Proposed Regionalization of Nutrient Criteria Development within the Central Valley of California[1]

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At the June 7, 2001, US EPA Region 9 RTAG meeting I was asked how I would regionalize nutrient criteria development in California. My response was based on my experience in working on these issues over the past 12 years or so, where I have had the opportunity to examine impairment of the beneficial uses of waters in various parts of the Central Valley that are caused by excessive nutrients in the waterbody as well as over 40 years of experience in investigating and managing successive fertilization of waterbodies located throughout the world. My recommended approach toward nutrient criteria regionalization in the Central Valley is presented below.

- **San Joaquin River Basin**
  The San Joaquin River Basin should be defined based on the watershed upstream of Vernalis. This watershed should be divided into two distinct units. One is the reservoirs and upstream of the reservoirs on the eastern side. The other is the rivers, streams and sloughs downstream of the reservoirs on the eastern side, as well as all western side streams, rivers and sloughs.

- **Deep Water Ship Channel**
  Because of its unusual morphological and hydrological characteristics, the San Joaquin River Deep Water Ship Channel between the Port of Stockton and Disappointment Slough/Columbia Cut should be classified as a distinct nutrient criteria unit that needs individual attention. The San Joaquin River Deep Water Ship Channel downstream of Disappointment Slough/Columbia Cut should be classified as part of the Delta unit. For much of the year, the water in the San Joaquin River Channel below Columbia Cut is primarily Sacramento River water that is being transported to the export pumps.

- **Lake McCloud and the Port of Stockton Turning Basin**
  The City of Stockton has special nutrient-related problems in Lake McCloud and the channel that connects the lake to the Port of Stockton Turning Basin where, at times, this dead-end channel experiences excessive growths of blue-green algae. This situation is somewhat unique in the Central Valley. This area should be considered a separate single-nutrient criteria.

- **Freshwater Part of the Delta**
  The Delta should be classified as a single nutrient criteria unit, although the South Delta may need to be considered as a separate sub-unit, since at times it is dominated by San Joaquin River water that is transported into the South Delta via Old River.

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1 Submitted to US EPA RTAG Nutrient Criteria Program, Report of G. Fred Lee & Associates, El Macero, CA (2001).

- **Downstream of Delta Water Users**
  The water supply reservoirs that are filled to a substantial extent with Delta water that are used for domestic water supply purposes should be considered a separate nutrient criteria unit because of their unique nutrient-caused problems for domestic water supplies.

- **Sacramento River Watershed**
  The Sacramento River watershed below Shasta and all other reservoirs should be classified as a single nutrient criteria unit. A special category of waterbodies in the valley floor of the Sacramento River watershed would include the domestic wastewater and ag drain effluent-dependent waterbodies. These waterbodies will likely need to be classified as separate nutrient criteria units since the impairment of the beneficial uses of these waters by nutrients is manifested significantly differently than in the mainstem of the Sacramento River and its major tributaries.

  Upstream of the reservoirs and any tributary that does not have a reservoir on it should be classified as another nutrient criteria unit. The rivers/tributaries to Shasta should be a third unit.

Recommended Nutrient Criteria Development Approach
For each of the nutrient criteria development regions, the Regional Board should organize a stakeholder process to hold a series of meetings in each of the regions to allow public input on the nutrient-related water quality that is desired within each region. The Regional Board would then, through normal Board procedures, formally adopt the water quality characteristics that, through the public process, are determined to be appropriate.

SJR Mainstem. Some of the characteristics that would be considered for the mainstem and major tributaries below reservoirs for the San Joaquin River would be an impairment of uses related to excessive growths of planktonic algae. Even though there are high nutrient concentrations and high planktonic algal chlorophyll in these areas, it is believed that the public who utilize these areas for recreation or other purposes do not consider the waters in this region "impaired" because of excessive fertility. This is due in part to the high background inorganic turbidity derived from upstream erosion. In my opinion, there is no justification for claiming that there is an impairment of the beneficial uses of the San Joaquin River and its major tributaries below the reservoirs, as well as non-reservoir-derived tributaries, due to nutrients. The nutrient criteria issue for the mainstem of the SJR becomes that of establishing criteria for this reach of the mainstem and its tributaries based on the impacts of the nutrients and the algae that develop from the nutrients on downstream of Vernalis water beneficial uses.

While unlikely, it is possible, especially if the high levels of inorganic turbidity derived from upstream watershed erosion were significantly controlled, that the public/stakeholders who are concerned about nutrient-related San Joaquin River water quality could judge that the high levels of nutrient/algae present in the mainstem water are detrimental to the beneficial uses of the River. If this occurs, then the issue of developing nutrient control programs in the SJR watershed to address the perceived nutrient related water quality problems in the mainstem of the San Joaquin River above Vernalis would need to be conducted.

