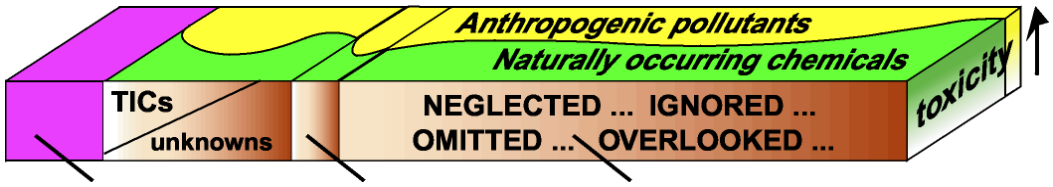
The inadequacy of current regulatory programs in defining hazardous chemicals has been discussed by Daughton, in his presentation, "Overview of Science Involved with Pharmaceuticals," that was made on August 23, 2005, at a Las Vegas workshop. Daughton stated in one of his PowerPoint slides,

"Further Truisms Regarding Environmental Monitoring

- *What one finds usually depends on what one aims to search for.*
- *Only those compounds targeted for monitoring have the potential for being identified and quantified.*
- *Those compounds not targeted will elude detection.*
- *The spectrum of pollutants identified in a sample represent but a portion of those present and are of unknown overall risk significance."*

He presented a diagram of this situation, which is presented in Figure 1. Dr. Daughton's presentation at the Las Vegas workshop is available from gfredlee@aol.com upon request. While this presentation focused on pharmaceuticals, as he has discussed in other presentations and his writings, it is applicable to the full arena of hazardous chemicals that are not adequately identified, monitored and regulated.

Figure 1
Chemical Analysis Output for a Typical Environmental Sample



TICs = tentatively identified compounds

This figure is cited from the following web page:
Daughton, C. C., "The Critical Role of Analytical Chemistry," July (2002)
http://www.epa.gov/nerlesd1/chemistry/pharma/critical.htm

As additional funds become available to support SWAMP, there is need for SWAMP to become proactive in searching for the presence of unidentified, unmonitored pollutants that are discharged to the state's waters by municipal, industrial and agricultural sources.

Overall
There is need to significantly expand and strengthen SWAMP to support more comprehensive, technically valid water quality management programs of the State and Regional Water Quality Boards.

References
Daughton, C. G., "The Critical Role of Analytical Chemistry," July (2002).
http://www.epa.gov/nerlesd1/chemistry/pharma/critical.htm

Daughton**,** CG "Non-Regulated Water Contaminants: Emerging Research," *Environ. Impact Assess. Rev.*, *24*(7-8):711-732 (in A. Steinemann and J Tickner, eds.: "Environment and Health - New Answers, New Questions," special issue (2004a).
http://www.sciencedirect.com/science/journal/01959255.

Daughton**,** C.G., "PPCPs in the Environment: Future Research — Beginning with the End Always in Mind," In *Pharmaceuticals in the Environment*, Kümmerer, K. (Ed.), 2nd edition, Springer, (2004b), Chapter 33, pp. 463-495. also see
http://search.epa.gov/s97is.vts and
http://www.epa.gov/esd/chemistry/pharma/tracers.htm.

Lee, G. F. and Jones-Lee, A., "Issues in Developing a Water Quality Monitoring Program for Evaluation of the Water Quality - Beneficial Use Impacts of Stormwater Runoff and Irrigation Water Discharges from Irrigated Agriculture in the Central Valley, CA," California Water Institute Report TP 02-07 to the California Water Resources Control Board/ Central Valley Regional Water Quality Control Board, 157 pp, California State University Fresno, Fresno, CA, December (2002). http://www.gfredlee.com/Agwaivermonitoring-dec.pdf

Lee, G. F. and Jones-Lee, A., "Overview of Sacramento-San Joaquin River Delta Water Quality Issues," Report of G. Fred Lee & Associates, El Macero, CA, June (2004).
http://www.members.aol.com/apple27298/Delta-WQ-IssuesRpt.pdf

Lee, G. F., and Jones-Lee, A., "Water Quality Issues That Could Influence Aquatic Life Resources of the Delta," Comments submitted to CALFED Science Program, Sacramento, CA, by G. Fred Lee & Associates, El Macero, CA, November 28 (2005a).
http://www.members.aol.com/annejlee/POD-Com.pdf

