Comments on
"NPDES Permit Renewal Issues Drinking Water Supply and Public Health
Sacramento Regional County Sanitation District
Sacramento Regional Wastewater Treatment Plant"
Dated 14 December 2009

Submitted by
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In response to a request for comments on issues pertinent to reissue of the Regional County Sanitation District Sacramento Regional (Sac Regional) Wastewater Treatment Plant we offer the following comments.

Overall, we found significant technical deficiencies in the "issues" report. Key among those deficiencies was the limitation of scope of potential water quality impacts considered, as reflected in the water quality criteria/objectives used for evaluation of the impact of the Sac Regional effluent on Delta water quality. For some unexplained reason, "water quality" considerations in the Sac Regional NPDES permit "issues" review were limited to so-called drinking water and sanitary quality/contact recreation issues. The Sac Regional treatment plant discharge stands to potentially adversely impact many other aspects of water quality in the Delta and downstream that were not considered; many of those other aspects are of at least equal importance with drinking water quality issues in the Delta. The CVRWQCB needs to clearly articulate and justify its rationale for not conducting a comprehensive review of all of the potential impacts of the Sac Regional treatment plant discharge on Delta water quality.

In addition to the limitations in water quality scope, substantial, important literature on Delta water quality issues was not reported or considered in the review of the Sac Regional NPDES permit. It is recommended that the "issues" report be redone as necessary to more appropriately and completely address the all potential impacts of the Sac Regional wastewater discharge on Delta water quality.

Background to these Comments
Dr. Lee has been involved in evaluating water quality impacts of domestic wastewater discharges throughout his five-decade-long professional career; he has worked on Delta water quality issues for more than 20 years. Together with Dr. Anne Jones-Lee, he has published extensively on these issues; their papers and reports are available on their website, www.gfredlee.com in the Watershed Studies section and San Joaquin River Watershed-Delta subsection at http://www.gfredlee.com/psjriv2.htm. A summary of Dr. Lee's experience is appended to these comments.

Specific Comments

Page 2: The section headed, "Beneficial Uses and Water Quality Objectives," states,
"The Basin Plan designates beneficial uses for the Sacramento River and the Delta. The Basin Plan includes, in part, the following beneficial uses for the Delta: municipal and domestic water supply (MUN), water contact recreation (REC-1) non-contact water recreation (REC-2), and agricultural water supply (AGR)."

The section neglects to address aquatic life-related beneficial uses of the Delta and downstream waters including numbers and types of fish and aspects that impact propagation of resident and migratory fish populations. This deficiency needs to be corrected. The updated Sac Regional NPDES discharge permit needs to reliably consider how constituents in the wastewater discharge impact **all** of the beneficial uses of the Delta and downstream waterbodies.

Page 3 Table 1, "Water Quality Objectives and Effluent and Sacramento River Concentrations," presents "Lowest Criteria (Human Health)" and concentrations for a list of chemical and pathogen parameters. It includes, as being applicable to the Sac Regional effluent: "Chloroform µg/L 80 Primary MCL." That listing is incorrect for that effluent. The 80 µg/L value is the total trihalomethane (TTHM) MCL for treated drinking water; it is not applicable to a wastewater source. The California Toxics Rule (CTR) did not provide a chloroform criterion for wastewater discharges. The proper criterion for chloroform in a wastewater discharge such as the Sac Regional wastewater discharge to the Sacramento River is the US EPA cancer-risk-based water quality criterion of 5.7 µg/L ("National Recommended Water Quality Criteria 2005")
[http://www.epa.gov/waterscience/criteria/wqctable/nrwqc-2009.pdf]. That criterion value was developed with a risk-based approach similar to that used in the development of the CTR criteria for dichlorobromomethane, dibromochloromethane, and bromoform, the other TTHM components listed in Table 1 of the issues paper. The US EPA risk-based approach used for developing criteria for the latter chemicals also should be used to establish the criterion for chloroform.

Table 1 also presents a water quality objective for ammonia: "1.5 mg/L Taste & Odor Threshold[1]." It has been well-established that ammonia in concentrations much lower than 1.5 mg/L can impact the quality of Delta water, including its quality for use for domestic water supply. The review of the impact of Sac Regional wastewater discharge to the Sacramento River should include a date by which a discussion will be presented on when ammonia discharge limits will be included in the NPDES permit.

Page 4 states in the "Drinking Water Supply Issues" section:
"*For the SRWTP discharge, the drinking water supply issues are primarily far-field issues that are experienced many miles downstream and throughout the Delta.*"
As discussed below, the concerns about the impacts of constituents in the Sac Regional wastewater on drinking water quality extend well-beyond the Delta - to the San Francisco Bay area as well as to southern California water supply reservoirs that receive Delta water as part of their source. The review of potential impacts of Sac Regional wastewater discharges on drinking water quality must include all domestic water supply water quality issues.

The Delta drinking water issues report also neglects to incorporate the large amount of information presented in the California Water and Environmental Modeling Forum workshop devoted to Delta nutrient water quality issues. As organizers of this workshop we have developed the following overview and reviews of information presented therein:

> 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., 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
>
> "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), March 25, 2008 in Sacramento, CA (2008). http://www.gfredlee.com/SJR-Delta/CWEMF_Workshop_Agenda.pdf

The CWEMF workshop agenda and presentations are available online at http://www.cwemf.org/workshops/NutrientLoadWrkshp.pdf. Additional discussion of the CWEMF Delta Nutrient Workshop is also presented below.