SJR Upstream of Reservoirs. With respect to the east-side reservoirs and upstream of these reservoirs, it is my impression that, generally, the nutrient-related water quality in the tributaries and the reservoirs is high, and there is no need to limit nutrient inputs to these waterbodies. There may be localized areas, especially downstream of wastewater inputs to the tributaries where there could be an alteration of the aquatic life-related characteristics. Under those situations, unless there is severe degradation of the waterbody, I would develop a sub-classification of aquatic life-related beneficial uses which would allow alteration of the beneficial uses from those that would occur if there were no nutrient inputs from local sources.

SJR Deep Water Ship Channel. The issues of the impact of nutrients on the Deep Water Ship Channel (DWSC) water quality are being addressed in the low DO TMDL. The prevention of DO concentrations below the water quality objective through upstream control of algae, carbonaceous oxygen demand, and nitrogenous oxygen demand that contribute to the low DO, as well as channel aeration and management of flows through the DWSC should eliminate the need for any further nutrient control that might arise from exceedances of nutrient criteria, even though the total nutrients present are well in excess of any US EPA default nutrient criteria development guideline value. This approach is recommended since the beneficial uses of the DWSC would be protected if the DO objective is not violated. It should be noted that the impacts of nutrients/algae on the DWSC are significantly ameliorated by the elevated inorganic turbidity present in the channel waters. If the turbidity were reduced, it is possible that the additional algal growth that could occur in the DWSC could impair recreational and other uses of these waters.

SJR Mainstem Tributaries. It is unlikely that it will be possible to control nutrient concentrations in the mainstem of the San Joaquin River and the Deep Water Ship Channel derived from agricultural runoff or other sources such as domestic, industrial, agricultural wastewater discharges and wetlands releases, to prevent algal growth in the mainstem of the San Joaquin River that would represent what are typically considered to be desirable planktonic algal chlorophyll levels, i.e. less than about 10 µg/L. As discussed above, however, the elevated planktonic algal chlorophyll within the SJR is not significantly detrimental to the beneficial uses of the mainstem of the river, largely as a result of the inorganic turbidity in these waters. The high cost and the difficulty of controlling nutrients in stormwater runoff from ag land and some wastewater discharges creates a situation where it will likely will be very difficult if not impossible to reduce the nutrient concentrations in the mainstem of the SJR to achieve low levels of chlorophyll in these waters.

However, during the summer of 2000, over 50% of the oxygen demand present in the SJR and Vernalis, was derived from algae discharged to the SJR by Mud and Salt Sloughs, and the SJR above Landers Avenue. It may be possible that nutrient control within the tributaries of the SJR (such as Mud and Salt Sloughs and the SJR above Landers Avenue), could potentially significantly reduce the algal oxygen demand load within these tributaries so that the headwaters of the SJR start out with a significantly lower total oxygen demand. This, in turn would significantly lower the algal related oxygen demand that is present in the SJR at Vernalis and that at times, is discharged to the

DWSC. Under these conditions, the residual elevated concentrations of nutrients in the tributary waters would not develop a large algal oxygen demand in the transport to the DWSC, since there is insufficient time between where the tributaries to the SJR enter the SJR and Vernalis to allow algae to develop to excessive levels within the SJR.

There is need to investigate the potential impacts of selective nutrient control in the major SJR tributaries on the potential to reduce the algal related oxygen demand that is contributed to the mainstem of the SJR that at times represents a significant contribution of oxygen demand to the DWSC. These investigations could lead to the development of nutrient criteria within the SJR tributaries designed to limit algal growth within these tributaries in order to reduce algal related oxygen demand contributed to the DWSC.

Delta. There are several aspects of the San Joaquin River watershed discharges of nutrients/algae into the Delta that need to be evaluated with respect to the need for nutrient control to protect beneficial uses. One of these is the issue as to whether the nutrients that are developed within the SJR watershed that enter the Delta, either through Old River or through the Deep Water Ship Channel, cause a significant adverse impact on the beneficial uses of the Delta waters. The Delta has several nutrient-related water quality problems, such as excessive growths of water hyacinth and egeria, which necessitate herbicide application for their control. There are low DO problems within at least the South Delta and possibly the Central Delta related to the algal caused oxygen demand that develops in the SJR upstream of Vernalis and within the DWSC that is discharged to Delta waters either via Old River or through the DWSC under high flow conditions. While low DO situations are documented in the South Delta, there is a lack of data on the dissolved oxygen concentrations in the Central Delta as influenced by the export pumping of Central Delta water to Central and Southern California.

Delta Water Exporters Reservoirs. The water utilities that export water from the Delta for domestic water supply purposes that store this water in downstream reservoirs experience taste and odor problems and other treatment problems associated with algal growth in these reservoirs. Part of the nutrients that contribute to these problems are derived from the San Joaquin River watershed. Nutrient control to eliminate algal growth in water utility reservoirs that export Delta water from agricultural and other sources could be very expensive, and could be judged to be excessively expensive when considered in light of the ability of agricultural interests in the SJR watershed to financially support anything other than modest nutrient control. One of the issues that needs to be evaluated, however, is whether it may be more cost-effective for the water utilities that experience these problems to provide the additional treatment than to try to initiate nutrient control in the SJR watershed.