Lee, G. F., and Jones-Lee, A., "Interpretation of Nutrient Water Quality Data Associated with Irrigated Agricultural Ag Waiver Monitoring," Submitted to Central Valley Regional Water Quality Control Board, Rancho Cordova, CA, by G. Fred Lee & Associates, El Macero, CA, November (2005b). http://www.members.aol.com/annejlee/InterprNutrWQData.pdf

Lee, G. F. and Jones-Lee, A., "Recommended Pesticide-Caused Aquatic Life Toxicity Monitoring," Report of G. Fred Lee & Associates, El Macero, CA, November 4 (2005c).
http://www.members.aol.com/annejlee/PestToxMonitor.pdf

Lee, G. F. and Taylor, S., "Results of Aquatic Toxicity Testing Conducted During 1997-2000 within the Upper Newport Bay Orange County, CA Watershed," Report of G. Fred Lee & Associates, El Macero, CA (2001). http://www.members.aol.com/apple27298/295-319-tox-paper.pdf

SWRCB, "Comprehensive Monitoring and Assessment Strategy to Protect and Restore California's Water Quality," California State Water Resources Control Board, Sacramento, CA (2005).

Appendix A

Summary of Drs. G. Fred Lee and Anne Jones-Lee's Expertise and Experience in Developing Water Quality Monitoring Programs

Dr. G. Fred Lee is President of G. Fred Lee and Associates, which consists of Drs. G. Fred Lee and Dr. Anne Jones-Lee (Vice President) as the principals in the firm. They specialize in addressing advanced technical aspects of water supply water quality, water and wastewater treatment, water pollution control, and solid and hazardous waste impact evaluation and management.

After obtaining a bachelor's degree at San Jose State University in 1955, a Master of Science Degree in Public Health from the University of North Carolina in 1957 and a PhD from Harvard University in 1960 in Environmental Engineering and Environmental Sciences, Dr. Lee taught graduate-level university environmental engineering and environmental science courses for 30 years at several major U.S. universities. During this time, he conducted over $5 million of research and published over 500 papers and reports.

Dr. Lee was active as a part-time consultant during his 30-year university teaching and research career. Drs. G. F. Lee and A. Jones-Lee have been full-time consultants since 1989. Dr. Lee has extensive experience in developing approaches that work toward protection of water quality without significant unnecessary expenditures for chemical constituent control. He has been active in developing technically valid, cost-effective approaches for the evaluation and management of chemical constituents in domestic and industrial wastewater discharges and urban and rural stormwater runoff since 1960.

Dr. Anne Jones-Lee was a university professor for a period of 11 years in environmental engineering and environmental sciences. She has a BS degree from Southern Methodist University and obtained a PhD in Environmental Sciences in 1978 focusing on water quality evaluation and management from the University of Texas at Dallas. At the New Jersey Institute of Technology she held the position of Associate Professor of Civil and Environmental Engineering with tenure. She and Dr. G. F. Lee have worked together as a team since the mid-1970s.

Dr. G. F. Lee has been an active participant in helping to organize and review the adequacy of the water quality monitoring programs conducted in the Sacramento River Watershed Program since the mid-1990s. Further, he is familiar with the San Joaquin River watershed and Delta water quality monitoring database through active participation in the San Joaquin River DO TMDL program, where he was PI coordinator for an approximately $2 million/year CALFED-sponsored Directed Action water quality evaluation and management program in the San Joaquin River watershed, as it relates to impacts of constituents derived from the watershed on water quality in the San Joaquin River and the Deep Water Ship Channel near Stockton. Dr. G. F. Lee was a part of the review team for the IEP monitoring program for water quality in the Delta.

Dr. G. F. Lee has been a member of the APHA, *et al*., (1998) Standard Methods committee for development of Standard Methods for the Examination of Water and Wastewater since the early 1960s. Also during this time, he has been a member of the ASTM Committee D-19 on Water. This committee work involves his periodically reviewing new or revised analytical methods for water and wastewater components. It enables him to stay current with analytical method development and their appropriate utilization.

