Comments on
Environmental Protection Agency 40 CFR Part 131 [EPA-HQ-OW-2009-0596; FRL-XXXX-X] [RIN 2040-AF11] Water Quality Standards for the State of Florida's Lakes and Flowing Waters

Submitted by
G. Fred Lee, PhD, PE, BCEE, F.ASCE and Anne Jones-Lee PhD
G. Fred Lee & Associates
El Macero, California
gfredlee@aol.com www.gfredlee.com

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The Environmental Protection Agency (US EPA) is proposing numeric nutrient water quality criteria to protect aquatic life in lakes and flowing waters, including canals, within the state of Florida, and regulations to establish a framework for Florida to develop "restoration standards" for impaired waters. Page 16 of the Executive Summary of that proposed rule states, "*Overall, EPA is soliciting comments and data regarding EPA's proposed criteria for lakes and flowing waters, the derivation of these criteria, the protectiveness of the streams and rivers criteria for downstream waters, and all associated alternative options and methodologies discussed in this proposed rulemaking."* In response to the Agency's request, we submit these comments.

Overall Finding on Proposed Nutrient Standards

The technical foundation of the US EPA's nutrient criteria development is invalid; the application of the proposed nutrient criteria can be expected to result in unjustified waste of money in controlling nutrients that are not responsible for excessive fertilization of receiving waters.

The basis for the US EPA's nutrient criteria is what is well-recognized to be an unreliable statistical approach that can be founded in spurious correlations. It is not based on a technically sound quantitative cause-and-effect relationship between nutrient concentrations and planktonic algal chlorophyll or other aquatic plant biomasses, which is paramount if there is to be any expectation, much less a quantitative expectation, that reducing the "cause" will reduce the "effect." The Florida nutrient criteria are based on statistical analysis of TP and TN lake P and N concentration data. The nutrient criteria should be based on water quality impact of phosphorus and/or nitrogen on the waterbodies nutrient related water quality such as planktonic algal chlorophyll, chlorophyll impacted water clarity as measured by Secchi depth, and or the area extent and density of macrophytes etc. While for many waterbodies there is a correlation between phosphorus concentration in a waterbody and the water quality impacts of phosphorus there are waterbodies where this relationship is not valid.

Those fundamental defects are compounded by the inclusion of total nitrogen as a parameter presumed to be controlling the amount of planktonic algal biomass in a subject waterbody. Including total nitrogen in the constituents that must be controlled for all waterbodies when the focus is eutrophication-related water quality will for many waterbodies result in the expenditure of large amounts of money for nitrogen control in runoff and discharges with little or no impact

on a lake's planktonic algal chlorophyll beyond that which could be achieved by controlling available phosphorus loads to the waterbody.

Our comments on specific items in the draft water quality standards document follows the brief summary of our five decades of professional experience in matters pertaining to the impacts of nutrients and nutrient control on eutrophication-related water quality, and nutrient criteria issues. Our comments on the proposed nutrient criteria focus on lakes and reservoirs and reflect our experience in investigating impact of nutrients on these types of waterbodies located in many areas of the world, including Florida. However, our experience and comments also have applicability to many of the issues faced in applying such criteria to other types of waterbodies that are proposed for regulation under this rule, including streams, springs, canals, and nearshore marine waters in Florida.

Experience in Establishing Nutrient Water Quality Criteria/Standards

Dr. G. Fred Lee has been active in investigating the impacts of nutrients on water quality since the early 1960s. Additional information on his work in this area is appended to these comments; many of his numerous papers and reports on the sources, water quality significance, assessment, regulation, and control of aquatic plant nutrients are available on our website [www.gfredlee.com] in the Excessive Fertilization/Eutrophication section at http://www.gfredlee.com/pexfert2.htm.

We have investigated the impacts of nutrient loads on eutrophication-related water quality of many waterbodies. Our single most comprehensive effort was a US EPA-sponsored review and synthesis of nutrient load and response data collected on US waterbodies as part of the Organization for Economic and Development (OCED) international eutrophication study. The OECD eutrophication study was a 5-year, $50-million investigation of about 200 waterbodies in North America, Western Europe, Japan, Australia, to evaluate the impacts of nutrient loads on the algae-related water quality of lakes and reservoirs. Using Vollenweider's normalized load–response model developed through his OECD eutrophication study work, Lee and his colleagues described empirical relationships between normalized 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. They also expanded the original Vollenweider–OECD eutrophication study model concepts to include several additional fertilization impacts including water clarity, hypolimnetic oxygen depletion rates. The synthesis report for US waterbodies was published by the US EPA as,

> Rast, W. and Lee, G. F., "Summary Analysis of the North American (US Portion) OECD Eutrophication Project: Nutrient Loading-Lake Response Relationships and Trophic State Indices," EPA 600/3-78-008, US EPA-Corvallis (1978).

A summary paper covering that report was published as a featured article:

> Lee, G. F.; Rast, W. and Jones, R. A., "Eutrophication of Water Bodies: Insights for an Age-Old Problem," Environ. Sci. & Technol. 12:900-908 (1978).
> http://www.gfredlee.com/Nutrients/Eutrophication-EST.pdf

The final overall OECD report was published as:

OECD, “Eutrophication of Waters, Monitoring, Assessment, and Control,” Organization for Economic Cooperation and Development, Paris (1982).

Following the completion of their work on the US OECD database, Dr. Lee and colleagues continued the OECD-type eutrophication studies of waterbodies and expanded the total database foundation of the model beyond the OECD database, to more than 700 waterbodies of varied character located in areas covering most of the world. Several of his papers that describe that work include:

Jones, R. A., and Lee, G. F., "Recent Advances in Assessing the Impact of Phosphorus Loads on Eutrophication-Related Water Quality," Journ. Water Research 16:503-515 (1982). http://www.gfredlee.com/Nutrients/RecentAdvWaterRes.pdf

Jones, R. A. and Lee, G. F., "Eutrophication Modeling for Water Quality Management: An Update of the Vollenweider-OECD Model," World Health Organization's Water Quality Bulletin 11:67-174, 118 (1986).
http://www.gfredlee.com/Nutrients/voll_oecd.html

More recently a summary of our work on excessive fertilization of waterbodies was published in:

Jones-Lee, A., and Lee, G. F., “Eutrophication (Excessive Fertilization),” Water Encyclopedia: Surface and Agricultural Water, Wiley, Hoboken, NJ pp 107-114 (2005).
http://www.gfredlee.com/Nutrients/WileyEutrophication.pdf

Lee and Jones-Lee have further expanded the Vollenweider–OECD normalized load–response relationships to define such a relationship between phosphorus loads and the fish production in waterbodies:

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

That paper demonstrated that, as expected, altering the phosphorus loads to waterbodies impacts the fish production in a waterbody. We discussed the importance of considering impacts on fish production when reducing nutrient loads or establishing nutrient criteria for a waterbody.

