



California Regional Water Quality Control Board San Diego Region

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Edmund G. Brown Jr.
Governor

February 6, 2012

In reply refer to:
CWIQS Place Id 771065:LWalsh

Mr. Robert Hilber, COO
LDG Holdings, LLC
1295 Discovery Street
San Marcos, CA 92078

Dear Mr. Hilber:

**SUBJECT: COMMENTS ON LAKE SAN MARCOS NUTRIENT IMPAIRMENTS
INTERIM INVESTIGATION WORKPLAN – December 2011**

In accordance with Directive A. of Investigative Order No. R9-2011-0033 (Order), the San Diego Regional Water Quality Control Board (San Diego Water Board) received an "Interim Investigation Workplan" (Workplan) prepared by Nautilus Environmental, LLC and ESA PWA, consultants to Citizens Development Corporation (CDC) on November 30, 2011. The San Diego Water Board reviewed the Workplan, along with associated public comments, including comments from Dr. Michael Anderson (attached), on behalf of the Public Agencies Work Group (PAWG). The San Diego Water Board finds that the Workplan, as drafted, does not fully comply with the conditions specified in Directives of the Order. In order to find that the Workplan meets the conditions of the Order, CDC's Workplan should be revised to address the following:

Workplan Comments

- 1) Provision D.7 of the Order requires the Workplan to include a *Certification Statement* and signature of either a principal executive officer, ranking elected official, or the person with overall responsibility for the environmental matters. This Workplan does not include this Certification Statement, nor was it signed by a person from CDC with overall responsibility for environmental matters. Failure to include the Certification Statement is a violation of the Order. The final Workplan and all subsequent reports submitted in accordance with the Order must include the Certification Statement and signature from the person from CDC with overall responsibility for the environmental matters at LSM.
- 2) Section 3.0 Conceptual Site Model Elements – The Site Conceptual Model (SCM) "lacks an explicitly defined groundwater flux term that may be an important part of the water and nutrient budgets for the lake." (Anderson comment letter, p.3) The SCM must be revised to include a groundwater flux

term so that the effects of groundwater inputs and outputs on the Lake nutrient budget are considered.

- 3) Section 4.0 Bathymetry – The Workplan lacks detail on the specifics of the bathymetry survey. Substantial additional information is needed to describe the specific survey technology, lake bottom sediment profiling, data acquisition methods, accuracy of measurements, fish abundance characterization methods. Comments provided by Dr. Anderson include several questions pertaining to the specifics of the bathymetry survey. He further suggests CDC consider using “volume-backscatter strength to increase understanding of the abundance and distribution of zooplankton in the lake.” Substantial additional detail with regards to the type of bathymetry survey CDC intends to perform is needed in the Workplan. The details provided should be commensurate with level of detail presented in Dr. Anderson’s questions. Further discussion of this matter is warranted.
- 4) Section 5.2.2 Precipitation: CDC proposes to calculate direct precipitation to the Lake by multiplying meteorological measurements from the California Irrigation Management Information System (CIMIS) station in Escondido by lake surface area. Weather conditions in Escondido can differ considerably from those in San Marcos. In order to support a more accurate characterization of local meteorological data and a more accurate modeling effort, CDC should install a weather station at the Lake.
- 5) Section 5.2.3 Temperature & 5.2.4 Evaporation: CDC proposes to use temperature data recorded at “numerous weather stations around California.” CDC further proposes to use these temperatures to calculate evaporation rates from the Lake. In order to support a more accurate calculation of evaporation rates, CDC should install a weather station at the Lake.
- 6) Section 5.2.5 Stream Flow: *“We assume stream inflows will be provided through the watershed evaluation being conducted by the PAWG”*. As the owner of the Lake and associated water rights license, CDC is responsible for accurately monitoring inflows to the Lake (Division of Water Rights October 17, 2011 Report of Investigation). To whatever extent a third party is conducting work that may satisfy the directives of the Order, it is CDC’s responsibility to communicate directly with those parties to establish the exact measurements, methods, and frequencies being collected, if CDC is to rely on the data. CDC must rewrite this section of the Workplan to include a clear description of its exact actions to obtain stream flow data.
- 7) Section 5.2.6 Storm Drainage: *“We assume runoff from any municipal storm drains discharging directly to the lake will be quantified and provided by the*

watershed evaluation being conducted by the PAWG.” Again, assumptions of this nature are not acceptable. CDC must communicate directly with the PAWG to establish the exact storm drain measurements the PAWG is, or is not collecting, and at what frequency. CDC must rewrite this section of the work plan so that it describes exact actions planned to obtain storm drain flow data to incorporate into the Lake water balance.

- 8) Section 5.2.8 Groundwater: CDC proposes to research public and private well data, *“to determine depth to ground water and ground water quality from the area around the dam.”* Furthermore, based on that “available data” CDC will *“estimate groundwater seepage into and out of Lake San Marcos on a weekly basis for the water balance model.”* CDC’s planned approach to characterize geology, ground water hydrology, and ground water quality lacks sufficient detail and appropriate contingencies.