In 2001 the authors completed an approximately half-million-dollar, five-year water quality monitoring and evaluation study in Orange County, CA, on behalf of the Santa Ana Regional Water Quality Control Board. Their work included studies on organophosphate (OP) and organochlorine pesticides and PCBs (OCls) and heavy metals. The results of this program are being used by the Santa Ana Regional Board as a basis for developing several TMDLs in the Upper Newport Bay watershed.

Dr. G. F. Lee has over 37 years of experience working on helping to develop, implement and evaluate water quality criteria and state standards based on US EPA criteria. This experience includes advising a number of states (such as Wisconsin, Texas and Colorado) on the development of appropriate water quality criteria. Further, Dr. G. F. Lee was part of the National Academies of Science and Engineering's "Blue Book" of water quality criteria peer review panel that developed the Blue Book of water quality criteria in 1972. In the late 1970s he was a member of the American Fisheries Society Water Quality Section panel that reviewed the US EPA "Red Book" of water quality criteria released in 1976. Further, in the early 1980s Dr. G. F. Lee was a US EPA invited peer reviewer for the then proposed water quality criteria development approach. This is the approach that is still being used today to develop new water quality criteria. In addition, Dr. G. F. Lee served as an invited peer reviewer for several sections of the US EPA "Gold Book" of water quality criteria (ammonia and copper) as part of promulgating the Gold Book criteria in 1986.

Overall, Dr. G. F. Lee is highly familiar with how water quality criteria have been developed, their strengths and weaknesses, and, most importantly, their proper application in water quality management programs. He and Dr. Jones-Lee published an invited paper, "Appropriate Use of Numeric Chemical Water Quality Criteria," discussing how the US EPA criteria and state water quality standards based on these criteria should be implemented, considering the approach for their development and their appropriate use to regulate constituents in ambient waters from various sources.

Dr. G. F. Lee has extensive experience in conducting water quality monitoring/water quality impact evaluation studies from agricultural and urban stormwater runoff. These studies were initiated in the early 1960s while he held the position of Professor of Water Chemistry and Director of the Water Chemistry Program at the University of Wisconsin, Madison. As Vice Chair of the Lake Mendota Problems Committee, he worked with the committee members representing various university departments to develop nutrient export coefficients from various types of agricultural lands in the Lake Mendota watershed. These coefficients have subsequently, through additional studies, been found to have national application in assessing the amounts of nitrogen and phosphorus derived from agricultural lands, as well as urban areas.

In the 1970s, the US EPA Great Lakes program selected Dr. G. Fred Lee to develop a water quality monitoring program for the Great Lakes focusing on toxic constituents. Upon moving back to California in 1989, Dr. G. Fred Lee and Dr. Anne Jones-Lee brought that report up-to-date with respect to broadening its scope where it now focuses on stormwater runoff water quality impacts. That report, "Guidance for Conducting Water Quality Studies for Developing Control Programs for Toxic Contaminants in Wastewaters and Stormwater Runoff," emphasizes the importance of properly developing a monitoring program to ensure that meaningful results are developed that can be used to appropriately manage water quality without unnecessary expenditures for constituent control from various sources.

A list of recent Lee and Jones-Lee publications concerned with water quality monitoring issues is presented below. Many of their publications are available from their website, www.gfredlee.com.

Lee, G. F., "Inadequate Approach for Implementation of the SJR OP Pesticide TMDL Compliance Monitoring," Comments submitted to William Jennings, California Sportfishing Protection Alliance, by G. Fred Lee & Associates, El Macero, CA, November 8 (2005). http://www.members.aol.com/annejlee/OPPestSJRBasinPlanAmend.pdf

Lee, G. F. and Jones-Lee, A., "Recommended Pesticide-Caused Aquatic Life Toxicity Monitoring," Report of G. Fred Lee & Associates, El Macero, CA, November 4 (2005). http://www.members.aol.com/annejlee/PestToxMonitor.pdf

Lee, G., F., and Jones-Lee, A., "Need for Reliable Water Quality Monitoring/Evaluation of the Impact of SWRCB Water Rights Decisions on Water Quality in the Delta and Its Tributaries," Submitted to CA Water Resources Control Board Workshop on D-1641 Water Rights, Sacramento, CA, March 22 (2005). http://www.members.aol.com/annejlee/DeltaWaterExportImpactsPaper.pdf