They also demonstrated the utility of the modeling approach in assessing ecosystem functioning:

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

Lee and his colleagues investigated and documented the predictive capability of the Vollenweider–OECD eutrophication modeling approach, and applied and described the use of the model for water quality evaluation and management.

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

http://www.gfredlee.com/Nutrients/PredictiveCapabilityOECD.pdf

Lee and his graduate students applied the Vollenweider–OECD modeling approach to managing excessive fertilization of water supply reservoirs in, for example:

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

Throughout his work it has been clear that a key factor that must be considered in assessing the impacts of phosphorus on waterbodies is the role of total phosphorus versus algal-available phosphorus in impacting the fertilization of waterbodies. This issue was understood and discussed in the technical literature 30 years ago:

Lee, G. F., Jones, R. A., and Rast, W., "Availability of Phosphorus to Phytoplankton and its Implications for Phosphorus Management Strategies," IN: Phosphorus Management Strategies for Lakes, Ann Arbor Science Publishers, Inc., Ann Arbor, MI (1980).
http://www.gfredlee.com/Nutrients/Avail-P.pdf

A number of our more recent papers/reports discuss technical deficiencies in the US EPA's position that all forms of particulate phosphorus are available, or become available, to support algal growth. We have become involved in the issues of the development of appropriate approaches for controlling phosphorus from agricultural land runoff to improve those conditions, focusing in part on the comparative effects of controlling total phosphorus versus algal-available P in runoff waters. These issues have been discussed in:

Lee, G. F., "Assessing Algal Available Phosphorus," Submitted for Inclusion in the Proceedings of US EPA Science Symposium: "Sources, Transport, and Fate of Nutrients in the Mississippi River and Atchafalaya River Basins," Minneapolis, MN, November 7-9 (2006). http://www.gfredlee.com/Nutrients/AvailPEPASymp06.pdf

Lee, G. F., "A Proposal for Assessing Algal-Available Phosphorus Loads in Runoff from Irrigated Agriculture in the Central Valley of California," Report of G. Fred Lee & Associates, El Macero, CA, November (2006).
http://www.gfredlee.com/Nutrients/AlgalAssayAvailP.pdf

Lee, G. F., "Assessing Algal Available Phosphorus," Proceedings of US EPA Science Symposium: Sources, Transport, and Fate of Nutrients in the Mississippi River and Atchafalaya River Basins, Minneapolis, MN, November 7-9 (2006).
http://www.gfredlee.com/Nutrients/AvailPEPASymp06.pdf

Cowen, W. F., and Lee, G. F., "Phosphorus Availability in Particulate Materials Transported by Urban Runoff," Journ. Water Pollut. Control Fed. 48(3):580-591 (1976).
http://www.gfredlee.com/Nutrients/AvailPParticulatesCowen.pdf

They have also been discussed in our Stormwater Runoff Water Quality Newsletters NL- 1-2, 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, 10-13, 11-2, 11-5, 11-7/8, 11-9,11-10. 12-3, 12-5, 12-6, 12-7/8 available at

http://www.gfredlee.com/newsindex.htm. As discussed in those sources, and elsewhere, the literature shows that the US EPA position of requiring phosphorus regulation based on total phosphorus, rather than algal-available phosphorus, is not technically valid and can cause agricultural and urban interests to spend large amounts of money for phosphorus control beyond that needed to control excessive fertilization of waterbodies.

In 2002 Lee and Jones-Lee published a paper discussing the development of technically valid nutrient criteria/standards:

> Lee, G. F. and Jones-Lee, A., "Developing Nutrient Criteria/TMDLs to Manage Excessive Fertilization of Waterbodies," Proceedings Water Environment Federation, TMDL 2002 Conference, Phoenix, AZ, November (2002).
> http://www.gfredlee.com/Nutrients/WEFN-Criteria.pdf

That paper discussed why the US EPA statistical approach for developing nutrient criteria as set forth in,

> "U.S. EPA. 2000a. Nutrient Criteria Technical Guidance Manual: Lakes and Reservoirs. Office of Water, Washington, DC. EPA-822-B-00-001.
> U.S. EPA. 2000b. Nutrient Criteria Technical Guidance Manual: Rivers and Streams. Office of Water, Washington, DC. EPA-822-B-00-002.
> U.S. EPA. 2001. Nutrient Criteria Technical Manual: Estuarine and Coastal Marine Waters. Office of Water, Washington, DC. EPA-822-B-01-003), and wetlands (U.S. EPA, 2007)

and in our comments on the US EPA RTAG efforts available on our website.

It also discussed why a site-specific approach that considers the waterbody characteristics and water quality management objectives should be used, and how such an approach could be developed and implemented. That approach has been adopted by the California State Water Resources Control Board as discussed in:

> SWRCB, "Estuarine Nutrient Numeric Endpoint Coastal Stakeholder Advisory Group (Coastal SAG) Meeting May 1, 2009," PowerPoint Slides, SWRCB, Sacramento, CA, May (2009). http://www.gfredlee.com/Nutrients/CoastalSAGMeeting5-1-2009.pdf
>
> SWRCB, "Estuarine NNE Project - NNE STRTAG Meeting Conference Call August 17, 2009," California State Water Resources Control Board (SWRCB) Coastal Nutrient Development Program Sacramento, CA, August 17 (2009).
> http://www.gfredlee.com/Nutrients/STRTAG8-17-09Mtg.pdf

The State of California has Water Resources Control Board rejected the US EPA RTAG statistics-based approach in favor of a site-specific approach for coastal waterbodies. This issues have been discussed in our Stormwater Runoff Water Quality Newsletters, NL-1-3, 5-1, 9-1/2, 9-8, 10-4, 10-5, 10-6, 10-7, 10-13, 11-2, 11-5, 11-9, 12-3, 12-5, 12-6, and 12-7/8.

An ancillary finding that evolved from Vollenweider's work in the OECD eutrophication studies was the relationship between the phosphorus load to a lake or reservoir and the phosphorus concentration in the waterbody. Vollenweider found that in theory and in the OECD data, the phosphorus load to a waterbody, properly normalized by the waterbody's area, mean depth, and hydraulic residence time (filling time), is approximately equal to the average

phosphorus concentration in the waterbody. Chapra (1997), in his book, "Surface Water Quality Modeling," confirmed that relationship. However, as we have discussed elsewhere, P concentration in a waterbody, especially instantaneous concentration, is not a reliable eutrophication-related water quality indicator. A key issue that needs to be addressed in considering nutrient criteria is how to relate phosphorus and nitrogen in-waterbody concentrations to a waterbody to their impact on the waterbodies beneficial uses. Phosphorus, in itself, is not a water quality concern; it is only of concern to the extent that it is used by algae and aquatic plants in the production of nuisance or other adverse impacts of excessive amounts of biomass.