Review of the State Water Resources Control Board Geotracker Database (Geotracker) www.geotracker.waterboards.ca.gov for the area around Lake San Marcos, indicates two active release sites with depth to ground water data. These sites are located to the north/northwest of the Lake. The area around the Lake San Marcos dam (LSM Dam) is undeveloped open space. Geotracker does not show any wells in the area of the LSM Dam.

Ground water well data is sporadic within the area around the Lake and LSM Dam. Analysis of any existing “available” ground water data can require significant interpolation across long distances, rendering any conclusion regarding ground water behavior or contributions to the Lake less reliable than if direct measurements of ground water data are collected. Any analyses and interpretations CDC reports regarding ground water depth, flow, and direction from existing public or private wells, or regional ground water information must be conducted by a licensed geologist or hydrogeologist. Additionally, if CDC finds that there is indeed insufficient groundwater data publically available, then direct measurement of the local groundwater table and hydraulic conductivities to determine the ground water contributions to the Lake would be required. CDC must provide additional details regarding its approach to achieving ground water data. Further discussion of this matter is warranted.

- 9) Section 6.1 Groundwater Nutrient Loading: *“If existing available data are not sufficient to characterize the groundwater nutrient load for the purposes of this study, we will recommend locations for sampling wells for additional data collection. This investigation does not include any groundwater data collection.”* Provision A.3 of the Order requires CDC to prepare a workplan that includes: *“Sampling to ... measure flow volumes from all known and suspected ... ground*

water inputs and discharge locations. CDC states that if existing available data are not sufficient to characterize nutrient loads to the Lake from ground water, it does not plan on sampling ground water during this investigation. CDC's failure to measure (directly or indirectly) ground water flow volumes to and from the Lake is a violation of this Investigative Order. CDC must revise this Workplan to include assurances that, if there is insufficient data available, ground water inputs and discharges from the Lake will be measured so that a Lake water balance can be completed.

10) Section 6.2.1 Coordination with Lakefront Property Owners: *"It is envisioned that the LSMRG will be utilized as a resource to query local land use managers (including homeowners) with regard to fertilizer use and landscaping practices which may contribute to nutrient enrichment... with a two-fold purpose: first, to inform CDC...and second to collect information which may inform ongoing (CDC) management priorities."* Notwithstanding any agreements to delegate work to other parties, CDC is responsible for ensuring that the work conducted complies with the Directives of the Order. Since the LSMRG is a voluntary group from within the community, it is inappropriate for CDC to rely on the LSMRG to "query homeowners on their fertilizer use and irrigation practices" or "to document releases" or inform CDC on its "management priorities." The San Diego Water Board does not support the use of the LSMRG in this manner. Any use of the LSMRG by CDC must be agreed to by the LSMRG.

11) Section 7.0 In-Lake Processes: CDC proposes to sample in-lake processes at seven (7) stations (i.e. the two existing LSM-1 and LSM-2, and 5 additional). Water column sampling is proposed quarterly and once for sediment. Grab water samples will be collected at these 7 stations from the surface, mid-column and bottom waters and analyzed for nutrients, chlorophyll a, temperature, dissolved oxygen, pH and salinity.

Dr. Michael Anderson is the Department Chair and Professor of Environmental Chemistry at UC Riverside. Dr. Anderson's experience and knowledge with regards to assessment of shallow lakes is well known among CDC, PAWG, and LSMRG. The San Diego Water Board supports Dr. Anderson in the following comments, which should be addressed in the revised Workplan. Further discussion of these comments is warranted.

- a) The sampling frequency to quantify relevant processes operating in the Lake should be increased. An increase to the proposed sampling frequency is supported by both Dr. Anderson¹ and Dr. Anne Spacie².

¹ "It is recommended that water column sampling be conducted monthly during the spring-summer-fall and bimonthly in the winter." Anderson comment letter, p.5

- b) Sampling at 5 locations may be adequate based on the "modest" size of the Lake; four locations along the long axis and one near the center of one of the small embayments.
- c) CDC's sampling plan relies heavily on the LSMRG weekly collection of data for inclusion into the hydrodynamic-water quality model. Although the LSMRG has been consistently collecting this critical data, CDC should have contingencies in place should the LSMRG not be available to collect the data in the future or not be able to collect it at the intervals necessary to match other sampling conducted by CDC's consultants. Notwithstanding any agreements to delegate work to other parties, CDC is responsible for ensuring that the work conducted complies with the Directives of the Order; including necessary quality assurance.
- d) CDC must discuss how (i.e. piston core, universal, or other method), the proposed sediment cores were to be collected, the length of the cores, or to what depths the cores will be collected.
- e) Greater detail is needed to describe the method by which nutrient flux will be measured in the Lake. Dr. Anderson discusses the need to understand how the sediments will be collected and warns against CDCs proposed plan to introduce deionized water into the samples due to its effect on pH, salinity, and dissolved oxygen.
- f) CDC should define within the Workplan, the conditions under which flux measurements will be made. Dr. Anderson identifies several factors that have a profound effect on the rate of nutrient flux and thus recommends flux measurements be conducted at least quarterly from each sample location.
- g) CDC proposes to measure flux using a hydraulically-driven method (Section 7.4.2). CDC's discussion fails to explain how reliable the data is when using a hydraulically-driven process. CDC must provide additional information to justify the reliability of the data produced by a hydraulically driven sample collection method.
- h) This Workplan should include an evaluation of discontinuities in the bathymetric survey(s), suggestive of spring or seep inputs.

