COUNTY OF LAKE
WATER RESOURCES
255 N. Forbes Street
Lakeport, California 95453
Telephone 707-263-2344
Fax 707-263-1965
watershed.co.lake.ca.us

Scott De Leon
Director

Will Evans
Deputy Director

July 20, 2016

Ms. Holly Grover
Central Valley Regional Water Quality Control Board
11020 Sun Center Dr., Suite 200
Rancho Cordova, CA 95570

Re: Clear Lake Nutrient TMDL 2017 Board Update

Dear Ms. Grover:

Thank you for contacting us about the Clear Lake Nutrient Total Maximum Daily Load (TMDL) 2017 Board Update. We welcome the opportunity to provide an update on all of our TMDL implementation activities as well as offer some suggestions for implementation of the Clear Lake Nutrient TMDL in the future. The County of Lake continues to implement many best management practices (BMP's) including construction site inspections, municipal good housekeeping, public outreach, and post-construction stormwater management in an effort to reduce nutrient loads from known pollutant-generating sources. We also continue to implement and expand our water quality monitoring programs to track the reductions in phosphorus that have been observed since the 1990's. However, due to the large size of Clear Lake, it is very difficult to tie any phosphorus reduction to actual BMP implementation within the watershed. This fact has also made obtaining implementation grants difficult. The information below discusses the types of management measures deployed by the county, projects to reduce nutrient loading, water quality monitoring programs, challenges, and recommendations for moving forward.

MANAGEMENT MEASURES

The County of Lake owns and directly manages approximately 6,500 acres of land and 423 miles of road in the Clear Lake watershed. The County also regulates land development activities (housing and commercial construction, agricultural land clearing, surface mining, etc.) on private property within the Clear Lake watershed through permitting. A significant portion of the Clear Lake watershed is owned and managed by the United States Forest Service (USFS) and Bureau of Land Management (BLM). The activities described below are only reflective of the County of Lake's efforts in TMDL implementation and do not cover activities carried out by other agencies with land management duties in the Clear Lake watershed.

The Lake County Clean Water Program is the vehicle for implementation of the Municipal Stormwater Permit (MS4) in Lake County. The Clean Water Program includes activities carried out by the City of Lakeport, City of Clearlake, and the County of Lake. Annual activities are summarized and highlighted in the program's annual report, which is submitted to the state in October each year. Out of all the minimum control measures contained in the MS4 permit, the

construction site runoff control BMP has the greatest impact on water quality and subsequent phosphorus reductions. All grading activities in unincorporated Lake County are subject to the county's grading ordinance and stormwater ordinance, which require a thorough environmental and plan review as well as follow-up inspections and mitigation monitoring. Illegal grading is aggressively abated and inspections are conducted for a year following all grading activities in order to verify that no erosion is occurring. However, as stated above, it is difficult, if not impossible to determine phosphorus reduction levels in Clear Lake based specifically on implementation of these BMP's.

PROJECTS

In addition to management measures, Lake County has pursued several restoration projects that strive to control nutrient loading in Clear Lake. Projects are described below:

Middle Creek Flood Damage Reduction and Ecosystem Restoration

The Lake County Watershed Protection District continues to pursue the Middle Creek Flood Damage Reduction and Ecosystem Restoration Project (Middle Creek Project). This project consists of restoring a historical wetland where approximately 50% of the runoff from the watershed enters Clear Lake. This project has been identified in studies to accomplish the majority of Clear Lake's external nutrient load reduction goal. To date, the LCWPD has acquired twenty five properties totaling 506 acres. Twelve properties totaling 365 acres are in the acquisition process with offers made by the LCWPD. If these acquisitions are completed, this will represent nearly half of the necessary property acquisitions and exhaust the $12.714 million in current grant funding from CDWR. The LCWPD will continue to pursue additional funding for property acquisition in addition to working with different government agencies to identify a source of funds to cover the remaining costs associated with the project, which are likely to exceed $25 Million.