Page 6 Table 2 presents "Daily Average SRWTP Effluent Fractions (%) at Delta Locations;" showing that about 0.1% of the San Joaquin River (SJR) water @ Stockton is derived from Sac Regional effluent. Based on our work as principal investigators for the several-year, $2-million CALFED DO TMDL project, that 0.1% projection is too high. It is very rare that any Sacramento River water is in the SJR at the Port of Stockton. We therefore question the reliability of the model that was used to make the calculations presented in that table. (The synthesis reports we developed for the CALFED DO TMDL studies are:

> Lee. G. F., and Jones-Lee, A., "Synthesis and Discussion of Findings on the Causes and Factors Influencing Low DO in the San Joaquin River Deep Water Ship Channel near Stockton, CA: Including 2002 Data," Report Submitted to SJR DO TMDL Steering Committee/Technical Advisory Committee and CALFED Bay-Delta Program, G. Fred Lee & Associates, El Macero, CA, March (2003). http://www.gfredlee.com/SJR-Delta/SynthesisRpt3-21-03.pdf
>
> Lee, G. F. and Jones-Lee, A., "Supplement to Synthesis Report on the Low-DO Problem in the SJR DWSC," Report of G. Fred Lee & Associates, El Macero, CA, June (2004).
> http://www.gfredlee.com/SJR-Delta/SynthRptSupp.pdf

This issue is also discussed in other papers and reports on our website [www.gfredlee.com] in the Watershed Studies San Joaquin River Watershed - Delta section [http://www.gfredlee.com/psjriv2.htm].)

Page 6, Drinking Water Issue 1 – Nutrients. This section is deficient in addressing the potential impacts of the Sac Regional wastewater discharge to the Delta on domestic water supply water quality. The statement, "*At this time it is uncertain whether nutrient loadings from the current permitted or expanded discharge are impacting beneficial uses due to biostimulation.*" does not reflect an understanding of current information on this issue. The CWEMF Delta Nutrient Workshop referenced above provides extensive information on the impact of nutrients on delta water quality. This issue is discussed further below.

Page 7, first paragraph, states, "*Excessive algal growth in the Delta may result in increased concentrations of total organic carbon*."
We have published several papers and reports on the role of nutrients in the growth of algae that impact the TOC in the Delta. Those papers include:

> Lee, G. F. and Jones, R. A., "Regulating Drinking Water Quality at the Source," Proc. University of California Water Resources Center Conference: Protecting Water Supply Water Quality at the Source, Sacramento, CA, 39 pp, April (1991). http://www.gfredlee.com/WSWQ/wswqsour.htm
>
> Lee, G. F. and Jones-Lee, A., "Issues that Need to Be Considered in Evaluating the Sources and Potential Control of TOC that Leads to THMs for Water Utilities that Use Delta Water as a Water Supply Source," Report of G. Fred Lee & Associates, El Macero, CA, May (2003). http://www.gfredlee.com/SJR-Delta/TOC_update.pdf

Page 7, paragraph 3, states,
"Although there are no state or federal numerical standards for nutrients, the USEPA has developed recommended nutrient levels for total nitrogen and total phosphorous that indicate levels of these nutrients that can create a high risks for eutrophication. USEPA's Aggregate Ecoregion 1[3] *that includes the Delta are 0.055 mg/L for total phosphorus and 0.66 mg/L for total nitrogen*[4]*. These recommended levels generally represent nutrient levels that protect against the adverse effects of nutrient over-enrichment."*
We have had extensive experience in establishing and evaluating nutrient criteria/loadings for managing water quality to prevent excessive fertilization of waterbodies, and in reviewing the US EPA's attempts to develop national and regional water quality criteria for nutrients. Our writings on these issues are available on our website in the Excessive Fertilization section [http://www.gfredlee.com/pexfert2.htm]. As discussed in the CWEMF Delta Nutrient workshop presentations and background reports referenced previously, the above-quoted US EPA nutrient concentrations are not valid for evaluating and regulating nutrient-related water quality issues in the Delta.

In his CWEMF workshop presentation entitled, "Impact of Sacramento River Input of Phosphorus to the Delta on Algal Growth in the Delta," Dr. Erwin Van Nieuwenhuyse summarized 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. His presentation and paper provide important information on the impact of phosphorus discharges from Sac Regional on planktonic algae in the Delta. His presentation is available at:

http://www.cwemf.org/workshops/DeltaNutrientsWrkshp/VanNieuwenhuyse.pdf.
As discussed in the Van Nieuwenhuyse workshop presentation and his published paper (as well as in the Lee and Jones-Lee workshop presentation, backup information, and papers referenced in their presentation) it has been well-established that reducing the phosphorus load and in-waterbody concentration results in reductions in the phytoplankton biomass, even when the phosphorus concentrations in the waterbody are surplus compared to growth-rate-limiting concentrations of available phosphorus.

It is also of concern that the US EPA bases it recommended phosphorus criterion on total phosphorus rather than on algal-available phosphorus. In various writings available on our website, we have discussed why the US EPA's approach is not technically valid for many forms of particulate phosphorus. For example, there is substantial evidence that inorganic phosphorus derived from urban and agricultural runoff is largely unavailable and does not convert to algal-available forms. An assessment of algal-available phosphorus loads should be based on algal-available forms and those particulate forms that convert to algal-available forms.