² "The proposed quarterly sampling for lake phosphorus and related parameters is clearly inadequate ... I recommend monthly sampling (T-DO profiles, nutrient sampling, chlorophyll, and Secchi) in winter and spring... But in summer and fall... do bi-weekly sampling." Spacie comment letter

- i) CDC proposes a biological resource assessment including sampling benthic macroinvertebrates. Although helpful in determining the health of streams and creeks, Dr. Anderson recommends phytoplankton and zooplankton populations be monitored in the Lake in lieu of benthic invertebrates because he suggests benthic invertebrates provide less ecologically useful information in a lake environment. Dr. Anderson further suggests quarterly sampling at 3 sites (i.e. near the dam, near the middle of the Lake, and near the northern sections of the Lake).

12) Section 8 Analyses, Data Evaluation, Schedule and Reporting:

- a) Section 8.3 Schedule of Investigation Components: - CDC proposed quarterly nutrient water quality sampling and a single sampling event to measure sediment loading/flux. These are inadequate to define seasonal changes in the Lake water quality or internal nutrient loading. Sampling must occur frequently enough to allow for the collection of a sufficiently robust data set to populate the nutrient loading model. In order to provide a robust data set, CDC must increase their planned monitoring. An increase to the proposed sampling frequency is supported by both Dr. Anderson¹ and Dr. Anne Spacie². Further discussion on this matter is needed.
- b) *"Status Reports: Summary status report will be generated on a quarterly basis."* CDC should include language within this section to clearly articulate that the status reports will be submitted to the San Diego Water Board.
- c) *"Following completion of the Year 1 activities, it is envisioned that data will be reviewed with regard to whether existing data gaps have been adequately addressed."* The PAWG is currently investigating the Lake San Marcos watershed. CDCs should work with the PAWG using an adaptive management approach to address any data gaps as each proceed their respective investigations efforts, modifying the SCM as data gaps are identified and filled. This sort of iterative approach should be deployed now, not after the year 1 activities.
- d) *"Within the context of this investigation, 'adequacy' shall be measured against the objective of characterizing Lake impairments to a degree sufficient to assess Lake management options."* CDC's discussion related to measuring the 'adequacy' of this investigation fails to recognize the overall goal of the coordinated Lake water quality effort.

The overall goal is to restore the beneficial uses of the water within the Lake, not simply identify "Lake management options." CDC must characterize Lake impairments to the degree necessary to evaluate Lake remediation options. Lake management strategies are likely to be a component of the final cleanup strategy. Further discussion of this matter is warranted.

13) Section 8.3.1 Contingency Elements – CDC states, "*Plankton Studies (i.e. phytoplankton and zooplankton) would be of interest ... However, the amount of monitoring necessary to characterize the lake outweighs the value in terms of the objectives of the investigation.*" We disagree with this conclusion. Algal speciation provides needed information about nutrient availability and utilization within the Lake. "Algal speciation should be conducted on photic zone samples since this provides **critical** (emphasis added) information about nutrient availability and utilization, capacity for nitrogen-fixation, and presences of toxin and scum-forming blue-green algae." (Anderson comment letter, p. 7) CDC must revise this Workplan to include identification of phytoplankton and zooplankton in the Lake. "Such integrative ecological assessments are increasingly used to diagnose and correct water quality problems." (Anderson comment letter, p. 7)

14) Section 8.4 Reporting

- a) CDC plans to submit an annual report. The Order does not require annual reporting. The quarterly status reports are sufficient to inform the San Diego Water Board on CDC's progress towards completing the tasks outlined in a final Workplan. The Order requires a Final Investigation Report including the information required in Provision B at the conclusions of the investigation work.
- b) CDC identifies several elements to be reported upon at the completion of the work described in the Workplan. Pursuant to Provision B.10 of the Order, the San Diego Water Board expects a final report that not only describes the results of the work performed in accordance with the Workplan, but an assessment of the data collected, an evaluation of the conditions of the Lake, as well as recommendations for cleanup and abatement actions at the Lake. Further discussion is warranted.