Small Stream Restorations

Over a dozen small stream restoration projects have been conceptualized by county staff. These include Schindler Creek in Clearlake Oaks and Molesworth Creek in Lower Lake. Most of these projects involve reconnection of the stream to its historical floodplain in an effort to prevent sediment from discharging to Clear Lake during high flow events. The goal of these projects is to address the remaining 50% of the watershed that does not drain through the Middle Creek marsh. These projects are in the conceptual phase and will be moving forward in the coming years if funding is available.

Tule Mitigation and Replanting Bank

Since 2014, the County has been pursing grant funds for the establishment of a tule mitigation and replanting bank. Studies have shown that Clear Lake has lost 79% of the historical tule wetlands that surrounded the perimeter of the lake and served as a natural filter for nutrients entering the lake in addition to pulling nutrients out of the water. Multiple attempts to obtain grant funding for this project have failed, primarily because nutrient reductions cannot easily be monitored and tracked within the timeframe that the grants allow, typically 1-3 years.

MONITORING

Lake County implements several water quality monitoring programs related to compliance with the Clear Lake Nutrient TMDL as discussed below:

Tributary Monitoring

Beginning Water Year (WY) 2015, the Lake County Watershed Protection District (LCWPD) restarted the monitoring program for nutrients in the Clear Lake tributaries. This program is a continuation of the 2007-2008 Clear Lake Watershed TMDL Monitoring Program[1], however, the number of analytes has been reduced based on the lessons learned in 2007-2008. We are measuring Total Suspended Solids, Total Kjeldahl Nitrogen, Total Nitrogen, Total Phosphorus, Nitrate (as N), and Nitrite (as N). We are collecting samples at the three California Department of Water Resources (CDWR) gages; Kelsey Creek below Kelseyville, Scotts Creek near Lakeport and Middle Creek near Upper Lake. We collected one set of samples in WY 2015 and five sets of samples in WY 2016. CDWR has identified issues with the calibration of all three gages, therefore, we have not been able to complete the analysis of this additional data. We plan on continuing this monitoring program annually.

We have started discussions with the United States Geological Survey (USGS) about adding stream gages near Tule Lake, which would add approximately 50 sq. mi. of the Scotts Creek watershed to the monitoring program and help evaluate impacts from the NRCS Tule Lake conservation easements (discussed below). To date, we have not added the additional gage(s) and technical limitations may prohibit installation of a gage upstream of Tule Lake.

Sediment Monitoring

We are continuing to monitor Clear Lake sediments for phosphorus and nitrogen. This monitoring program is conducted monthly in conjunction with the California Department of Water Resources Lake Sampling program. A sediment core is taken for the top 10cm of silt on the bottom of Clear Lake in one location for each arm (Upper, Lower, & Oaks arms). Sediment samples are collected in 2 cm increments and each is evaluated for phosphorus and nitrogen. ***Enclosure 1*** is an analysis we completed in April 2016. Of note are the following:

- Total Phosphorus content continues to decline in all three lake arms. The average total phosphorus concentration in the Upper Arm is slightly below the pre-European background concentration, however, the concentrations in the Lower and Oaks Arm continue to be twice the pre-European background concentration. At current rates of decline, the total phosphorus concentrations in the Lower and Oaks Arms will not reach background concentrations for 50 to 100 years.

- Iron and aluminum bound phosphorus is readily available for cycling into the water column. Concentrations continue to be substantially higher than the pre-European background concentrations in all three lake arms, although the overall mass of available

[1] Lake County Watershed Protection District, Final Report, Clear Lake Watershed TMDL Monitoring Program, April 14, 2009

phosphorus continues to decrease. The reason for the substantially increased available phosphorus is not known, however, it may be due to other chemical changes to Clear Lake's water and sediment chemistry as hypothesized by Richerson (2008)[2].

- While the amount of total and readily available phosphorus in the sediments continues to decrease, the amount of phosphorus cycled into the water column continues to be approximately 500 Tons per year.

- Although preliminary due to the limited amount of data, the sediments appear to contain a significant amount of nitrogen from the late summer through the spring. We hypothesize the nitrogen is released to the water column in the spring for biological use. If the hypothesis is true, sediment nitrogen could supply up to half of the annual nitrogen budget for Clear Lake, while annual nitrogen inflows are approximately one third of the annual nitrogen budget. The remaining nitrogen budget comes from nitrogen fixation. Additional data and analysis by qualified scientist(s) are necessary to confirm or discredit this hypothesis.