In our workshop synthesis review cited above, we discussed the importance of understanding quantitatively how altering nitrogen and phosphorus loads from all sources impacts the development of benthic bluegreen algae that are the source of tastes and odors in domestic water supply raw water, in downstream waterbodies.

We have found through our evaluation of water quality impacts of aquatic plant nutrients over the past five decades, that the development of appropriate controls of phosphorus loads from all sources, including Sac Regional wastewater discharge to Delta, requires a clear understanding of the quantitative cause-and-effect relationships between nutrient loads/concentrations and the planktonic, attached and benthic algae, and macrophytes that develop. Also essential is a quantitative understanding of the relationship between the biomass of algae and macrophytes that develop in response to the nutrients and water quality/beneficial use impairment in various areas of the Delta and downstream waterbodies that receive Delta water.

As discussed in our writings another important issue that needs to be understood is the relationship between production of planktonic algae in the Delta and fish productivity. As described in:

> Lee, G. F. and Jones, R. A., "Effects of Eutrophication on Fisheries," Reviews in Aquatic Sciences, 5:287-305, CRC Press, Boca Raton, FL (1991).
> http://www.gfredlee.com/Nutrients/fisheu.html

while decreasing the phosphorus load to a waterbody reduces planktonic algal biomass, that reduction in primary production can adversely impact fish biomass production in that waterbody. It is, therefore, important to define the desired eutrophication-related water quality characteristics considering all beneficial uses of the Delta water, including fish production. While there are significant deficiencies in these understandings for the Delta at this time, without this information it will not be possible to develop technically valid permitted nutrient discharge limitations for the Delta and its tributaries.

Page 8 mentions, without providing adequate discussion, potential impacts of ammonia in the Sac Regional wastewater effluent discharged to the Delta, including potential impacts on the development of bluegreen algae and toxicity to aquatic life. These are two key issues that need to be addressed in the update of the current Sac Regional NPDES permit. As discussed in our writings, it has been our experience that ammonia is not a key issue in the development of bluegreen algae. Many waterbodies not impacted by ammonia have large populations of bluegreen algae.

With respect the toxicity of ammonia discharged to the Delta by Sac Regional, available evidence as presented at the CVRWQCB/CALFED Science workshop shows that ammonia in concentrations below the current US EPA water quality criterion cause toxicity to some forms of aquatic life in the Delta. As I noted at the ammonia workshop, I served as a member of the US EPA water quality criteria peer review committee, which made it well-known that the current US EPA criteria only protect about 90% of the species. In light of how those criteria are developed it is likely that there are species in the Delta that are more sensitive to ammonia than the species that were used to develop the current ammonia criteria. The revised NPDES permit issued to Sac Regional should be composed so as to require permit revision to consider data that are being developed on the toxicity of ammonia to Delta species.

Page 8, at the end of the second paragraph the statement is made, "*Phosphorus removal treatment is possible, but is not a common treatment process*." That statement reflects a lack of understanding of the widespread use of advanced domestic wastewater treatment throughout the world. In many areas of the US and Western Europe, phosphorus removal from domestic wastewater is commonly used for controlling excessive fertilization in waterbodies impacted by phosphorus from domestic wastewater discharges. It is estimated that the domestic wastewaters from more than 100 million people worldwide are treated for phosphorus removal.

Page 9, "Drinking Water Issue 2 – Total Organic Carbon (TOC)" section contains the statement,
"*Without numeric water quality objectives, should and how does the Central Valley Water Board address the issue of TOC in the discharge? "*
Contrary to that statement, the role of TOC in a raw water supply in causing excessive TTHM concentrations in treated water is understood. The lack of discussion of the role of Sac Regional's discharge of TOC in the occurrence of TOC in domestic water supply intakes that derive water from the Delta is a significant deficiency in the "issues" paper. As discussed in our review of Delta TOC issues, TOC is not a conservative constituent; it is not possible to use TOC concentrations in the Sac Regional effluent to calculate the Sac Regional contribution to TOC at a particular location in the Delta. To make such assessments there is need to conduct studies of the fate and transport of TOC from various sources in the Delta and in downstream water supply waterbodies.

Page 12, "Drinking Water Issue 4 – Salinity" section discussion is deficient in that it fails to present and discuss the importance of salinity in the Delta to the south state use of domestic wastewaters for groundwater recharge. Table 7, "Salinity Water Quality Criteria/Objectives

and Effluent Concentrations," should be expanded to include consideration of the impacts of the salts discharged to the Delta on the beneficial uses of Delta water, including the use of southern California domestic wastewaters as part of groundwater recharge.