General Request for Modifications to the Order

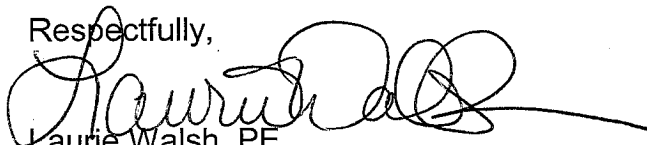
With submittal of the Workplan, CDC requested: 1) an extension to the December 1, 2012 due date of the Investigation Report required pursuant to Directive B of the Order; 2) an extension to the duration of the study beyond the time required by the Order to include at least one full dry season and one full wet season; and 3) the opportunity to incorporate 'critical' information (i.e. current bathymetry information and a better understanding of the stakeholder investigation and monitoring program) into a revised Workplan.

As indicated above, a revised workplan is warranted to incorporate the necessary changes. It should take no longer than 60 days to incorporate the revisions above. Once the workplan is finalized it will be incumbent upon CDC to update the site conceptual model throughout the investigation as 'critical' data is gathered and conclusions are reached.

The monitoring period should include at least one full dry season and one full wet season. The San Diego Water Board's position is supported in the recommendations made by both Dr. Anderson¹ and Dr. Spacie². However, the December 1, 2012 due date for submittal of the Lake San Marcos Nutrient Impairment Investigation Report will not be extended, at this time. The San Diego Water Board will reassess this request upon its determination that CDC's Lake investigatory work is proceeding in accordance with the final workplan schedule and in coordination with the work conducted by the PAWG.

Comments provided herein must be addressed prior to CDC beginning work. Multiple tasks presented in the Workplan require close coordination with the PAWG and the LSMRG. It is incumbent upon CDC to closely coordinate with PAWG and the LSMRG as it goes forward with this investigative effort. The San Diego Water Board is willing to host or moderate a meeting with the CDC, PAWG, LSMRG, and other interested parties to ensure proper communication and coordination. Additionally, Dr. Anderson has offered to meet and discuss his comments and recommendations for CDC's benefit in revising the Workplan.

Respectfully,



Laurie Walsh, PE

Water Resource Control Engineer
San Diego Water Board

LAW:cmc

Cc: Mr. Nick Buhbe, Project Manager, Nautilus Environmental
Ms. Laura Lavelle, P.E., Division of Water Rights llavallee@waterboards.ca.gov
Mr. Kyle Wooldridge, Division of Water Rights kwooldridge@waterboards.ca.gov
Catherine Hagan, OCC, San Diego Waterboard chagan@waterboards.ca.gov
Region 9 Lake San Marcos Lyris List

Attachments

Anderson, Michael A., Review of: "Lake San Marcos Nutrient Impairments Interim Investigation Workplan" prepared by Nautilus Environmental, LLC and ESA PWA, December 2011 for Citizens Development Corporation, December 22, 2011.

Spacie Ph.D., Ann, Comments on Lake San Marcos Interim Investigation Work Plan, December 23, 2011.

References

Lavallee, Laura, Report of Investigation – Compliance By Citizens Development Corporation With Terms and Conditions of Water Right License 7224 (A010711) To Divert From San Marcos Creek In San Diego County, October 17, 2011.

USEPA, Office of Water, Volunteer Lake Monitoring: A Methods Manual EPA440-4-91-002
http://water.epa.gov/type/watersheds/monitoring/upload/2002_08_02_monitoring_volunteer_lake_lakevolman.pdf

22 December 2011

Michael A. Anderson
17639 Log Hill Rd
Riverside, CA 92504

Ms. Erica Ryan
City of San Marcos
1 Civic Center Drive
San Marcos, CA 92069-2918

22 December 2011

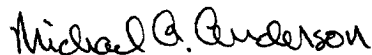
Dear Erica:

Attached is my review of the Lake San Marcos Nutrient Impairments Interim Investigation Workplan prepared by Nautilus Environmental, LLC and ESA PWA for the Citizens Development Corporation.

I would be happy to meet with the Regional Board and representatives from Nautilus and ESA PWA to discuss my comments and recommendations if that would be helpful.

Thank you for the opportunity to again work with you on issues concerning Lake San Marcos.

Sincerely,



Michael A. Anderson

Review of:

**“Lake San Marcos Nutrient Impairments Interim Investigation Workplan”
prepared by Nautilus Environmental, LLC and ESA PWA, December 2011 for
Citizens Development Corporation**

Summary

A third-party review of the Lake San Marcos Nutrient Impairments Interim Investigation Workplan was conducted to ensure it adequately addresses requirements outlined in the Investigative Order R9-2011-0033, the recommendations in the SWRCB Division of Water Rights Report, and conforms with the scope of work for the watershed outlined in the Participation Agreement. The Investigative Order and Water Rights Report have placed significant requirements upon CDC to investigate nutrient impairments in Lake San Marcos and address water rights issues. In response to the investigative order, CDC has retained Nautilus Environmental, LLC and ESA PWA to develop a Workplan, conduct monitoring and measurements at the lake, and prepare an investigation report.