Lake Sampling

Lake County participates in monthly lake sampling on Clear Lake in conjunction with the California Department of Water Resources (CDWR). This lake sampling program collects the following analytes:

Analyte	**Frequency**	**Analyte**	**Frequency**
Boron	10X / yr	Aluminum	4X / yr
Calcium	10X / yr	Arsenic	4X / yr
Magnesium	10X / yr	Cadmium	4X / yr
Potassium	10X / yr	Chromium	4X / yr
Sodium	10X / yr	Copper	4X / yr
Chloride	10X / yr	Iron	10X / yr
Nitrate	10X / yr	Lead	4X / yr
Sulfate	10X / yr	Manganese	4X / yr
Alkalinity	10X / yr	Nickel	4X / yr
Hardness	10X / yr	Selenium	4X / yr
Electrical conductivity	10X / yr	Silver	4X / yr
Total Dissolved Solids	10X / yr	Zinc	4X / yr
Ammonia Nitrogen, Total	10X / yr	Phytoplankton	10X / yr
Ammonia Nitrogen, Dissolved	10X / yr	Zooplankton	10X / yr
Total Kjeldahl Nitrogen	10X / yr	pH	10X / yr
Organic Nitrogen	10X / yr	Conductivity	10X / yr
Ortho-phosphate	10X / yr	Temperature	10X / yr
Phosphorus	10X / yr	Turbidity	10X / yr
Nitrite & Nitrate	10X / yr	Dissolved Oxygen	10X / yr

[2] Richerson, Peter J., Thomas H. Suchanek, Robert A. Zierenberg, David A. Osleger, Alan C. Heyvaert, Darell G. Slotten, Collin A. Eagles-Smith, and Charles E. Vaughn, "Anthropogenic Stressors and Changes in the Clear Lake Ecosystem Recorded in Sediment Cores," Ecological Applications, 18(8) Supplement, 2008, pp. A257–A283

In 2015, we attempted to calibrate the surface Chl-a data with the MERIS satellite data. While the available data was limited, it initially appears that satellite data hold promise as one tool for measuring Chl-a concentration in Clear Lake. Additional MERIS images were requested for analysis, however, they have not been provided. If the MERIS data proves to be a good measurement of Chl-a concentrations in Clear Lake, the historical images could be used to analyze long term trends in Clear Lake. Similar analyses with the new satellite (OLCI) will be useful for tracking future Chl-a concentrations.

WORK BY OTHERS

In addition to the County's management measures, projects, and monitoring, several other researchers and government agencies have conducted research on Clear Lake. Below is a summary of conclusions and activities that we feel are important to the Clear Lake Nutrient TMDL:

- While not being completed by the County, the USDA Natural Resources Conservation Service (NRCS) acquired 788 acres of conservation easements in the Tule Lake Reclamation District. This will permanently remove several hundred acres of wild rice land from production and contribute to the restoration of the historic floodplain, wetlands and seasonal lake in Tule Lake. The Reclamation District has been dissolved. As Tule Lake restores itself, it should significantly improve the water quality leaving the Scotts Creek watershed and entering Clear Lake. We are not aware of any estimates of water quality improvement anticipated by this project.

- We have noted a reduction of Clear Lake turbidity over time, both in data collected by CDWR and in data collected by the Lake County Vector Control District (LCVCD). ***Enclosure 2*** shows the trend analysis of the annual average of the CDWR turbidity data for 1970 through 2008. Turbidity has decreased significantly since the 1970's, an indication of both reduction in very fine particles in the water column, both during the winter and the summer. ***Enclosure 3*** shows the turbidity data collected by LCVCD for Station R3S5, which is located approximately 6,350 feet south of the mouth of Rodman Slough. Charts show a decrease in turbidity year round as well as during the winter months (January through March). This appears to indicate a substantial reduction in fine particles from the Rodman Slough (Middle and Scotts Creeks) watershed, Clear Lake's largest contributing watershed. This infers a reduction in sediment, and consequently phosphorus, since the 1970's.