Page 14. The section, "Drinking Water Issue 5 - Contaminants of Emerging Concern," states, "*Pharmaceuticals, personal care products and endocrine disrupting chemicals are referred to as contaminants of emerging concern (CECs).*" That listing of CECs should be expanded to include unregulated industrial chemicals and nanomaterials. Presented in Figure 1 is a recently published figure on the CECs from the December 2009 issue of *Estuary News*. Additional information on water quality concerns for unregulated/inadequately regulated chemicals is provided in writings on our website, including Newsletters NL- 7-3, 8-5, 9-3, 10-7, 11-7/8, 11-11, 12-3, 12-4, 12-6, 12-7/8 [http://www.gfredlee.com/newsindex.htm], as well as in our report:

> Lee, G. F., and Jones-Lee, A., "Monitoring Pollutants in Stormwater Runoff from Superfund Sites and Other Locations," Report of G. Fred Lee & Associates, El Macero, CA, November 5 (2009).
> http://www.gfredlee.com/HazChemSites/MonitorRunoffSuperfund.pdf

Additional information on our "Monitoring" report is available in the January 2010 issue of our Newsletter (NL13-1) [http://www.gfredlee.com/Newsletter/swnewsV13N1.pdf].

The Sac Regional "issues" report needs to present a plan and its implementation schedule evaluation of the occurrence and impact of unrecognized and unregulated chemicals present in Sac Regional wastewater discharges to the Delta on Delta water quality.

Page 15. The discussion in the section, "Disinfection Issue 1 – Pathogens" relies on the Department of Public Health's current, limited regulatory approach for the protection of public health from pathogens derived from domestic wastewaters when exposure is associated with contact recreation in waters near domestic wastewater discharges. There is need to increase the level of protection to address the full range of pathogens normally present in disinfected domestic wastewaters that can cause disease in those who participate in contact recreation in waters near the wastewater discharge. Such pathogens would include viruses and pathogenic protozoans in domestic wastewater discharges.

Figure 1 Source:
Published in Estuary News 18(6) December (2009).
[http://www.sfestuary.org/pages/newsletter.php]
(Based on Figure 1 in: Muir, D., and Howard, P., "Are There Other Persistent Organic Pollutants? A Challenge for Environmental Chemists," Environ. Sci. & Technol. 40:7157-7166 (2006);
subsequently updated in: "Managing Contaminants of Emerging Concern in California: Developing Processes for Prioritizing, Monitoring, and Determining Thresholds of Concern," Report of California Ocean Protection Council et al. workshop, "Managing Contaminants of Emerging Concern in California: A Workshop to Develop Processes for Prioritizing, Monitoring and Determining Thresholds of Concern," Costa Mesa, CA, April 28-29 (2009);
[http://www.nwri-usa.org/pdfs/CACCECReport.pdf] and updated further for Estuary News.)