Vollenweider's work in the OECD eutrophication studies revealed that the relating factors between P load and eutrophication-related water quality response were the site-specific morphologic and hydrologic characteristics of the waterbody in question, namely the waterbody's area, mean depth, and hydraulic residence time; that finding has been corroborated in substantial amounts of follow-on work. Thus in order to implement the proposed criteria into source discharge limitations for various dischargers, it is necessary to consider the target waterbody's area, mean depth, and hydraulic residence time to relate the phosphorus load to the waterbody to its eutrophication-related water quality characteristics. As noted above, that normalized P loading is also related to in-lake phosphorus concentrations through Vollenweider's empirical relationships, although that is not a reliable eutrophication-related water quality response parameter. Additional papers and reports that address these issues are available at www.gfredlee.com in the Excessive Fertilization/Eutrophication section [http://www.gfredlee.com/pexfert2.htm].

It is somewhat surprising that the vast literature and the results of the international OECD eutrophication study were not even mentioned in the proposed Florida nutrient criteria rule. That body of work, briefly described above, represents the most expansive and comprehensive study and verification ever undertaken of the quantitative relationships between phosphorus loads and eutrophication-related water quality characteristics, especially planktonic algal chlorophyll, and in-lake P concentrations. That body of work, as well as other studies, clearly shows that nitrogen loads and in-lake nutrient concentrations are poor predictors of planktonic algal chlorophyll that develops in lakes and reservoirs. Rast and Lee, referenced above, for example, specifically examined the predictive ability of nitrogen loads and in-lake nitrogen concentrations and planktonic algal chlorophyll that develops in waterbodies and found that there was no common relationship.

While it is of interest to examine the relationships between nutrient loads/concentrations to/within a waterbody and nutrient-related water quality characteristics of the waterbody, great caution must be exercised in using statistical relationships developed from such exercises to establish regulatory requirements enacted for the purpose of achieving desired nutrient-related water quality characteristics. Employment of technically inappropriate statistical relationships can readily lead to arbitrary nutrient discharge restrictions that can trigger large expenditures for "nutrient control" from domestic wastewaters, urban and agricultural runoff/discharges, and others without the expectation or achievement of the desired water quality.

Over the past four decades that Dr. G. Fred Lee has been active in examining nutrient load – response relationships, he has repeated observed the unreliability of statistical correlations developed between nutrient concentrations and assumed responses. It has been his experience that the current "Empirical Approach" being used by the US EPA can readily lead to unreliable approaches for developing nutrient criteria for the management of excessive fertilization of waterbodies. It is not a matter of the approaches' yielding overly protective, or under-protective regulation and management. The problem is that they are not technically sound; a technically unsound approach cannot be expected to render reliable criteria/standards, or conclusions regarding the necessity for or water quality impacts of nutrient loads or management steps that could be required to achieve arbitrary criteria/standards.

There are many other "statistical approach" relationships reported in the literature that are not valid for relating nutrient loads/concentrations to fertilization response. Statistical "relationships" can be developed that have little or no capability to reliably predict changes in nutrient-related water quality characteristics that would result from changes in nutrient loads. Such a demonstration is of paramount importance for the development of nutrient criteria developed for the purpose of controlling nutrient-related water quality. Any statistical relationship between nutrient load and waterbody response must be solidly grounded in fundamental mechanisms (cause-effect) that influence how a nutrient could impact a fertilization response. Without such a foundation, the statistical relationship is simply game playing.

The statistical manipulations at the foundation of the various iterations of the US EPA's approach for nutrient criteria have typically disregarded the need for a foundation in cause-and-effect relationships. An example is the US EPA's recent attempt to develop nutrient criteria for streams based on spurious correlations. We commented on the fundamental technical flaws of mechanically using statistics to provide the illusion of a meaningful "relationship" between total phosphorus and nitrogen concentrations and the impact of those chemicals on a stream's ecosystem. The NAS NRC review of that approach also concluded it is not valid for developing nutrient criteria. Our comments on these issues are provided in:

> Lee, G. F., and Jones-Lee, A., "Comments on 'US EPA "Empirical Approaches for Nutrient Criteria Derivation" Prepared by US EPA, Office of Water, Office of Science and Technology, Science Advisory Board Review, Draft August 17, 2009'," Report of G. Fred Lee & Associates, El Macero, CA, September 4 (2009).
> http://www.gfredlee.com/Nutrients/EPA_Empirical_CritDevel.pdf
>
> Hall, J., "Request for Peer Review of New EPA Region III Approach to Developing Instream Standards for Nutrients," Letter with attachments to Stephen Johnson, Administrator, US EPA, Washington, DC, Submitted by Hall & Associates, Washington, DC, August 21 (2008).
> http://www.gfredlee.com/Nutrients/Hall_Cond_Prob_Eval.pdf
>
> Lee, G. F., and Jones-Lee, A., "Comments on US EPA's Conditional Probability Approach for Developing Phosphorus Nutrient Criteria," Report of G. Fred Lee & Associates, El Macero, CA, September 26 (2008).
> http://www.gfredlee.com/Nutrients/PCriterionCondProb.pdf

Overall, the US EPA should abandon it present efforts to develop nutrient criteria based on "statistical approaches" and focus on supporting research to reliably define the adverse and beneficial impacts caused by addition of nutrients to waterbodies.

Specific Comments

Page 12 of the Executive Summary states,

"*For lakes, EPA is proposing a classification scheme using color and alkalinity based upon substantial data that show that lake color and alkalinity play an important role in the degree to which TN and total phosphorus (TP) concentrations result in a biological response such as elevated chlorophyll a levels. EPA found that correlations between nutrients and biological response parameters in the different types of lakes in Florida were sufficiently robust, combined with additional lines of evidence, to support stressor response criteria development for Florida's lakes. The Agency is also proposing an accompanying supplementary analytical approach that the State can use to adjust TN and TP criteria for a particular lake within a certain range where sufficient data on long-term ambient TN and TP levels are available to demonstrate that protective chlorophyll a criteria for a specific lake will still be maintained and attainment of the designated use will be assured."*

The US EPA proposed numeric nutrient criteria are presented on page 42 as shown below.