- Richerson (2008)[2] evaluated inorganic mass accumulation rates (MAR) in sediment cores in Clear Lake. The MAR reflects erosion within the watershed and delivery of eroded sediments to Clear Lake. MAR in the period 1927 to 1954 was over ten times the pre-1927 MAR and have dropped to five times the pre-1927 MAR since 1954. Unfortunately, limitations to dating of the cores did not allow refinement of the post 1954 MAR. The authors acknowledge that the MAR continues to decrease due to improved practices in the watershed, however, they were unable to quantify the most recent MAR.

- Richerson (2008)[2] hypothesizes that an increase in sulfate loading resulting from strip mining at the Sulphur Bank Mercury Mine in 1927 changed the sediment chemistry in Clear Lake by increasing the activity of sulfate reducing bacteria, which increased phosphorus (and mercury) release from the sediments. The timeline corresponds to the increased awareness of cyanobacteria blooms in Clear Lake as noted in the Clean Lakes Report[3]. Additional research is needed to confirm this hypothesis. ***Enclosure 4*** shows sulfate concentrations in Clear Lake from the DWR data. A significant reduction in sulfate in 1990 (approximately 30%) coincides with the change in clarity and internal loading noted above.

- ***Enclosure 5*** is a professional paper that indicates cyanobacteria blooms can be a major driver of nitrogen and phosphorus cycling. One of the cyanobacteria noted is *Gloeotrichia echinulata*. *G. echinulata* was first noted in Clear Lake in the early 1990s when internal nutrient cycling increased substantially, and its presence continues to this day. It states, "Together, these lines of evidence suggest the potential for *G. echinulata* to initiate positive feedback loops that accelerate eutrophication." The article goes on to state "...that cyanobacteria that can tap into pools of both nutrients (N and P) may....thwart attempts to manage symptoms of eutrophication in high nutrient systems." If Clear Lake is subject to this positive feedback loop driven by cyanobacteria, it is not clear that a reduction in external phosphorus loading will significantly affect the internal loading and nuisance cyanobacteria growth.

CHALLENGES

The County and its partners have been unable to complete two of the most important components identified in the Clear Lake Nutrients TMDL:

- *Studies to assess the current limnological conditions and to determine the appropriate measures necessary for Clear Lake to meet the Basin Plan objectives.*
- *Develop criteria to determine when Clear Lake is no longer impaired.*

The County and other stakeholders do not have adequate resources to fund these studies. These studies are necessary to:

- Understand the drivers behind internal nutrient cycling in Clear Lake. Only when the nutrient cycling is understood, can appropriate remediation activities be identified and implemented to reduce nuisance blue-green algal blooms.
- Determine the pre-European condition of Clear Lake so an attainable target for the TMDL can be determined. This work should have been completed during the TMDL development process as part of a Use Attainability Analysis (UAA).

Regional Water Board staff has directed the County to seek out grants to complete these items, but grants have been difficult to obtain for Clear Lake for the following reasons:

---

[3] Richerson, Peter J., Suchanek, Thomas H., Why, Stephen J., The Causes and Control of Algal Blooms in Clear Lake, Clean Lakes Diagnostic/Feasibility Study for Clear Lake, California, prepared for Lake County Flood Control and Water Conservation District, 1994