Lee, G., F., and Jones-Lee, A., "Need for Reliable Water Quality Monitoring/Evaluation of the Impact of SWRCB Water Rights Decisions on Water Quality in the Delta & Its Tributaries," PowerPoint Slides Submitted to CA Water Resources Control Board Workshop on D-1641 Water Rights, Sacramento, CA, March 22, (2005). [153 kb] http://www.members.aol.com/annejlee/DeltaWaterExportImpactsPowerPoint.pdf

Lee, G. F., "Comments on the Monitoring and Reporting Program for CVRWQCB Order No. R5-2003-0826 Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands, Dated July 11, 2003," Submitted to California Regional Water Quality Control Board, Central Valley Region, Sacramento, CA, by G. Fred Lee & Associates, El Macero, CA, September 11 (2003).

Lee, G. F., "Comments on SWRCB January 9, 2004 Review of Irrigated Agriculture Waiver Water Quality Monitoring Requirements," Comments submitted to the California State Water Resources Control Board by G. Fred Lee & Associates, El Macero, CA, January 19 (2004). http://www.gfredlee.com/AgWaiverComments1-19-04.pdf

Lee, G. F., "Need for Comprehensive Monitoring to Justify Issuance of a Waiver of WDRs for Irrigated Agriculture and Managed Wetlands in the Central Valley of California," Submitted to Tom Pinkos, Executive Officer, Central Valley Regional Water Quality Control Board, by G. Fred Lee & Associates, El Macero, CA, May 20 (2003).

Lee, G. F., "Comments on SWRCB January 9, 2004 Review of Irrigated Agriculture Waiver Water Quality Monitoring Requirements," Submitted to the California State Water Resources Control Board by G. Fred Lee & Associates, El Macero, CA, January (2004).

Lee, G. F. and Jones-Lee, A., "Issues in Developing a Water Quality Monitoring Program for Evaluation of the Water Quality - Beneficial Use Impacts of Stormwater Runoff and Irrigation Water Discharges from Irrigated Agriculture in the Central Valley, CA," California Water Institute Report TP 02-07 to the California Water Resources Control Board/ Central Valley Regional Water Quality Control Board, 157 pp, California State University Fresno, Fresno, CA, December (2002). http://www.gfredlee.com/Agwaivermonitoring-dec.pdf

Lee, G. F. and Jones-Lee, A., "Developing Central Valley, California, Agricultural Runoff/Discharges Water Quality Monitoring Programs," Proceedings of 2003 AWRA Spring Specialty Conference, "Agricultural Hydrology and Water Quality," American Water Resources Association, Kansas City, MO, May (2003).

Lee, G. F. and Jones-Lee, A., "Evaluation Monitoring vs Chemical Constituent Monitoring Chemical Concentrations vs Chemical Impacts," Presented at CA Water Environment Association Training Seminar, "Recent Advances in Receiving Water Monitoring," Anaheim, CA, February (1999).

Lee, G. F., "Review of 'CALFED Directed Action Proposal: Monitoring and Investigations of the San Joaquin River and Tributaries Related to Dissolved Oxygen,' Proposal Number 262DA," Comments submitted to the DeltaKeeper, Report of G. Fred Lee & Associates, El Macero, CA, October 28 (2003). http://www.members.aol.com/duklee2307/deltakeeper-ups-mon.pdf

Lee, G. F., "Comments on the Draft Monitoring and Toxics Subcommittee PowerPoint Slides Dated February 25, 2004, by Tom Grovhaug," Comments Submitted to Sacramento River Watershed Program by G. Fred Lee & Associates, El Macero, CA, March (2004). http://www.gfredlee.com/grovhaug-comments.pdf

Taylor, S. and Lee, G. F., "Evaluation Monitoring Demonstration Project Phase IV," Eastern Transportation Corridor Drainage Report, submitted to Orange County Transportation Corridor Agency, Silverado Constructors, Irvine CA, December (2000).

Lee, G. F. and Jones-Lee, A., "Development of TMDLs from Evaluation Monitoring Program Results," Report of G. Fred Lee & Associates, El Macero, CA, May (1997).