(1) Proposed Numeric Nutrient Criteria for Lakes

EPA is proposing the following numeric nutrient criteria and geochemical classifications for Florida's lakes classified as Class I or III waters under Florida law (Rule 62-302.400, F.A.C.):

A	B	C	D	E	F
Long Term Average Lake Color and Alkalinity	Chlorophyll *a* [f] (µg/L) [a]	Baseline Criteria [b]		Modified Criteria (within these bounds) [c]	
		TP (mg/L) [a]	TN (mg/L) [a]	TP (mg/L) [a]	TN (mg/L) [a]
Colored Lakes > 40 PCU	20	0.050	1.23	0.050-0.157	1.23-2.25
Clear Lakes, Alkaline ≤ 40 PCU [d] and > 50 mg/L $CaCO_3$ [e]	20	0.030	1.00	0.030-0.087	1.00-1.81
Clear Lakes, Acidic ≤ 40 PCU [d] and ≤ 50 mg/L $CaCO_3$ [e]	6	0.010	0.500	0.010-0.030	0.500-0.900

Page 54 of the document presents the following description of the basis for the nutrient criteria:

"*(c) Methodology for Proposed Total Phosphorus (TP) and Total Nitrogen (TN) Criteria in Lakes EPA proposes TP and TN criteria for each of the classes of lakes described in Section*

III.B(2)(a). The proposed TP and TN criteria are based principally on independent statistical correlations between TN and chlorophyll a, and TP and chlorophyll a for clear and colored lakes in Florida Each data point used in the statistical correlations represents a geometric mean of samples taken over the course of a year in a particular Florida lake After establishing the protective levels of chlorophyll a as 20 µg/L for colored lakes and clear alkaline lakes and 6 µg/L for clear acidic lakes, EPA evaluated the data on TN and TP concentrations associated with these chlorophyll a levels and the statistical analyses performed by FDEP in support of the State's efforts to develop numeric nutrient criteria."

Based on our experience, the technical literature, and the OECD eutrophication study results, the approach described is not technically valid. Total nitrogen should not be incorporated into the criterion focused on achieving a planktonic algal chlorophyll concentration in waterbodies. "Independent statistical correlations" between total nitrogen and chlorophyll are not founded in a demonstrated and quantitative cause-and-effect relationship, but rather can be based on spurious correlations. Including total nitrogen in the constituents that must be controlled for the purpose of limiting planktonic algal biomass in all waterbodies can force large expenditures for nitrogen control in runoff/discharges that can be expected to result in little or no improvement in many lake's planktonic algal chlorophyll beyond that which can be achieved by controlling available phosphorus loads to the waterbody.

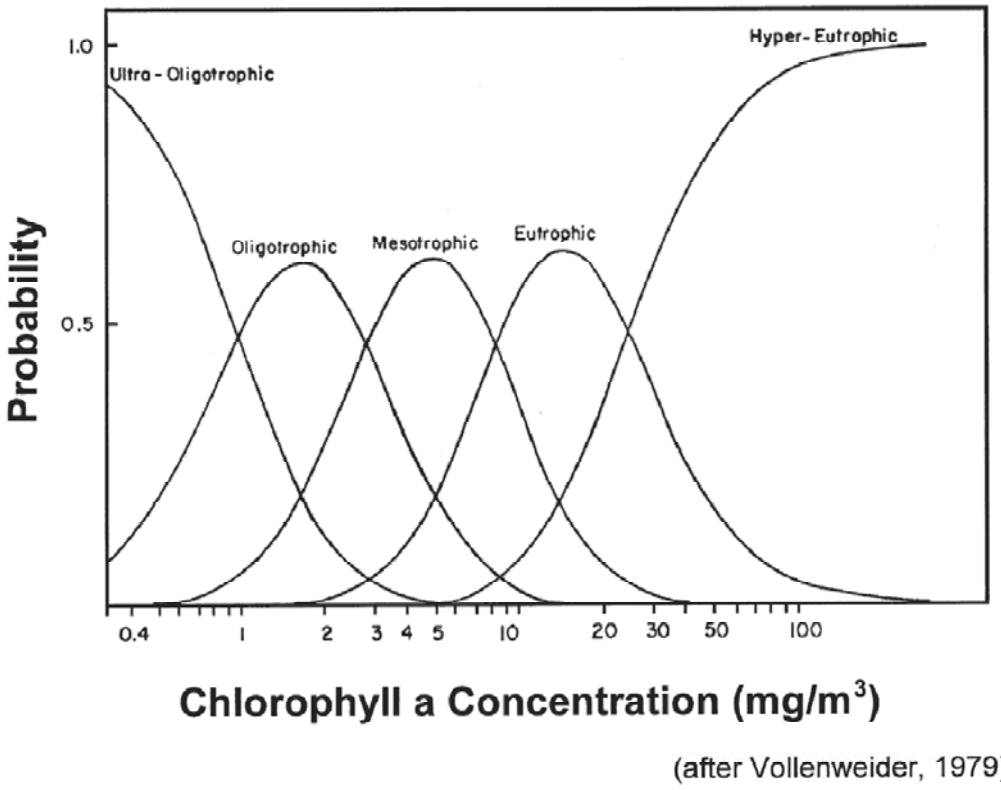
Based on the expanded OECD eutrophication study database described by Lee and Jones, the 20 µg/L planktonic algal chlorophyll value set as the water quality criterion goal translates to about 100 ug/L mean in-lake phosphorus concentration. The US EPA proposed phosphorus concentration criterion value for that level of planktonic algal chlorophyll is markedly lower (30 to 87 ug/L).

The US EPA proposed criteria do not clearly articulate whether the 20 ug/L chlorophyll target is intended to be a not-to-exceed value, a summer average value, or an annual average value. The use of a 20 ug/L average summer planktonic algal chlorophyll target is in line with generally acceptable average levels of planktonic algal chlorophyll. It should be understood, however, that a waterbody having a summer average planktonic algal chlorophyll level of 20 ug/L will occasional experience chlorophyll concentrations above that level that the public will generally consider to be excessive and constitute an impairment of their use of the waterbody. The international OECD eutrophication study steering committee members agreed that a waterbody having average chlorophyll levels of 15 to 20 ug/L during the summer growing season would likely be described, in limnological terms, as eutrophic. Vollenweider's illustration of the relationships among the limnological categories, in terms of chlorophyll concentration, is shown in Figure 1.

Another problem with the US EPA proposed nutrient criteria is the use of the geometric mean annual in-lake phosphorus concentrations. As discussed in the Lee and Jones-Lee papers and reports on their website, in-lake P concentration is an inappropriate focus for controlling eutrophication-related water quality. Phosphorus itself is not a problem; it is only a problem to the extent it is used in the production of nuisance levels of planktonic algae and aquatic weeds. Thus, the focus needs to be on the problem – measures of planktonic algae (e.g., chlorophyll), and aquatic weeds in situations where they are problematic. While statistical relationships have

been described between in-lake P and chlorophyll, the key element missing in the criteria is the relationship between the in-lake algae/aquatic weeds and the driving force for their development to nuisance amounts, i.e., the phosphorus loading.