- There is little planning grant money available, and when it is, it is usually too limited to address the issues in a large and complicated ecosystem, such as the Clear Lake ecosystem. It takes years to really understand the nuances of a half million year old lake. Significant progress was made understanding Clear Lake during the five year Clear Lake Algal Research Unit (CLARU) with Dr. Alex Horne (UC-Berkeley) and during the 1990s with the Clean Lakes Grant followed by the Clear Lake Environmental Research Center (CLERC) with Drs. Peter Richerson, Tom Suchanek and numerous others (UC-Davis). This is the type of program that needs to be established and funded for Clear Lake. Lake County, one of the poorest counties in California (the poorest according to data released in January 2015 by the Census Bureau's American Community Survey), does not have the resources to fund such a program.
- Implementation grants are frequently limited. To make a measurable difference in water quality in a watershed that is greater than 440 square miles (a requirement in one of the latest rounds of funding from the SWRCB), implementation projects have price tags of several million dollars and grants limited to less than one million dollars have little impact on the ability to implement the project. This has been problematic for the Middle Creek Project ($60+ million total cost), as most agencies will not provide a grant for an activity (i.e. wetland restoration) that is incomplete and may not be complete until several years after the grant is complete (due to its configuration, the Middle Creek Project cannot be implemented in phases).
- Grant priorities frequently disqualify projects in Lake County. For instance:
    - A recent application for ecosystem restoration required the project to have measurable benefits for the Bay-Delta ecosystem. We are not aware of any project in Lake County that meets those criteria.
    - We recently applied for a "flow enhancement" project with the Wildlife Conservation Board. Although the project ranked number 5 among all the applications, 24 other projects were funded, all of which benefited salmonids (salmonids were extirpated from Upper Cache Creek in 1914). Our project was not funded.

In FY15-16, as a result of County lobbying efforts, the California State Legislature appropriated $1 Million for Clear Lake water quality programs; however, this funding was vetoed by Governor Jerry Brown at budget signing. In his signing statement, the Governor states, "There are existing grant programs that are available and appropriate to support the restoration of Clear Lake." However, we do not find this to be true given the reasons stated above.

Enclosure 6 summarizes all the grants related to Clear Lake and water resource management issues that were obtained or applied for by Lake County or a partnering agency from 2000-2016.

ISSUES & CONCERNS

The cause and solution to excess biological (cyanobacteria) growth in Clear Lake is unknown. During the TMDL adoption process, the county provided documentation of internal loading and other factors that affect cyanobacteria growth in Clear Lake in addition to external loading. In response to this information, the staff report was revised to recognize that there may be other

causes for excess cyanobacteria growth. As a result, Item 4 was added to Attachment 1 of Resolution R5-2006-0060. Item 4 states:

> 4. Regional Water Board staff will work with the responsible parties – Stormwater permittees, Caltrans, USBLM, USFS, County and irrigated agriculture – *to develop and implement a plan to collect the information needed to determine what factors are important in controlling nuisance blooms and to recommend what control strategy should be implemented.* The responsible parties will submit the plan to the Regional Water Board by [one year after approval by OAL]. The plan should address the following topics:
>
> - *Studies to assess the current limnological conditions and to determine the appropriate measures necessary for Clear Lake to meet the Basin Plan objectives*
> - Appropriate monitoring for evaluating conditions in the lake
> - Effective collection of phosphorus loading information from the various sources
> - Practices implemented or planned to control phosphorus loading to the lake
> - *Develop criteria to determine when Clear Lake is no longer impaired* (emphasis added)

The italicized verbiage above indicates the Regional Board staff did not fully understand "...what factors were important in controlling nuisance blooms..." or what control strategies were "...necessary for Clear Lake to meet Basin Plan objectives." The TMDL Update (2012) also indicates that the causes of cyanobacteria blooms are still unknown. It states:

> Staff agrees with the conclusion of researchers that factors (in addition to phosphorus) likely play a role in determining the occurrence of bloom conditions and that more study is needed to evaluate these factors. (p. 14)

County staff agrees with the conclusion that multiple factors contribute to nuisance cyanobacteria blooms in Clear Lake, however, in our opinion that it is the TMDL developer's responsibility to determine what factors are important in controlling nuisance blooms and to recommend what control strategy should be implemented, not the permittees.

If all the factors causing the "excess biological growth" in Clear Lake are not known, then an effective "control strategy" cannot be recommended, therefore, the Clear Lake Nutrient TMDL does not meet the requirements of the Clean Water Act.