Lee, G. F., "Stormwater Monitoring: Appropriate Approach," Guest Editorial, *Stormwater* 3:8, May/June (2002).

Jones-Lee, A. and Lee, G. F., "Evaluation Monitoring as an Alternative to Conventional Water Quality Monitoring for Water Quality Characterization/Management," Proc. of the NWQMC National Conference "Monitoring: Critical Foundations to Protect Our Waters," US Environmental Protection Agency, Washington, D.C., pp. 499-512 (1998). http://www.gfredlee.com/wqchar_man.html

Lee, G. F., Jones-Lee, A. and Taylor, S., "Developing of Appropriate Stormwater Infiltration BMPs: Part I Potential Water Quality Impacts, Monitoring and Efficacy Evaluation," Proc. of Ground Water Protection Council's 98 Annual Forum, Sacramento, CA, pp. 55-72, Sept (1998).

Lee, G. F. and Jones-Lee, A., "Evaluation Monitoring as an Alternative to Conventional Stormwater Runoff Monitoring and BMP Development," *SETAC News*, 17(2):20-21 (1997).

Lee, G. F. and Jones-Lee, A., "Evaluation Monitoring for Stormwater Runoff Water Quality Impact Assessment and Management," Presented at Society of Environmental Toxicology & Chemistry 18th Annual Meeting, San Francisco, CA, November (1997).

Lee, G. F. and Jones-Lee, A., "Development and Implementation of Evaluation Monitoring for Stormwater Runoff Water Quality Impact Assessment and Management," Report of G. Fred Lee & Associates, El Macero, CA, June (1997).

Lee, G. F. and Jones-Lee, A., "Stormwater Runoff Quality Monitoring: Chemical Constituent vs. Water Quality," *Public Works*, Part I 147:50-53 (1996), Part II 147:42-45, 67 (1996).

Lee, G. F. and Jones-Lee, A., "Deficiencies in Stormwater Quality Monitoring," In: Proc. Engineering Foundation Conference, American Society of Civil Engineers, New York, NY, pp. 651-662 (1994).

Lee, G. F. and Taylor, S., "Evaluation Monitoring Demonstration Project, Phase 1 Report for Upper Newport Bay and Lower Santa Ana River Quality," Report to Silverado, Irvine, CA, April (1997).

Lee, G. F. and Jones-Lee, A., "Evaluation Monitoring of Stormwater Runoff Water Quality Impacts: Initial Screening of Receiving Waters," Report of G. Fred Lee & Associates, El Macero, CA, 24pp, June (1995).

Lee, G. F. and Jones-Lee, A., "Evaluation Monitoring as an Alternative for Conventional Stormwater Runoff Water Quality Monitoring and BMP Development," Report of G. Fred Lee & Associates, El Macero, CA, April (1997).

Lee, G. F. and Jones-Lee, A., "Water Quality Monitoring of Stormwater Runoff: Chemical Constituent vs. Pollutant Monitoring," Report to the State of California Storm Water Quality Task Force Committee on General Permit Revisions, April (1996).

Lee, G. F. and Taylor, S., "Stormwater Runoff Toxicity in Orange County, CA: A Demonstration of Evaluation Monitoring," Presented at State of CA Stormwater Quality Task Force Meeting, Ontario, CA, November (1997).

Lee, G. F. and Jones-Lee, A., "Evaluation Monitoring for Stormwater Runoff Monitoring and BMP Development," Report of G. Fred Lee & Associates, El Macero, CA, 96pp (1996).

Taylor, S. M. and Lee, G. F., "Evaluation Monitoring Demonstration Project: Phase 1 Report," Report of G. Fred Lee & Associates, El Macero, CA submitted to Silverado Constructors, Irvine, CA, June (1997).

Lee, G. F., Watson, R. A. and Taylor, S. M., "Evaluation Monitoring Program Baseline Implementation Project," In: Technical Appendices Runoff Management Plan for the Eastern Transportation Corridor, Volume 2, Silverado Constructors, Irvine, CA, June (1996).

Lee, G. F. and Jones-Lee, A., "Guidance for Conducting Water Quality Studies for Developing Control Programs for Toxic Contaminants in Wastewaters and Stormwater Runoff," Report of G. Fred Lee & Associates, El Macero, CA, 30pp, July (1992). Available as WQ042 upon request from gfredlee@aol.com.