The investigation outlined in the Workplan focuses on 4 elements: (i) lake bathymetry, (ii) lake water budget, (iii) lake nutrient budget (including surface water and groundwater nutrient loading), and (iv) in-lake processes (water quality, sediment quality and sediment nutrient release, and biological resources). These focus areas directly address the principal Investigation Report elements prescribed in the Investigative Order, although the Workplan lacks, in my view, sufficient detail and effort to meet the requirements and objectives of the Investigative Order. Moreover, as presently written, the Workplan addresses only a portion of the issues and requirements outlined in the Water Rights Report. Recommended revisions to the Workplan include: measurement of groundwater flow and water quality; reduction in number of lake sampling sites from 7 to 5; increase in water quality sampling frequency from quarterly to monthly during spring-summer-fall and bimonthly in the winter; quarterly sampling of phytoplankton and zooplankton abundance and speciation at 3 sites in lieu of benthic invertebrate sampling; and quarterly measurements of nutrient flux from sediments.

Introduction and Objective

The purpose of this document is to provide a third-party review of the Workplan proposed on behalf of Citizens Development Corporation (CDC) by Nautilus Environmental, LLC and ESA PWA. My comments are offered based upon the requirements of the Investigative Order R9-2011-0033, the SWRCB Division of Water Rights Report, and the scope of work outlined in the Participation Agreement.

As summarized in §30 of the Tentative Investigative Order, CDC must prepare a Nutrient Impairment Investigation Report (Report) developed under this Order “to provide the Regional Board with information on the existing physical, biological, and chemical conditions and processes of the Lake, the nature and extent of pollution conditions in the Lake, information on Lake operations and management and how the existence and operation of the dam affects Lake water quality”.

The Investigative Order requires that the Report must contain detailed information concerning:

- Surface Water Nutrient Load
- Groundwater Nutrient Load
- Lake Water Budget
- Lake Nutrient Budget
- In-Lake Processes

The Investigative Order thus requires a comprehensive assessment be conducted at the Lake. The Workplan was thus evaluated in light of these requirements, and recommendations offered where appropriate.

General Comments

The Investigative Order indicates that the Report be received by the Board no later than December 1, 2012. In their letter dated 30 November 2011, Nautilus Environmental, LLC, on behalf of CDC, has requested an extension of the due date for the Report to allow review, consultation and collaboration with other stakeholder parties. They have also recommended extending the duration of the study to incorporate at least one full dry season and one full wet season, and further propose extending the study beyond 1-yr to better incorporate inter-annual variability. Given the requisite comprehensiveness of the study, allowing for a full year of sampling and analyses would be appropriate. It will be important to fully capture the annual cycle of stratification-mixing in the reservoir and associated water quality, and to carefully quantify the water budget through the full wet and dry seasons. The benefits of extending the measurements beyond 1-year are thought to be limited however; to quantify the range of hydrologic conditions likely experienced at the Lake and watershed, given the El Nino cycle in the region, would require potentially 5-6 yrs or more of regular monitoring. This is generally not practical. There is some advantage to having an additional year of monitoring against which one can verify watershed-lake model predictions, although the details of the modeling to be conducted by TetraTech Inc. were not available at the time of this critique.

It is important to note that the Lake San Marcos Remediation Group (LSMRG) has been conducting weekly measurements of temperature, DO, Secchi depth and lake surface elevation since June 2010. This is a very important dataset, and these measurements should be continued; this can also be used in the future as a primary long-term monitoring program, against which model prediction can be compared, as well as the basic assessment method for effectiveness of restoration actions in the watershed and/or lake. Moreover, the LSMRG monitoring data for 2010-2011 can also be used to assess lake model performance. In my view, then, in the absence of an extreme drought or flooding this upcoming year, extending the measurements proposed by the CDC team beyond one full year is not required, but ongoing support for the LSMRG monitoring program is needed. The CDC team is strongly encouraged to increase the frequency of sampling to better capture seasonal trends, however. While the proposed quarterly sampling scheme offers a convenient look at broad seasonal conditions in the lake, it provides weak statistical power and makes it very difficult to clearly demonstrate finer scale seasonal trends. Sampling monthly in the spring-summer-fall and bimonthly in the winter is recommended to better define seasonal trends.

Specific Comments Concerning Responsiveness of Workplan to Investigative Order

§.3. Conceptual Site Model Elements

The proposed Workplan includes a well defined Site Conceptual Model (SCM) (§.3) that describes inputs, losses, and storage of water, sediment and nutrient in the Lake. I do note, however, that the SCM lacks an explicitly defined groundwater flux term that may be an important part of the water and nutrient budgets for the lake. The SCM also lacks ecological factors. The SCM should include, as an inset, a simplified foodweb to highlight the relationship between available nutrients and lake response variables and related metrics (chlorophyll concentration, zooplankton, benthic invertebrate and fish populations), since restoration actions in the lake or watershed may favorably shift the algal ecology and food web and since biomanipulation is a possible in-lake restoration strategy (Moss, 1998). This is also important since water quality is generally defined by residents and lake users through water clarity, color, presence of surface algae, and other factors that reflect ecological conditions.