Figure 1. OECD Eutrophication Study Steering Committee
Consensus Trophic State Classification



(after Vollenweider, 1979)

The Vollenweider–OECD normalized P load–response models generally consider a waterbody's annual loading of P. However, depending on the characteristics of a particular waterbody, it may be more appropriate to focus on the load of algal-available phosphorus that occurs just before the peak algal biomass that leads to impaired water quality. For those waterbodies, the phosphorus load that occurs at other times of the year may have little impact on the water quality that is of concern to the public and users of the waterbody. This is especially important in short-residence-time waterbodies.

The Rast et al. (1983) review referenced above discussed the available data describing P loading and response characteristics of waterbodies before and after substantial reductions had been made in the P loads. They normalized the P loads based on the Vollenweider–OECD model and compared them with the associated planktonic algal chlorophyll concentrations as prescribed by the model. They found that using the Vollenweider–OECD model and the pre-load-change normalized P load–response coupling for a waterbody, the change in chlorophyll that resulted from the P load reduction could be predicted. They found that that relationship held even when the phosphorus concentrations in the waterbodies were well-above growth-rate-limiting concentrations as based on Redfield N to P "limiting" ratios.

Relationship developed by Dr. Erwin van Nieuwenhuyse as presented at the Delta Nutrient Workshop as "Response of chlorophyll to reduced phosphorus concentration in the Delta and the Rhine River" at,
http://www.cwemf.org/workshops/DeltaNutrientsWrkshp/VanNieuwenhuyse.pdf. Lee in his synopsis of the CWEMF Delta Nutrient Workshop at,
http://www.cwemf.org/workshops/DeltaNutrientsWrkshp/Nutrientworkshop_files/CWEMF_WS_synopsis.pdf provides additional discussion of this issue, and in,

> Lee, G. F., and Jones-Lee, A., "Application of Vollenweider OECD Modeling: Limiting Nutrient Issues," Report of G. Fred Lee & Associates, El Macero, CA, February (2009). http://www.gfredlee.com/Nutrients/LimitingNutrientIssues.pdf

Another issue of concern with regard to the nutrient criteria is their exclusive focus on planktonic algal chlorophyll. There are many waterbodies in which the nutrient-related water quality problem is not planktonic algae, but rather excessive growth of aquatic plants – floating and/or attached macrophytes or benthic algae. The cause-and-effect couplings between nutrient load and aquatic plant response are quite different from those for planktonic algae. Response assessment is not as readily or universally quantified; effective management approaches are also quite different. Waterbody morphology and sediment sources of nutrients play a significantly different role in the development of aquatic plants than of planktonic algae. Indeed, in many waterbodies, the reduction in planktonic algae induces the manifestation of problems associated with aquatic macrophytes, and vice-versa.

As discussed in Lee and Jones-Lee's synopsis of the CWEMF Delta Nutrient workshop [http://www.cwemf.org/workshops/DeltaNutrientsWrkshp/Nutrientworkshop_files/CWEMF_WS_synopsis.pdf] the primary nutrient-caused water quality problem in the Sacramento San Joaquin Delta is aquatic plants – water hyacinth, Egeria, and benthic algae. Bluegreen benthic algae that develop in domestic water supply reservoirs in that system cause severe taste and odor problems that necessitate in increased expenditures for treating the water for domestic use.

Thus, as discussed in our writings, it is important to understand how nutrients added to a waterbody actually result in impairment of the uses of the waterbody. The presentations at the CWEMF Delta nutrient workshop showed that there is a poor understanding of the relationships between nutrient concentrations/loads and macrophytes biomass that develops in a waterbody. (see discussion by L. Anderson in Nutrient Sources for Growth of Exotic Aquatic Plants in the Sacramento San Joaquin Delta and G. F. Lee in the CWEMF Delta Nutrient Workshop synopsis at
http://www.cwemf.org/workshops/NutrientLoadWrkshp.pdf,
http://www.cwemf.org/workshops/DeltaNutrientsWrkshp/Nutrientworkshop_files/frame.htm,
http://www.cwemf.org/workshops/DeltaNutrientsWrkshp/Nutrientworkshop_files/CWEMF_WS_synopsis.pdf. and in,

> 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)

Mechanically focusing on planktonic algal chlorophyll could lead to large expenditures for nutrient control while failing to address the real most significant water quality problems of concern to the impairment of the beneficial uses of the waterbody. In short, it is exceedingly short-sighted to develop "nutrient criteria" that consider only one aspect of the water quality problems/beneficial use impacts that are caused by excessive inputs of nutrients.

Page 133 under (b) "*Proposed Criteria: Duration and Frequency*
EPA is proposing a duration and frequency expression of an annual geometric mean not to be surpassed more than once in a three-year period to be consistent with the expressions of duration and frequency for other water body types (e.g., lakes, streams, canals) for TN and TP and for the same reasons EPA selected a three-year period for those waters. Second, EPA proposes that the long-term arithmetic average of annual geometric means not exceed the criterion-magnitude concentration.

As discussed above the annual average of the geometric mean is not a valid approach for implementation of nutrient water quality criteria. The time of the year that the criteria are applied should be governed by when the most significant excessive aquatic planktonic algae or other excessive growths of aquatic plants occur. The limitation of nutrient loads to a waterbody should be related to the nutrients that are primarily responsible for the greatest water quality problems.

Page 12 and 13 of the Executive Summary,
"*Regarding numeric nutrient criteria for streams and rivers, EPA considered the extensive work of FDEP to analyze the relationship between TN and TP levels and biological response in streams and rivers. EPA found that relationships between nutrients and biological response parameters in rivers and streams were affected by many factors that made derivation of a quantitative relationship between chlorophyll a levels and nutrients in streams and rivers difficult to establish in the same manner as EPA did for lakes (i.e., stressor-response relationship). EPA considered an alternative methodology that evaluated a combination of biological information and data on the distribution of nutrients in a substantial number of healthy stream systems. Based upon a technical evaluation of the significant available data on Florida streams and related scientific analysis, the Agency concluded that reliance on a statistical distribution methodology was a stronger and a more sound approach for deriving TN and TP criteria in streams and rivers."*

The relationships between nutrient input to flowing systems and water quality impact are substantially more complex and less-well quantified than they are in lakes and reservoirs. The "*statistical distribution methodology"* put forth in the criteria document is technically indefensible and is little more than statistical gaming. Claiming that such an approach was deemed "stronger" and "more sound" than a recognizably unreliable approach does not impart technical credibility to it.