Figure 1

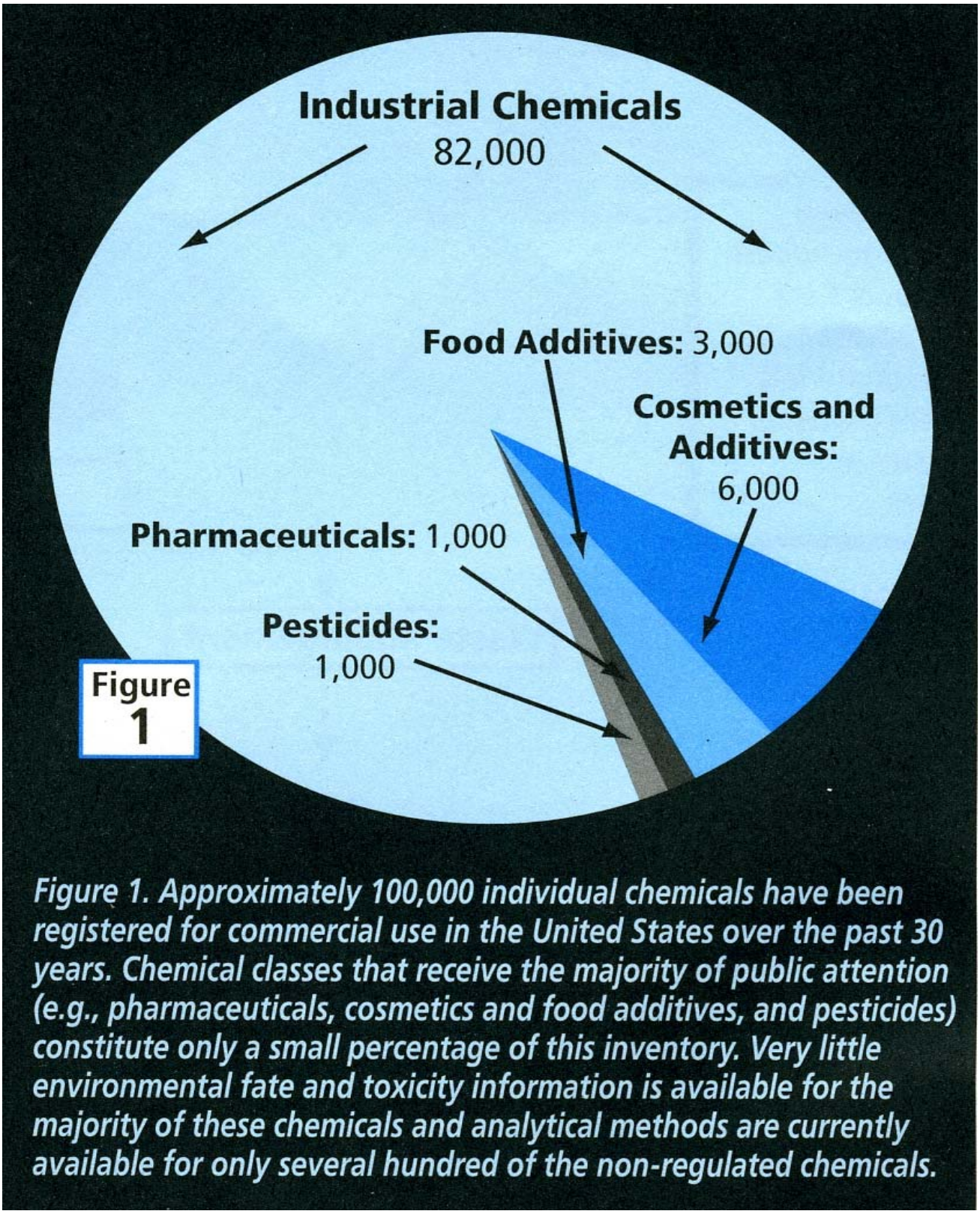

Figure 1. Approximately 100,000 individual chemicals have been registered for commercial use in the United States over the past 30 years. Chemical classes that receive the majority of public attention (e.g., pharmaceuticals, cosmetics and food additives, and pesticides) constitute only a small percentage of this inventory. Very little environmental fate and toxicity information is available for the majority of these chemicals and analytical methods are currently available for only several hundred of the non-regulated chemicals.

Summary of Experience in Evaluating the Impact of
Domestic Wastewater Discharges on Receiving Waterbody Quality

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Dr. G. Fred Lee has been involved in evaluating water quality impacts of domestic wastewater discharges throughout his more than five-decade-long professional career. After earning his PhD degree at Harvard University in environmental engineering with minors in aquatic chemistry and public health in 1960, Dr. Lee held faculty teaching and research positions in environmental engineering and science at several major US universities for the following 30 years. During his academic career he taught graduate-level courses in water and wastewater treatment, and evaluation and control of water pollution from domestic and industrial wastewater discharges and other sources, and conducted more than $5-million in research in these areas. Several of those projects were specifically devoted to evaluating the water quality impacts of domestic wastewater treatment plant discharges. He published about 500 professional papers and reports on his research and findings; about 50 of those papers and 50 of those reports were devoted to various aspects of treatment and water quality impacts of domestic wastewaters. A list of those papers and reports is available upon request; many are available as downloadable electronic files on Drs. G. Fred Lee and Anne Jones-Lee's website, www.gfredlee.com. A summary of the more relevant projects and study areas is provided below.

Domestic Wastewater Discharges of Nutrients

One of the major thrusts of Dr. Lee's evaluation of domestic wastewater discharges has been the impact and control of aquatic plant nutrients (phosphorus and nitrogen compounds) on the excessive fertilization of waterbodies. In the 1960s while holding the position of Professor of Water Chemistry and Director of the Water Chemistry Program in the Department of Civil and Environmental Engineering at the University of Wisconsin, Madison Dr. Lee devoted particular attention to excessive fertilization of the US Canadian Great Lakes and inland lakes and reservoirs. The research of one of his graduate students included studies on the removal of phosphorus in domestic wastewater treatment plant discharges with advanced treatment processes. That PhD dissertation resulted in the paper,

> Malhotra, S. K., Lee, G. F., and Rohlich, G. A., "Nutrient Removal from Secondary Effluent by Alum Flocculation and Lime Precipitation," Air & Water Pollut. 8:487-500 (1964). http://www.gfredlee.com/Nutrients/MalhotraNutrRemAlum.pdf

In the 1970s Dr. Lee served as the US representative for the international Organization for Economic Cooperation and Development (OECD) Eutrophication Study. That Study was a five-year, $50-million investigation of about 200 waterbodies conducted by 22 countries in Western Europe, North America, Japan, and Australia to evaluate the impacts of nutrient loads on the algae-related water quality of lakes and reservoirs. Of particular concern in that effort were the impacts of nitrogen and phosphorus compounds discharged by domestic wastewater treatment plants on the excessive fertilization of waterbodies. Dr. Lee was also

selected by the US EPA to evaluate, and develop the synthesis report for, the US part of the OECD Eutrophication Study. That effort led to his development of a summary paper, which appeared as a feature article in the journal, *Environmental Science and Technology*:

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

That paper described empirical relationships between P load and eutrophication-related water quality characteristics for a diverse group of lakes and reservoirs across the US, relationships that were in keeping with those subsequently developed upon the entire OECD study database. (Those relationships formed the foundation of what has become known as the Vollenweider-OECD eutrophication modeling approach, in recognition of the conceptual contributions of Dr. R. Vollenweider.) Following the completion of their work on the US OECD database, Dr. Lee and colleagues continued the OECD-type eutrophication studies of waterbodies, beyond the OECD database, expanding the total database to more than 700 waterbodies of varied character located in areas covering most of the world. They also investigated and documented the predictive capability of the modeling approach using load and response data collected before and after P load reductions to about a dozen waterbodies. Lee's and his associates' studies on excessive fertilization of waterbodies resulted in their development of procedures to reliably evaluate the impact of a domestic wastewater discharge on planktonic algae-related water quality characteristics of a lake or reservoir and to reliably quantify the impact on those characteristics that would be caused by altering the phosphorus load discharged by a treatment. Lee's professional papers and reports on his work in this area are available on Drs. Lee and Jones-Lee's website [www.gfredlee.com] in the Excessive Fertilization section [http://www.gfredlee.com/pexfert2.htm].