§.4. Bathymetry

The Workplan correctly identifies the importance of accurate reservoir bathymetry, hypsography (area-volume-depth relationships) and sediment distribution to this overall study and assessment. Per the Workplan (p.9, 1.1-5), the survey data will be obtained from east-west vessel transects spaced approximately 50 ft apart. Data will then be used to estimate particle size of bottom sediments that will be verified with sediment grab samples.

While this description provides some useful information (e.g., 50 ft spacings on E-W transects), insufficient information is provided to ensure this survey will meet the needs of the project and maximize the value of this effort. The Workplan hints at use of hydroacoustics, although this is not explicitly stated. Assuming use of hydroacoustics, what frequency(ies) will be used in this survey? While a range of frequencies can be used for bathymetric measurements, the acoustical characterization of surficial bottom sediment is better achieved with high frequency(ies) (Anderson and Pacheco, 2011). Acoustic absorption by water and bottom sediments varies strongly with frequency (Lurton, 2002); as a result, high frequencies can effectively probe surficial bottom sediments, but are not useful for sub-bottom profiling and measurement of sediment thickness. Conversely, low frequencies can propagate many meters into soft organic sediments, and therefore are commonly used in sub-bottom profiling to acoustically measure sediment thickness, but provides weaker predictive power for estimating surface sediment properties. Will sub-bottom profiling/sediment thickness measurements be made? A dual-frequency system that includes both a high- and low-frequency transducer provides greater information than a single frequency system since it would allow characterization of bottom sediment properties and thickness.

Additional details concerning data acquisition are needed as well. Will single-beam, dual-beam or split-beam transducers be employed? What ping rate and boat speed are proposed? How will the acoustical data be georeferenced and what is the positional accuracy expected? Further details are also needed regarding data analysis. In particular, how will echograms be analyzed to determine sediment acoustical properties? What attributes of the echo envelope will be used (cumulative energy, energy of 1st or 2nd bottom echoes, fractal dimension of bottom echo, other)?

Finally, it is indicated that survey data will also be processed to provide qualitative fish presence data (p.9, l.5). I wholly endorse this and recommend greater detail here as well. Will echo-counting or echo-integration be used? The type of transducer becomes important in this regard, since split-beam transducers can determine target strength (“acoustical size”) that is related to physical size of fish; thus, a survey conducted with a split-beam transducer should be able to resolve, *e.g.*, threadfin shad from other larger fish. I agree that the results are qualitative in the sense that it is not possible to directly determine fish species, but acoustical size combined with habitat use (pelagial vs. bottom) and general knowledge of the fishery are usually sufficient to quantify important features of the fishery (and monitor their recovery following restoration efforts). The CDC team should also consider using volume-backscatter strength (after removal of fish echoes) to increase understanding of the abundance and distribution of zooplankton in the reservoir (*e.g.*, Hembre and Megard, 2003). The zooplankton community is important since it both affects, and is affected by, water quality in the Lake.

Based upon the lack of detail provided concerning the bathymetric survey, it is in my view premature to provide the expedited approval for this portion of the Workplan as requested in the transmittal letter prepared by Nautilus Environmental LLC.

§.5. Lake Water Budget

Accurate measurement of the water budget for Lake San Marcos is needed to help develop the nutrient budget for the lake and apportion loads, and also to help quantify the possible role that groundwater plays in this system. The spreadsheet model approach described in the Workplan should be appropriate, subject to adequately quantified model inputs. The CDC team proposes use of water level data collected weekly by the Lake San Marcos Remediation Group (LSMRG). Subject to verification of the elevation datum for the staff gage and dam crest, this is a very good use of citizen monitoring data. One notes that the USEPA has sponsored volunteer monitoring programs for many years, including the annual Secchi Dip-In.

Meteorological measurements from the nearest CIMIS station in Escondido may be sufficient, although it would be better to install a recording weather station in the watershed or at the lake to provide more accurate local meteorological data. The advantage of installing the station at the lake is that this will provide data also needed for the most accurate modeling of lake hydrodynamics (stratification, mixing) and water quality.

While CIMIS or other local meteorological data should be adequate, the CDC team is relying extensively on watershed monitoring efforts of the Participation Agreement Work Group (PAWG). The appropriateness of this is a matter of interpretation, as the Investigative Order mandates that the Workplan includes measurement of water flow volumes from all known and suspected surface water and groundwater inputs and discharge locations (and associated water quality measurements to develop nutrient loading estimates). If the understanding is that the PAWG will conduct these measurements and provide this data to the CDC team, then some formal agreement and approval of the Regional Board indicating so would be helpful.

The groundwater assessment is the weakest part of this section, and relies on well records and any other accessible information. It seems unlikely that sufficient public

records exist to make an informed estimate of the volume and water quality of any groundwater or subsurface runoff potentially flowing to Lake San Marcos. A licensed hydrogeologist should be retained by CDC to review geological records and perform an analysis for the region around the lake. It is possible, with a sufficiently detailed monitoring of all other flows to and from the reservoir, that the contribution of groundwater flow can be indirectly determined, but this would still be inferential. Some direct evidence of an active groundwater system, *e.g.*, measurement of the piezometric surface or local groundwater table and hydraulic conductivities, should be conducted by the appropriate party(ies).