Beginning on page 47 is a discussion of the Carlson Trophic State Index. The Carlson Trophic state index approach follows a "limnological" study rather than problem-solution approach to developing nutrient criteria. Lee et al. (1995) discussed the development of a trophic state

classification based on water quality considerations, i.e., based on the impacts of nutrients on the beneficial uses of waterbodies.

> Lee, G. F., Jones-Lee, A. and Rast, W., "Alternative Approaches for Trophic State Classification for Water Quality Management, Parts I and II: (Suitability of Existing Trophic State Classification Systems and Application of Vollenweider-OECD Eutrophication Modeling Approach)," Report of G. Fred Lee & Associates El Macero, CA (1995). Available from gfredlee@aol.com as EF011

As they pointed out a major problem with the Carlson Trophic State Index approach in that it mixes the nutrient impact parameter of planktonic algal chlorophyll with a nutrient concentration, total P. Total P itself does not impact water quality, unless and until it stimulates the production of sufficient aquatic plant/algal biomass that impacts the beneficial uses of the waterbody. Phosphorus in a waterbody does not necessarily translate to planktonic algal chlorophyll, especially in those waterbodies with high inorganic P loads from erosion of soil-bound phosphorus from the watershed or stirred up from the sediments. Therefore, including total P in the nutrient criteria can skew the trophic state classification of a waterbody and make the nutrient criteria unreliable for assessing water quality impairments associated with nutrient additions.

Dr. G. Fred Lee Experience in
Excessive Fertilization/Eutrophication of Lakes, Reservoirs, Estuaries and
Near-Shore Marine Waters

A substantial portion of Drs. Lee and Jones-Lee's professional work has been, and continues to be, in the area of evaluation and management of the impacts of aquatic plant nutrients (nitrogen and phosphorus) on water quality/beneficial uses of waterbodies, including lakes, reservoirs, coastal marine waters, as well as riverine systems. Excessive fertilization (eutrophication) causes adverse impacts on recreational uses and aesthetics, raw water supply water quality (tastes & odors and THM formation), and fisheries resources through, among other things, food supply and oxygen depletion associated with algal decomposition. As discussed below, their work focuses on the causes, manifestation, and control of the wide range of excessive fertilization problems.

Dr. Lee's work in eutrophication evaluation and management began in the 1960s when he established, developed, and directed the Water Chemistry Program in the Department of Civil and Environmental Engineering at the University of Wisconsin, Madison. During the 13 years under his direction, that program was highly involved in lake and reservoir water quality investigation and management; approximately 100 of his graduate students did their Masters theses or Ph.D. dissertations on various aspects of lake and reservoir water quality. One of the principal focal points of that work was excessive fertilization issues. Dr. Lee pioneered in the development of approaches for evaluating the impact of a various sources of nutrients, including activities and conditions in a waterbody's watershed, on waterbodies' water quality.

In 1960, Dr. Lee was appointed vice-chair of the Lake Mendota Water Quality Management Committee. Lake Mendota is one of the most intensively studied waterbodies in the world due to the long history of limnological research conducted by the University of Wisconsin, Madison, faculty and students. From 1960 through the early 1970s many of the water chemistry studies conducted on Lake Mendota were under the direction of Dr. Lee. During that time Dr. Lee was also involved in Great Lakes water quality issues, and served as an advisor to the International Joint Commission for the Great Lakes and the US EPA on excessive fertilization issues. Over the years he has been an investigator or advisor on eutrophication-related water quality issues in many areas of the US as well as in the Netherlands, Norway, Italy, Spain, Israel, Jordan, Japan, the USSR, Dominican Republic, South Africa, Argentina, and Antarctica.

On behalf of the Water Resources Center at the University of Wisconsin, Madison, Dr. Lee developed the first comprehensive overview of the causes, processes, implications, and management of the eutrophication of waterbodies in the paper:

> Lee, G.F., "Eutrophication," University of Wisconsin Eutrophication Information Program Occasional Paper no. 2, 32 pp (1970) [also published in Transactions of the Northeast Fish and Wildlife conference, pp 39-60 (1973), and available upon request from gfredlee@aol.com as EF014]

More recently, he and Dr. Jones-Lee were asked to contribute the following review of eutrophication:

Jones-Lee, A. and Lee, G. F., "Eutrophication (Excessive Fertilization)," In: Water Encyclopedia: Surface and Agricultural Water, Wiley, Hoboken, NJ, pp 107-214 (2005). [available at: http://www.gfredlee.com/Nutrients/WileyEutrophication.pdf]

Those reviews discuss the roles of nitrogen, phosphorus, and other constituents and factors in causing excessive fertilization-related water quality problems, as well as, and most importantly, approaches that can be used to manage excessive fertilization and evaluate the effectiveness of management strategies. Those two writings remain the most comprehensive reviews of eutrophication and its management.

Dr. Lee was also involved in the lake and reservoir management studies conducted by the state of Wisconsin in the late 1960s to early 1970s. As part of that program, whole-lake experimental approaches were used to assess the efficacy of a variety of strategies for evaluating and managing water quality in excessively fertile lakes; strategies evaluated included adding alum to lakes to remove phosphorus, aeration of lakes to mix the hypolimnion and epilimnion, hypolimnetic aeration, aquatic plant harvesting, among others. Dr. Lee was involved in a number of additional projects in the state of Wisconsin in which alum was used to treat whole lakes for phosphorus removal; he supervised the masters thesis work of one of his students on this topic. Dr. Lee has developed specific guidance for discerning situations in which alum treatment for phosphorus removal can be effective, and where it should not be used. Critical to this assessment is the relative role of phosphorus in controlling excessive fertilization in the waterbody.

For a number of years beginning in the 1970s, Dr. Lee was a member of the American Water Works Association's national 'Quality Control in Reservoirs' Committee. During that time, the committee specifically addressed the value of mixing of lakes, either by aeration or pumping, for the purpose of managing eutrophication-related water quality problems. It was the committee's conclusion, supported by the fundamental chemistry of nutrients, that aeration of a whole waterbody could be significantly adverse to improving eutrophication-related water quality characteristics. Oxygenation of the hypolimnion, however, could be effective in maintaining cold-water fisheries and improving water supply water quality by reducing nutrient transport from the hypolimnion to the epilimnion. In 1965 Dr. Lee published a paper,

Lee, G.F. and Harlin, C.C., "Effect of Intake Location on Water Quality," Industrial Water Engineering 2:36-40 (1965). [available upon request to gfredlee@aol.com as publication DW003].

which specifically addressed the importance of evaluating domestic water supply water quality as a function of depth, and how, through selective withdrawal, water utilities can optimize their water quality in a thermally stratified waterbody.