An example of the use of the Vollenweider-OECD eutrophication modeling approach for assessing the impacts of nutrient loads on eutrophication-related water quality is Lee's investigation of Lake Ray Hubbard, a major domestic water supply reservoir for Dallas, Texas. The water supply water quality of that reservoir had been deteriorating due to the growth of algae supported by the nitrogen and phosphorus discharged into the reservoir from its watershed. Of particular concern was the impact of nutrient-rich domestic wastewaters discharged to the tributaries. While serving as Professor of Engineering and Director of Institute of Environmental Studies at the University of Texas at Dallas, Dr. Lee directed a comprehensive study of nutrient sources to Lake Ray Hubbard. With his graduate students he evaluated, employing the OECD Eutrophication Study results, the impacts on water supply-related water quality of increasing urbanization of the reservoir's watershed with the attendant increases in domestic wastewater discharges. They also evaluated the impacts of implementation of advanced treatment of the domestic wastewaters to remove phosphorus, on the algae-related water quality. A summary paper on those studies is available as:

Archibald, E. M. and Lee, G. F., "Application of the OECD Eutrophication Modeling Approach to Lake Ray Hubbard, Texas," Journ. AWWA 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).

Drs. Lee and Jones-Lee have conducted similar studies on lakes, reservoirs, estuaries, and coastal marine waters in the US and other countries. Many of their papers and reports discussing their findings are available on their website, including:

Jones, R. A. and Lee, G. F., "Impact of Phosphorus Removal at the Danbury, Connecticut Sewage Treatment Plant on Water Quality in Lake Lillinonah," Water, Air, Soil Pollut. 16:511-531 (1981).

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).

Impacts of City of Madison, Wisconsin's Domestic Wastewater Treatment Plant Discharge on Receiving Water Quality

While at the University of Wisconsin, Madison, Dr. Lee and his graduate students conducted studies on the impact of the Madison Metropolitan wastewater effluent on water quality in the lower Madison lakes, Waubesa and Kegonsa. They also evaluated the impact on those lakes of diverting that effluent around the lakes and discharging it into Bad Fish Creek and downstream waterbodies. The following papers were developed from those studies:

Sonzogni, W. C., Fitzgerald, G. P., and Lee, G. F., "Effects of Wastewater Diversion on the Lower Madison Lakes," Journ. Water Pollut. Control Fed. 47:535-542 (1975).

Sonzogni, W. C. and Lee, G. F., "Phosphorus Sources for the Lower Madison Lakes," Trans. Wisc. Academy Sciences, Arts and Letters LXIII:162-175 (1975).

Lee, G. F., "The Effects of Madison Metropolitan Wastewater Effluent on Water Quality in Badfish Creek, Yahara and Rock Rivers," Trans. Wisc. Academy Sciences, Arts and Letters 65:163-179 (1977).

Land Application of Domestic Wastewaters

Dr. Lee developed several papers on potential problems that can be caused by land application of domestic wastewaters including:

Lee, G. F., "Potential Problems of Land Application of Domestic Wastewaters," In: Land Treatment and Disposal of Municipal and Industrial Wastes, Ann Arbor Science, pp 179-192 (1976).

Jones, R. A. and Lee, G. F., "Chemical Agents of Potential Health Significance for Land Disposal of Municipal Wastewater Effluents and Sludges," Proc. Conference on Municipal Wastewater and Sludges, Univ. of Texas at San Antonio, pp 27-60 (1978).

Toxicity of Wastewater Effluents from
Colorado Front Range Cities in Receiving Waters

Drs. Lee and Jones conducted field studies to assess the aquatic life toxicity of domestic wastewater effluent from several Colorado Front Range cities, including Fort Collins (2 treatment plant discharges), Loveland, Colorado Springs, and Pueblo. The focus of those studies was the definition of acute lethal toxicity within and outside of the wastewater discharge plume in the receiving waters using in-stream caged fish toxicity tests. Summary papers on those studies include:

Heinemann, T. J., Lee, G. F., Jones, R. A. and Newbry, B. W., "Summary of Studies on Modeling Persistence of Domestic Wastewater Chlorine in Colorado Front Range Rivers," In: Water Chlorination-Environmental Impact and Health Effects, Vol. 4, Ann Arbor Science, Ann Arbor, MI, pp 97-112 (1983).

Newbry, B. W., Lee, G. F., Jones, R. A. and Heinemann, T. J., "Studies on the Water Quality Hazard of Chlorine in Domestic Wastewater Treatment Plant Effluents," In: Water Chlorination-Environmental Impact and Health Effects, Vol. 4, Ann Arbor Science, Ann Arbor, MI, pp 1423-1436 (1983).

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Dr Lee also developed:

Lee, G. F. and Jones, R. A., "Domestic Wastewater Dechlorination," Effluents, New Jersey Water Pollution Control Association 20:15-17 (1986).

Lee, G. F., "Application of the Hazard Assessment Approach for Evaluating the Need for Pueblo, CO to Remove Ammonia and Chlorine from Its Domestic Wastewater Discharges to the Arkansas River," Testimony before the Colorado Water Quality Control Commission, December (1980).