§.6. *Surface Water, Groundwater, Lake Nutrient Budget*

The Workplan explicitly states that no groundwater data collection will be conducted. From my interpretation, this directly conflicts with the requirements of the Investigative Order, and thus represents a critical shortcoming of the Workplan. The CDC team should resolve this discrepancy. Careful coordination with the Participation Agreement Work Group (PAWG), TetraTech Inc. and others will be needed. Proposed surface water sampling will be conducted as described in Section 7 of the Workplan and considered below.

§.7. *In-Lake Processes*

Seven (7) sites are proposed for quarterly water column sampling and one-time sampling of sediments. Water samples will be collected from surface, mid-column and bottom waters when depth intervals are at least 2 m and analyzed for the standard suite of parameters. While it is agreed that this limited sampling frequency can be used in a broad sense to assess seasonal changes in water quality and provides a benchmark against which subsequent water quality measurements can be made (*e.g.*, after watershed or in-lake restoration actions), greater frequency sampling is needed to quantify relevant *processes* operating in the lake and watershed. It is recommended that water column sampling be conducted monthly during the spring-summer-fall and bimonthly in the winter. This greater temporal resolution is thought to be more important than spatial resolution; given the modest size of the lake, sampling at 5 sites is likely adequate, *e.g.*, with 4 sites down the long axis of the lake and a fifth site collected from near the center of one of the small embayments. Final selection of sites could be made following completion of the bathymetric survey and acoustical characterization of bottom sediments.

The CDC team is also relying upon the weekly monitoring conducted by the LSMRG for Secchi depth (p.15, l.20-25). Although not explicitly discussed in the Workplan, water column profile measurements at regular intervals (as being made by LSMRG) are needed to quantify the development, extent and duration of thermal stratification and loss of dissolved oxygen (DO) in the hypolimnion. These measurements are central to understanding the current functioning of the reservoir, for validating hydrodynamic-water quality modeling, and designing a lake restoration strategy. For example, regular monitoring that tracks the onset of thermal stratification and loss of DO over time can be used to calculate oxygen demand of the bottom water and sediments. The rate of oxygen demand is a key measure needed for the sizing and operation of an oxygenation or aeration system. In a similar way, temperature profiles are a function of

heat flux and turbulent kinetic energy (TKE) inputs due to wind, convective mixing and inflows. Temperature profiles can be used to calculate the thermal stability of the water (the energy required to mix the water column) and thus quantify the energy inputs needed to mix the water column.

Sediment cores are proposed to be collected from each of the sampling sites in a single event, although the type of coring was not described (e.g., with a piston corer or universal/other coring device?). The lengths of the cores were also not specified; will the cores be collected through the sediments to the original graded lake bottom?

The measurement of nutrient flux from bottom sediments is a very important part of this study since the product of flux rate and sediment area define the internal loading component of the nutrient budget. Given the potential importance of internal nutrient recycling to the overall nutrient budget of the lake, greater detail is needed before the usefulness of these measurements can be confirmed. First of all, how will these sediments be collected? Beutel (2003) has developed a simple technique in which a surface grab sample collected with an Ekman dredge is cored, sealed from the bottom with a rubber stopper, filled with lake water, sealed and returned to the lab for incubation and regular sampling over time. This allows collection of short intact cores without the use of divers. The Workplan indicated subsequent addition of deionized water, although this should be avoided since it alters the natural pH, salinity, DO and other properties at the sediment-water interface. Moreover, daily sampling of the overlying water over 5-7 d allows one to more reliably calculate $\text{NH}_4\text{-N}$ and $\text{PO}_4\text{-P}$ flux than simply after 48-h as proposed. The CDC team should also define the conditions under which flux measurements will be made; in early work by Holdren and Armstrong (1980), temperature, DO and stirring levels were found to have a profound effect on the rate of nutrient flux. Measurements by numerous researchers have further demonstrated the strong temperature and seasonal effects on internal nutrient loading rates. It is thus urged that these measurements be conducted at least quarterly and that they be replicated (at least 3 samples from each site).

The CDC team should also use water column measurements described above to develop *in situ* estimates of $\text{NH}_4\text{-N}$ and $\text{PO}_4\text{-P}$ flux through the accumulation of these nutrients in the hypolimnion. That is, if one know when the lake stratifies and nutrient concentrations are regularly measured, one can use the increase in concentration and area of the hypolimnion (from profile measurements combined with elevation-area curves from the bathymetric survey) to determine the mean *in situ* flux rate. This provides a second, independently determined, estimate of nutrient flux during the summer stratified condition for the deeper sediments in the lake. Reasonable agreement between the 2 flux measurement methods (laboratory core-flux and *in situ* field estimates) increases the confidence in these values. Flux measurements for different types of sediments then allow extension across the lake based upon acoustically-inferred sediment types (Anderson and Pacheco, 2011).