While working with the state of Wisconsin Department of Conservation, Dr. Lee studied the impact of aeration of Comstock Reservoir on water quality. He examined the impact of aeration not only on chemical and biological characteristics of the reservoir, but also on the fisheries of the waterbody. Dr. Lee has had extensive experience in the evaluation of the impacts of various types of chemicals used to control algae and other aquatic weeds, including copper and diquat, on a waterbody's water quality and fisheries. Further, he is familiar with regulatory issues

associated with the use of chemicals for aquatic plant control and their impact on non-target aquatic life. More recently, in support of the DeltaKeeper and the California State Water Resources Control Board, Dr. Lee developed guidance for evaluating the water quality impact of herbicides used to control excessive growths of aquatic weeds, on non-target organisms:

> Lee, G. F., "Developing a Reliable Program to Monitor Water Quality Impacts of Aquatic Pesticides," Report of G. Fred Lee & Associates, El Macero, CA (2004). [available at: http://www.gfredlee.com/Nutrients/Aq-Pest-MonPgm.pdf]

Dr. Lee has had extensive experience in assessing and managing the couplings among eutrophication, eutrophication control, and fish and other aquatic organisms. He and Dr. Jones-Lee published what has become recognized as one of the most comprehensive reviews of the impacts of eutrophication and water quality management on fish populations:

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

That paper reviews how managing algae-related water quality in a reservoir can influence the fisheries of the waterbody.

During the 1970s, Dr. Lee was awarded the US EPA contract to develop a synthesis report for the US part of the Organization for Economic Cooperation and Development (OECD) eutrophication studies. The approximately $50-million OECD eutrophication studies examined the nutrient load—eutrophication-related water quality response relationships in about 200 waterbodies located in 22 countries (in western Europe, North America, Japan, and Australia) over a five-year period. Dr. Lee served as an advisor to the overall international studies, as well as developed the US OECD report synthesizing the data on about 40 US waterbodies. Dr. Lee's primary contribution to this effort was in the development, evaluation, and application of the Vollenweider–OECD empirical nutrient load—eutrophication-response relationship concepts. His work broadened the basis of the models, expanded the concept to other eutrophication-related water quality characteristics, documented their predictive capability, and described their ranges of applicability and limitations. He also demonstrated how those relationships that can be used by water utilities and others to examine how land use in a waterbody's watershed influences nutrient transport to the waterbody from the watershed and then, the waterbody's water quality. Drs. Lee and Jones-Lee and their associates have published extensively on these topics, including several comprehensive reviews such as:

> Lee, G. F., Rast, W. and Jones, R. A., "Eutrophication of water bodies: Insights for an age-old problem," Environmental Science & Technology 12:900-908 (1978).
> http://www.gfredlee.com/Nutrients/Eutrophication-EST.pdf
>
> Jones, R. A. and Lee, G. F., "Eutrophication Modeling for Water Quality Management: An Update of the Vollenweider-OECD Model," World Health Organization's Water Quality Bulletin 11(2):67-74, 118 (1986).
> http://www.gfredlee.com/Nutrients/voll_oecd.html.

Jones, R. A. and Lee, G. F., "Chlorophyll-A Raw Water Quality Parameter," Journal American Water Works Association 74:490-494 (1982). [available upon request from gfredlee@aol.com].

Key to the development and evaluation of effective nutrient/eutrophication control strategies is the ability to reliably assess the improvement in water quality that can result, or has resulted, from various control strategies. One of the important results of their work with the Vollenweider-OECD eutrophication modeling approach was their demonstration of the predictive capability and reliability of the models using data collected before and after nutrient load alterations. That work was discussed in:

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

While serving as chairman of the AWWA national Quality Control in Reservoirs Committee, Drs. Lee and Jones-Lee developed several committee reports that were designed to assist water utilities in managing their raw water quality:

Lee, G. F. and Jones, R. A., "Study Program for Development of Information For Use of Vollenweider-OECD Eutrophication Modeling in Water Quality Management for Lakes and Reservoirs," G. Fred Lee & Associates, El Macero, CA (1992). [available as EF007 upon request from gfredlee@aol.com].

Dr. Lee was asked by the organizers of a University of California Water Resources Center conference devoted to water supply source water quality issues, to develop a review of water quality issues in the Sacramento/San Joaquin Delta in the Central Valley of CA. This resulted in Drs. Lee and Jones-Lee's publication of the following paper and report:

Lee, G. F. and Jones, R. A., "Managing Delta Algal-Related Drinking Water Quality: Tastes and Odors and THM Precursors," Published in "Protecting Drinking Water Quality at the Source," proceedings of a Conference, Univ. of California Water Resources Center, Report no. 76, October (1991).

Lee, G. F. and Jones, R. A., "Regulating Drinking Water Quality at the Source," Presented at Univ. of California Water Resources Center Conference, "Protecting Drinking Water Quality at the Source," Sacramento, CA, April 3-4 (1991). http://www.gfredlee.com/WSWQ/wswqsour.htm

Those publications specifically discuss issues of how land use within and upstream of the Delta influences the quality of the domestic water supply derived from the Delta. Further, as part of the CA/NV AWWA Section Source Water Quality Committee, Dr. Lee developed a review for the committee on the impact of the drought in the late 1980s - early 1990s on domestic water supply water quality:

Lee, G. F. and Jones, R. A., "Impact of the Current California Drought on Source Water Supply Water Quality," Presented at CA/NV AWWA Fall conference, Anaheim, CA, 30pp, October (1991). [available upon request from gfredlee@aol.com].

That paper reviewed how the algae-related quality of the water derived from the Delta adversely impacts domestic water supply water quality through taste and odors and THMs.

Much of Dr. Lee's work on excessive fertilization of waterbodies has focused on eutrophic/hypertrophic waterbodies in which bluegreen algae dominate the flora. Bluegreen algae can be a significant source of tastes and odors in domestic water supplies. A number of Dr. Lee's graduate students did their Ph.D. dissertations on water quality issues associated with bluegreen algae; topics investigated included nitrogen fixation by bluegreen algae, the role of thermocline migration and erosion in the transference of hypolimnetic nutrients to surface waters where they stimulate bluegreen algal blooms, and the role of sediments and other sources of nitrogen and phosphorus compounds in controlling bluegreen algae dominance in waterbodies.