The Clear Lake Nutrient TMDL did not include a Use Attainability Analysis (UAA). County staff has had questions about the pre-European condition of Clear Lake and whether it would meet the stated water quality objectives. Clear Lake is a shallow, warm water, naturally eutrophic lake which has existed for at least 500,000 years. Naturally occurring pollutants (sediment bound phosphorus) have been deposited in Clear Lake for its entire existence. Livingston Stone, a fisheries biologist, who visited Lake County in 1873, reported to Congress that Clear Lake had significant algal populations at the time by stating:

> *It is a singular fact, illustrating the inaptness with which names are often given to natural objects, that the water of Clear Lake is never clear. It is so-cloudy, to use a mild word, that you cannot see three feet below the surface. The color of the water is a yellowish brown, varying indefinitely with the varying light. The water has an earthy taste, like swamp-water, and is suggestive of moss and water-plants. In fact, the bottom of the lake, except in deep places, is covered with a deep, dense moss, which sometimes rises to the surface, and often to such an extent in summer as to seriously obstruct the passage of boats through the water.*

It is not clear whether the "deep, dense moss" refers to water plants or cyanobacteria, however, the behavior of *Limnoraphis* (aka *Lyngbya*) is very similar to this description of moss. We believe this concern warrants a UAA, as it is not clear that the pre-European conditions in Clear Lake will support the designated beneficial uses. One of the reasons to prepare a UAA is "Naturally occurring pollutant concentrations prevent the attainment of the use."[4] County staff concurs that cultural eutrophication of Clear Lake has occurred and measures can be taken to return it to conditions closer to the pre-European condition. One of the real questions is, does the TMDL reflect what can be physically, chemically, biologically, and economically obtainable (the MEP standard)?

It appears that Regional Board staff recognized this concern and placed the condition on the permittees to "Develop criteria to determine when Clear Lake is no longer impaired." The County objects to this responsibility being placed on the permittees, as this is the purpose of the UAA and is the responsibility of the TMDL developer. In addition, with Lake County being one of the poorest counties in the state and Clear Lake being the largest and oldest natural freshwater lake in the state, it is not feasible or practical to place this cost on the County. This regulatory scheme has not produced the scientific knowledge needed to address Clear Lake's water quality issues and it will continue to fall short unless the Regional Board decides to invest the required funds to address this unique situation. Overall, at seems as though the citizens of Lake County are not receiving the full benefits of the Clean Water Act and we could in fact be wasting money controlling external loading, when the Regional Board acknowledges that the causes of the nuisance algae blooms is unknown.

RECOMMENDATIONS

In light of the shortcomings of the Clear Lake Nutrient TMDL, Lake County recommends that adoption of the TMDL be temporarily suspended until an adequate understanding of all the factors driving nuisance algae blooms are more thoroughly understood by the TMDL developers. Internal nutrient cycling is what is currently driving the cyanobacteria blooms in Clear Lake. Until the factors that are important in controlling internal nutrient cycling and nuisance cyanobacteria blooms are understood, effective control strategies cannot be developed or implemented. The pre-European conditions of the lake need to be determined and evaluated to determine if the beneficial use is physically, chemically, biologically, and economically obtainable. This should be conducted through a Use Attainability Analysis carried out by the Central Valley Regional Water Quality Control Board.

---

[4] 40 CFR 131.10(g)

The County will continue to implement nutrient control activities in the watershed, including sediment controls and riparian/wetland protection and restoration, as the County believes this is one of the factors leading to cultural eutrophication of Clear Lake and improved water quality is to the benefit of the citizens of Lake County. Based on previous studies, the control of erosion and reducing sediment delivery to Clear Lake are the primary tools for accomplishing this goal. Protection and restoration of riparian and wetland systems within the Clear Lake watershed and along the Clear Lake shoreline will lead to improved water quality in Clear Lake.

The County objects to placing the responsibility on the permittees "….to determine what factors are important in controlling nuisance blooms and to recommend what control strategy should be implemented…. to determine the appropriate measures necessary for Clear Lake to meet the Basin Plan objectives….(and to) Develop criteria to determine when Clear Lake is no longer impaired." As the developer of the TMDL, it is the State's responsibility to perform these tasks in order to improve water quality in Clear Lake, a water of the State and the United States. Placing the entire responsibility to fully manage the largest, natural, freshwater lake entirely within the State of California on one of the poorest counties in California is not the MEP standard and will not produce the results required under the Clean Water Act.

If you have any questions, please contact me.

Sincerely yours,

Will Evans
Deputy Water Resources Director

Enclosures

W:\TMDL\Nutrient TMDL\Update 2017\Response 072016.docx