Lubbock, Texas Wastewater Reuse

Drs. Lee and Jones conducted a study of the impact of reclaimed wastewater from the city of Lubbock, Texas on the sanitary quality of the Yellowhouse Canyon Lakes. Their findings were published as:

Lee, G. F. and Jones, R. A., "Indirect Reuse of Domestic Wastewater for Recreational Lakes: Evaluation of the Sanitary Quality of the Yellowhouse Canyon Lakes, Lubbock, Texas," In: Proceedings AWRA Symposium, "Water Supply and Water Reuse: 1991 and Beyond," San Diego, CA, pp. 1945-1975, June (1991).

Drs. Lee and Jones also developed several papers on surface and groundwater quality concerns associated with the use of reclaimed domestic wastewater:

Lee, G. F. and Jones-Lee, A., "Public Health and Environmental Safety of Reclaimed Wastewater Reuse," In: Proc. Seventh Symposium on Artificial Recharge of Groundwater, University of Arizona Water Resources Research Center, Tucson, AZ, pp. 113-128, May (1995).

Lee, G. F. and Jones-Lee, A., "Total Dissolved Solids and Groundwater Quality Protection," In: Artificial Recharge of Ground Water, II, Proc. International

Symposium on Artificial Recharge of Ground Water, American Society of Civil Engineers, NY, pp. 612-618 (1995).

Lee, G. F. and Jones-Lee, A., "Water Quality Aspects of Groundwater Recharge: Chemical Characteristics of Recharge Waters and Long-Term Liabilities of Recharge Projects,"In Artificial Recharge of Ground Water, II, Proc. Sec Interna Symp on Artificial Recharge of Ground Water, American Society of Civil Engineers, NY, pp. 502-511 (1995).

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).

Lee, G. F. and Jones-Lee, A., "Appropriate Degree of Domestic Wastewater Treatment Before Groundwater Recharge and for Shrubbery Irrigation," AWWA, WEF 1996 Water Reuse Conference Proceedings, American Water Works Association, Denver, CO, pp. 929-939, February (1996).

Hammond, Indiana – Impacts of Domestic Wastewater Treatment Plant Discharge on Water Quality

In the 1990s Drs. Lee and Jones-Lee served as consultants to the Hammond, Indiana Sanitary District in their evaluation of impacts of combined sewer overflows (CSO's) and wastewater discharges on water quality in the Grand Calumet River. Of particular concern was the impact of heavy metals in the treatment plant effluent and CSOs on river quality. They also reviewed Natural Resources Damage Action against the District by the US Fish and Wildlife Service on the West Branch of the Grand Calumet River. They developed the report:

Lee, G. F., "Comments on January 13, 2004, Draft Preliminary Problem Formulation Tech Memorandum for the West Branch of the Grand Calumet River, Lake County, Indiana, Prep by Tetra Tech for the US Fish and Wildlife Service," Comments Submitted to the U.S. Fish and Wildlife Service on behalf of the Sanitary District of Hammond, IN, by G. Fred Lee & Associates, (2004).

Sacramento San Joaquin Delta Studies

In 1989 while he held the position of Distinguished Professor of Civil and Environmental Engineering at the New Jersey Institute of Technology and Director of the Site Assessment and Remediation Division of a multi university hazardous waste research center, Dr. Lee served as a consultant to the Delta Wetlands water supply project to evaluate the anticipated water quality in proposed water supply reservoirs on Delta islands. Drs. Lee and Jones-Lee found that the levels of aquatic plant nutrients contributed to the area from the Delta watershed and within the Delta would be expected to support excessive growths of algae in the proposed Delta water supply reservoirs which would result in their having poor water quality for water supply purposes. Of concern were the nutrient loads that would be contributed from domestic wastewater treatment plants in the Delta watershed.

In 1999 Drs. Lee and Jones-Lee became advisors to the SJR Low-DO TMDL Steering Committee to evaluate the causes and the control of low-DO conditions that develop in the

Deep Water Ship Channel near the Port of Stockton. Drs. Lee and Jones-Lee were selected to serve as the principal investigators for a $2-million CALFED grant investigation of the SJR low-DO problem. They developed a synthesis report as well as several other papers and reports on the findings of those studies. Those reports and papers are available on their website in the Watershed SJR Delta section.

> Lee. G. F., and Jones-Lee, A., "Synthesis and Discussion of Findings on the Causes and Factors Influencing Low DO in the San Joaquin River Deep Water Ship Channel near Stockton, CA: Including 2002 Data," Report Submitted to SJR DO TMDL Steering Committee/Technical Advisory Committee and CALFED Bay-Delta Program, G. Fred Lee & Associates, El Macero, CA, March (2003).
> http://www.gfredlee.com/SJR-Delta/SynthesisRpt3-21-03.pdf

In 2004 Drs. Lee and Jones-Lee developed the first comprehensive review of Delta water quality issues:

> 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 (2004).
> http://www.gfredlee.com/SJR-Delta/Delta-WQ-IssuesRpt.pdf
>
> Lee, G. F., and Jones-Lee, A., "Overview—Sacramento/San Joaquin Delta Water Quality," Presented at CA/NV AWWA Fall Conference, Sacramento, CA, PowerPoint Slides, G. Fred Lee & Associates, El Macero, CA, October (2007).
> http://www.gfredlee.com/SJR-Delta/DeltaWQCANVAWWAOct07.pdf

Those reviews included discussion of the impacts of the city of Sacramento and Stockton wastewater discharges to the Delta on Delta water quality.