Impact of Nutrients on Fisheries Resources. One of the paradoxes of the nutrient situation within the Delta is that some fisheries resource managers feel that there is insufficient primary production within the Delta to support desirable fish populations. It is well known from the literature that significantly limiting nutrients entering a waterbody will reduce fish biomass. Controlling nutrient inputs to the Delta could be contrary to fisheries production within the Delta. Part of the problem with the low planktonic algal chlorophyll relative to the nutrients available within the Delta is sometimes attributed to invasive benthic organism harvesting of phytoplankton by *Corbicula*, a freshwater clam. There is need to better understand the relationship between phytoplankton biomass in the Delta and fish production.

Summary. In summary, the primary problems of excessive nutrients associated with the San Joaquin River watershed are excessive growths of algae that contribute to the low DO problem in the DWSC. This problem will be solved through a combination of nutrient control, oxygen demand control, aeration and management of flows through the DWSC. The focus of the need for nutrient control within the SJR watershed then shifts to problems caused by excessive growths of water hyacinth and egeria and the taste, odor and other water quality problems that develop for domestic water supplies that use the Delta as a raw water source.

The first step in exploring the development of a nutrient control program in the SJR watershed to control excessive water hyacinth/egeria development and algae in water supply reservoirs is an evaluation of the level of nutrient control needed from the SJR watershed, from the Sacramento River watershed and from in-Delta sources needed to control the water hyacinth/egeria and algal-caused tastes and odors to the desired level. Associated with formulation of a management plan and nutrient criteria to address this issue should be an evaluation of the cost of trying to control nutrients from municipal and industrial wastewaters and agricultural runoff/discharges, as well as atmospheric and other sources.

Establishing Nutrient Load-Eutrophication Response Relationships. Under current guidance, the US EPA provides a default national nutrient criteria development process which is based on an assessment of nutrient concentrations that would be expected in the waterbody in the absence of cultural activities (urbanization, agriculture, etc.)in the watershed. This chemical concentration based approach does not necessarily reflect the site-specific nature of how nutrient loads/concentrations impact nutrient-related water quality. The Agency also allows for a "scientifically defensible" development of site-specific nutrient criteria that will protect the beneficial uses of the waterbody for which the criteria are being developed. Generally those who have worked in the eutrophication management find that the US EPA's default nutrient criteria development approach can readily lead to technically invalid assessments of the allowed nutrient loads to a waterbody to protect the waterbody's beneficial uses without unnecessary expenditures for nutrient control.

It is strongly recommended that for each of the Central Valley nutrient criteria units, defined above, that site-specific investigations be conducted to determine the appropriate available nutrient load to the waterbody to achieve the public desired nutrient-related water quality in the waterbody. Generally this will require the development of an available nutrient load-eutrophication response relationship (model) for the waterbody. Jones-Lee and Lee, (2001) have provided a review of the OECD nutrient load eutrophication response relationships that can be used for some waterbodies to estimate the nutrient load to achieve the desired eutrophication related water quality. This approach, if properly applied, can work well for certain types of waterbodies, especially lakes and reservoirs where the nutrient impacts are manifested in the excessive growths of planktonic algae. For other waterbodies, however, such as streams, rivers, near-shore marine waters, etc, there will be need to conduct site-specific investigations to determine the appropriate available nutrient load to achieve the desired eutrophication-related water quality. It is important that those conducting these studies are familiar with and fully understand eutrophication management literature. Failure to do so can readily lead to unreliable development of nutrient criteria for a waterbody.

In general, the development of appropriate nutrient criteria for a waterbody requires the development of appropriate available nutrient loads to achieve the desired eutrophication-related water quality. As discussed by Jones-Lee and Lee (2001), it is extremely important that the available phosphorous load be used rather than the US EPA's recommended approach of total phosphorous, especially from ag and urban stormwater runoff can significantly overestimate the amount of phosphorous in the water that is available to support algae and other aquatic growth.

With respect to developing nutrient criteria for the Delta, its tributaries and downstream water users, there will be need to develop site-specific nutrient loads which can, in turn be translated into concentrations for each of the nutrient management units. This process should follow the approach that is used today in developing and implementing TMDLs. The important difference to conventional TMDLs is that the control goal is not a water quality standard, but is a publicly developed desired degree of fertility (eutrophication-related water quality) that is appropriate for each nutrient management unit. This approach can lead to scientifically defensible nutrient criteria for a waterbody.

References:

Jones-Lee, A. and Lee, G. F., "Evaluation of Inorganic and Organic Nutrient Source Impacts in Nutrient TMDLs," Presented at the AWWA/WEF/CWEA Joint Residuals and Biosolids Management Conference, San Diego, CA, February (2001).
http://www.gfredlee.com/eval_inorganic_022000.pdf

(Also a discussion of these issues is available in the Stormwater Runoff Water Quality Science/Engineering Newsletter, Volume 4, 3/4, issued in spring 2001. This and other stormwater newsletters are available from www.gfredlee.com/newsindex.htm)