Lee, G. F., Jones-Lee, A., "Expected Performance of the Pottstown Landfill Containment and Monitoring Systems," Report to Pottstown Landfill Closure Committee, Pottstown, PA, by G. Fred Lee & Associates, El Macero, CA, March (2005).
http://www.members.aol.com/annejlee/PottstownLFPerform.pdf

Lee, G. F., Jones-Lee, A., "Expected Performance of the Pottstown Landfill Containment and Monitoring Systems," PowerPoint slides by G. Fred Lee & Associates, El Macero, CA, presented to Pottstown Landfill Closure Committee, Pottstown, PA, June 1 (2005).
http://www.members.aol.com/annejlee/PottstownLF-PowerPt.pdf

Lee, G. F., and Jones-Lee, A., "Monitoring the Impacts of Landfills during Their Active Life," Report of G. Fred Lee & Associates, El Macero, CA May (2005).
http://www.members.aol.com/annejlee/MoniActiLifeImpactsLFs.pdf

Lee, G. F., and Jones-Lee, A., "Groundwater Quality Monitoring at Lined Landfills: Adequacy of Subtitle D Approaches," Report of G. Fred Lee & Associates, El Macero, CA (1993).
http://www.members.aol.com/apple27298/GW-MONITpaper93.pdf

Lee, G. F. and Jones-Lee, A., "Deficiencies in Subtitle D Landfill Liner Failure and Groundwater Pollution Monitoring," Presented at the NWQMC National Conference "Monitoring: Critical Foundations to Protect Our Waters," US Environmental Protection Agency, Washington, D.C., July (1998). http://www.gfredlee.com/nwqmcl.html

Lee, G. F. and Jones-Lee, A., "Unreliability of Groundwater Monitoring at Lined Landfills," *HydroVisions* 6(3):3, 10-12 (1997).

Lee, G. F., “Revisions of the Draft Water Quality Monitoring Program for the Union Mine Landfill,” Report to Sports Fishing Alliance, San Francisco, CA, submitted by G. Fred Lee & Associates, El Macero, CA, June (1998).

Lee, G. F. and Jones-Lee, A., “Appropriate Monitoring/Evaluation of Stormwater Runoff from Superfund Sites,” Report of G. Fred Lee & Associates, El Macero, CA, May (2000).

Lee, G. F., “Stormwater Runoff and Wastewater Discharge Monitoring Program for the UCD/DOE LEHR National Superfund Site,” Report to DSCSOC, submitted by G. Fred Lee & Associates, El Macero, CA, 13pp, July 20 (1998).

Lee, G. F., and Jones-Lee, A., "Interpretation of Nutrient Water Quality Data Associated with Irrigated Agricultural Ag Waiver Monitoring," Submitted to Central Valley Regional Water Quality Control Board, Rancho Cordova, CA, by G. Fred Lee & Associates, El Macero, CA, November (2005). http://www.members.aol.com/annejlee/InterprNutrWQData.pdf

Lee, G. F., “Followup to the October 24, 2003, Aquatic Pesticide Monitoring Program Steering Committee Meeting,” Comments Submitted to Program Manager, Aquatic Pesticide Monitoring Program, San Francisco Estuary Institute, Oakland, CA (2003).

Lee, G. F. and Jones-Lee, A., “Developing Water Quality Monitoring Programs Associated with the Use of Herbicides in the Control of Aquatic Weeds,” Report of G. Fred Lee & Associates, El Macero, CA (2003). http://www.gfredlee.com/AqWeed_Cont_Mon.pdf

Lee, G. F. and Jones-Lee, A., “Guidance on Pre-, Operational and Post-Operational Monitoring of Ground Water Recharge Projects,” Report of G. Fred Lee and Associates, El Macero, CA, April (1994). http://www.members.aol.com/apple27298/GW_Recharge.pdf

Lee, G. F. and Jones-Lee, A., “Monitoring Reclaimed Domestic Wastewater Usage on Public Parkland Vegetation to Reduce Risks,” *Water Engineering & Management*, 142:28-29,37 (1995).