In March 2008, on behalf of the California Water Quality Modeling Forum, Drs. Lee and Jones-Lee organized a one-day workshop devoted to Delta nutrient water quality issues. The workshop content and key findings discussed were described in:

> 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

Attention was given in those reviews to impacts of the Sacramento Regional Sanitation District's wastewater discharges on Delta water quality.

Water Quality Criteria/Standards Development and Implementation

In the late 1960s, Dr. Lee pioneered in the development of approaches for evaluating the water quality/environmental impact of chemicals. The focus of his work over the past five

decades has been the integration of aquatic chemistry and toxicology for evaluating the impacts of chemicals on water quality. Dr. Lee has been involved in the development, evaluation, and implementation of water quality criteria and state standards since the early 1960s. A summary of his experience is provided at http://www.gfredlee.com/exp/wqexp.htm. During the 1960s, while in the position of Professor of Water Chemistry and Director of the Water Chemistry Program at the University of Wisconsin, Madison Dr. Lee served as an advisor to the Wisconsin Department of Natural Resources on the development and implementation of water quality criteria and standards. During that time, and since then, he has served as an advisor to numerous governmental agencies including municipalities, industry, and environmental/citizen groups on water quality criteria issues. In the early 1970s, he served as an invited peer reviewer for the National Academies of Science and Engineering's "Blue Book" "Water Quality Criteria - 1972." In the late 1970s, he served as an invited member of the American Fisheries Society Water Quality Panel that conducted a review of the US EPA's 1976 "Red Book" of "Water Quality Criteria." In the early to mid-1980s he served as a US EPA-invited peer reviewer for the 1986 "Gold Book" Water Quality Criteria development approach, and for several of the specific chemical criteria, including ammonia. During the 1960's through the mid-1970's he served as an advisor to the International Joint Commission for the US-Canadian Great Lakes in developing water quality objectives for the Great Lakes and their implementation. His pioneering work on PCB's in the 1960's led to his being selected to head the US Public Health Service committee on developing drinking water standards for PCBs.

Drs. Lee and Jones-Lee have published extensively on the development of water quality criteria and their implementation into state standards to appropriately regulate water quality impacts without significant over-regulation of wastewater and other discharges. Many of those publications are available on their website, www.gfredlee.com in the Surface Water section, http://www.gfredlee.com/pwwqual2.htm#criteria.

Dr. Lee has served as a technical consultant to several chemical companies including Procter & Gamble, FMC, and Monsanto to provide guidance in the evaluation of potential water quality impacts of new or expanded-use chemicals. His work with Monsanto included evaluating the water quality environmental impacts of phosphorus used in detergent formulations. With FMC, he helped evaluate the fate and effects of a carbon tetrachloride spill on the Ohio River water quality. For about 10 years Dr. Lee assisted Procter & Gamble in reviewing and evaluating potential water quality impacts of new products. In the early 1970s, Dr. Lee became an advisor to the President's Council on Environmental Quality (CEQ) in Washington DC to help develop programs for screening new and expanded-use chemicals for their potential environmental impacts. That effort was sparked by the finding of increasingly widespread occurrence of environmental pollution by PCBs, DDT and other organochlorine pesticides, and mercury.

During the 1970s Dr. Lee was a member of a group, composed of representatives of chemical companies, regulatory agencies, and academic professionals, that developed a series of "Pellston" workshops devoted to developing technically sound approaches for screening chemicals for environmental impact. In the late 1970s, the efforts of that group led to the development of the environmental hazard assessment approach for evaluating expected

toxicological impacts and water quality impacts associated with new or expanded-use chemicals that could cause large-scale environmental pollution. Those efforts ultimately led to the development of the Toxic Substances Control Act (TSCA). Drs. Lee and Jones together with their graduate students expanded and applied those principles to the conduct water quality hazard assessments for domestic wastewaters. Their work included the development of environmental chemistry-fate models for assessing the water quality impacts of domestic wastewater constituents such as chlorine (used for disinfection of domestic wastewaters) and ammonia using integrated laboratory and field toxicity testing. This approach became a foundation for the water quality and public health risk assessment approaches that are widely used today.

During the 1970s, on behalf of the Corps of Engineers Dredged Material Research Program, Dr. Lee conducted about $1 million in research to develop technically sound approaches for evaluating the water quality implications of open water disposal of sediments dredged from US waterways as part of maintaining navigation depth. Dredged sediment toxicity tests were developed and evaluated for assessing whether chemicals in dredged sediments are in toxic/available forms that could be adverse to aquatic life at a dredged sediment disposal site. Those studies demonstrated that the high concentrations of most chemicals such as heavy metals in dredged sediments are in non-toxic forms. His work served as a technical foundation for the development of dredged sediment disposal criteria.

Drs. Lee and Jones-Lee have been active in reviewing the reliability of aquatic sediment criteria developed by regulatory agencies. As they have discussed, the approach followed by the California Water Resources Control Board for incorporating chemical concentration information in the evaluation of "sediment quality" is not technically valid; application of such approaches can readily lead to incorrect evaluations of sediment quality and the impacts of sediment-associated chemicals on a waterbody's water quality.

Their website contains several papers and reports on water quality criteria and their implementation in discharge permits [http://www.gfredlee.com/pwwqual2.htm#criteria]. Their papers and reports on water quality criteria have application to regulating domestic wastewater discharges.