Dr. Lee has been involved in several major projects on behalf of water utilities specifically designed to examine how land use in a water supply reservoir's watershed influences raw water quality. In what is believed to be one of the most comprehensive studies of this type ever undertaken, Dr. Lee conducted a multi-year, several hundred-thousand-dollar project on behalf of the city of Dallas, Texas, water utility. That study specifically addressed the issues of how changes in land use in the watershed of Lake Ray Hubbard, one of the primary water supply reservoirs for the city of Dallas, influenced taste- and odor-related water quality. The study considered not only algae but also actinomycetes as sources of taste and odors. Dr. Lee and one of his graduate students published a paper on the results of that investigation:

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

Dr. Lee conducted a similar study for the Olathe, Kansas, water utility, in which he examined the relationship between land-use practices in Lake Olathe's watershed and the waterbody's raw water quality.

Dr. Lee also conducted a study on behalf of the Lubbock, Texas, water utility related to controlling THMs in its finished water by controlling the sources of organic carbon in its raw water derived from Lake Meredith. That was an unusual situation in that a freshwater sponge was growing in the raw water transmission line between the reservoir and the water utility; it developed to a thickness of a foot or more inside the pipe. The sponge was obtaining its nutrients from organics derived from in-line open reservoirs along the transmission line.

One of the areas that Dr. Lee has pioneered is the development of guidance to water utilities and others on how to design a water supply reservoir to minimize raw water quality problems. He presented a paper on this topic:

> Lee, G. F. and Jones, R. A., "Predicting Domestic Water Supply Raw Water Quality in Proposed Impoundments," IN: Proc. American Water Works Association 1984 Annual Conference Proceedings, pp 1611-1630 (1984).
> http://www.gfredlee.com/WSWQ/RawWQProposedImp84.pdf

Drs. Lee and Jones-Lee assisted the Municipal Water Supply Authority for Santo Domingo in the Dominican Republic to evaluate the adequacy of a proposed water treatment plant for treating the waters derived from a yet-to-be-developed water supply reservoir on a river. They were able to develop predictions of the raw water quality in the proposed reservoir based on land use in the reservoir's watershed. From that prediction, they concluded that the proposed water treatment plant would not be able to produce high-quality water, and recommended changes in the design of the treatment plant to more appropriately address the water quality characteristics that would be expected based on the proposed reservoir's watershed.

Dr. Lee has been active for many years in work on the impacts of releases from reservoirs on downstream water quality. For example he served as an advisor to the Tennessee Valley Authority and other agencies on the impact of reservoir releases on downstream water quality and co-authored a review on this topic:

> Krenkel, P. A., Lee, G. F. and Jones, R. A., "Effects of TVA Impoundments on Downstream Water Quality and Biota," IN: The Ecology of Regulated Streams, Plenum Press, New York, pp 289-306 (1979). [available upon request from gfredlee@aol.com.]

Another major concern about the impact of excessive fertilization on water quality is the utilization of dissolved oxygen in the bacterial decomposition of algae, which can lead to low dissolved oxygen or anoxic conditions in waterbodies. Drs. Lee and Jones-Lee served as the coordinating principal investigators for a $2-million CALFED project devoted to evaluating the cause and developing control programs, for the low dissolved oxygen problem in the San Joaquin River (SJR) Deep Water Ship Channel (DWSC) near the Port of Stockton. One of the primary causes of the dissolved oxygen depletion there is the oxygen utilization in the decomposition of algae that had developed upstream in the SJR. Upon entering the DWSC the algae settle, die and decompose; the decomposition depletes the oxygen resources of the channel. They developed a comprehensive synthesis report and supplementary discussion on that situation:

> 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 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

They have become involved in the issues of the development of appropriate approaches for controlling phosphorus from agricultural land runoff to improve those conditions, focusing in part on the comparative effects of controlling total phosphorus versus algal-available P in runoff waters. The following reviews address those issues:

> Lee, G. F., "A Proposal for Assessing Algal-Available Phosphorus Loads in Runoff from Irrigated Agriculture in the Central Valley of California," Report of G. Fred Lee & Associates, El Macero, CA, November (2006).
> http://www.gfredlee.com/Nutrients/AlgalAssayAvailP.pdf

Lee, G. F., "Assessing Algal Available Phosphorus," Proceedings of US EPA Science Symposium: Sources, Transport, and Fate of Nutrients in the Mississippi River and Atchafalaya River Basins, Minneapolis, MN, November 7-9 (2006). http://www.gfredlee.com/Nutrients/AvailPEPASymp06.pdf

Drs. Lee and Jones-Lee are serving as advisors on the excessive fertilization of the Upper Mississippi River, examining the relative roles of agricultural land runoff and domestic wastewater sources in contributing to the problems. They are also working with the California Central Valley Regional Water Quality Control Board on the development of guidance for evaluating the water quality impact nitrogen and phosphorus in agricultural runoff/discharge and presented their findings in,

Lee, G. F. and Jones-Lee, A., "Assessing the Water Quality Significance of N & P Compound Concentrations in Agricultural Runoff," Invited presentation to the Agrochemical Division, American Chemical Society national meeting, San Francisco, CA, September (2006). http://www.gfredlee.com/Nutrients/N-PRunoffACS.pdf

Lee, G. F., and Jones-Lee, A., "Assessing Water Quality Significance of N & P Compound Concentrations in Agricultural Runoff," PowerPoint Slides for Invited Paper Presented at Agrochemical Division, American Chemical Society National Meeting, San Francisco, CA, September (2006). http://www.gfredlee.com/Nutrients/N-PSlidesACS.pdf

With support of the California State Resources Board they developed,

Lee, G. F., and Jones-Lee, A., "Managing Nutrient (N & P) Water Quality Impacts in the Central Valley, CA," [Excerpts from: Lee, G. F. and Jones-Lee, A., "Review of Management Practices for Controlling the Water Quality Impacts of Potential Pollutants in Irrigated Agriculture Stormwater Runoff and Tailwater Discharges," California Water Institute Report TP 02-05 to California Water Resources Control Board/Central Valley Regional Water Quality Control Board, 128 pp, California State University Fresno, Fresno, CA, December (2002)], Report of G. Fred Lee & Associates, El Macero, CA (2002). http://www.gfredlee.com/SJR-Delta/CentralValleyNutrientMgt.pdf

That report presents a comprehensive review of nutrient evaluation/management issues. More recently, Drs. Lee and Jones-Lee worked with the California Water Environmental Modeling Forum to develop and present a workshop devoted to Delta Nutrient Water Quality Issues. Information on that workshop is available in

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). [available at: http://www.gfredlee.com/Nutrients/NutrWorkshopRev4.pdf]

A list of their publications concerning eutrophication evaluation and management is available on this website. For further information, contact G. Fred Lee at gfredlee@aol.com