The CDC team has also outlined measurements of hydraulically-driven nutrient flux. While a creative approach, the results will be strongly sensitive to the applied hydraulic flux, temperature, DO concentration and other factors, making it difficult to extrapolate this to the lake setting in any defensible way. Moreover, based upon sediment characterization for other lakes in the region, much of the sediments are expected to be very fine textured organic sediments that would not be easily contained within most mesh. Notwithstanding, the acoustic signature of the bottom sediments from the

bathymetric survey should be carefully scrutinized for evidence of discontinuities suggestive of spring or seep inputs, and thus may offer some insight into possible distribution of springs or seeps if present.

The CDC team further proposed a biological resource assessment through a twice annual measurement of the benthic macroinvertebrate community. Sediment grab samples collected with a Ponar sampler will be sieved through a 1-mm sieve, with the organisms rinsed and preserved with 70% ethanol and identified to the lowest practical taxonomic level. This is a fairly standard assessment that is especially useful for streams and creeks, although less useful for eutrophic lakes. For example, we recently completed an ecological assessment that included bimonthly phytoplankton, zooplankton and benthic invertebrate surveys along with a fish hydroacoustic-gill net survey. While quite dramatic seasonal changes were seen in the phytoplankton and zooplankton communities, the benthic invertebrates were almost exclusively restricted to chironomids, with densities related to availability of DO (with no chironomids in deeper water with anoxic bottom sediments). Similar findings would be expected in Lake San Marcos, with benthic invertebrates providing less ecologically useful information than phytoplankton and zooplankton.

Moreover, the nutrient-phytoplankton-zooplankton-fish linkages in a food web can be very strong, with ample evidence in the scientific literature for alternate stable states (Moss, 1988). It is thus recommended that phytoplankton and zooplankton populations in the reservoir be monitored in lieu of benthic invertebrates. These measurements are presently only considered in the Workplan as Contingency Elements in §.8.3.1. Algal speciation should be conducted on photic zone samples since this provides critical information about nutrient availability and utilization, capacity for nitrogen-fixation, and presence of toxin and scum-forming blue-green algae. Vertical zooplankton tows with a 63 µm Wisconsin net will allow the CDC team to assess the role that zooplankton grazing may currently have on the phytoplankton community and, with a hydroacoustic fishery survey, the role that zooplanktivorous fish (*e.g.*, threadfin shad) may have on the zooplankton community. Such integrative ecological assessments are increasingly used to diagnose and correct water quality problems, *e.g.*, as part of the EU Water Framework Directive. Quarterly sampling at 3 sites, near the dam and middle and northern sections of the lake, should be sufficient. A number of commercial laboratories are available to provide phytoplankton and zooplankton identification and enumeration.

§.8. Analyses, Data Evaluation, Schedule and Reporting

The analytical methods are thought by this reviewer to be appropriate and, with suitable QA/QC, should provide valuable new information concerning water quality in the Lake. As noted above however, quarterly nutrient water column sampling and the single monitoring event proposed for sediment nutrient loading/flux are not adequate to define the seasonal changes in water quality and internal nutrient loading that result from different temperatures, DO concentrations, antecedent water quality and suspended sediment inputs over the course of an annual cycle.

Specific Comments Concerning Responsiveness to Water Rights Report

Although this Workplan was not developed to explicitly address the findings and recommendations of the Water Rights Report, it is useful to briefly consider this

Workplan in light of this report, with the goal of maximizing the usefulness of the proposed study.

As previously noted, the water budget evaluation proposed in the Workplan relies on volunteer measurements by LSMRG and related measurements as part of watershed monitoring on behalf of the Participation Agreement Work Group (PAWG). The Division of Water Rights in the Water Rights Report stipulates daily measurements of inflow, outflow, irrigation diversions and change in storage to demonstrate that CDC operates within the limitations of its license. Continuous real-time monitoring systems are best suited to meet this requirement. While not necessarily required for TMDL work, such a system put in place would provide very high resolution data and further improve our understanding of the water budget and potentially also water quality in the Lake.

Providing the resolution and quality of flow data required by the Division of Water Rights will nonetheless be potentially challenging. Measurement of outflow over the spillway would, in theory, be straightforward enough with measurements of lake surface elevation and an appropriate rating curve for the dam, although it is not clear from prior review of documents that such an elevation-flow relationship exists. If not, one would need to be developed, although the presumptive rating curve for the dam is likely to have some significant uncertainty especially at lake surface elevations close to the crest height. The contributions (or loss) to the water budget due to groundwater will also be difficult to directly determine. As previously noted, if all other inputs and losses are well-defined, then inputs or loss to groundwater could be reasonably accurately determined. The Workplan explicitly states that no groundwater data collection will be undertaken (p.14, l.9) in contrast with the Investigative Order. It will be critical for the overall effort to establish whether or not groundwater is an important part of the water and nutrient budgets for the Lake.

Specific Comments Concerning Coordination with Other Efforts

The PAWG is undertaking a parallel monitoring effort in the watershed to quantify surface and nuisance flows and their water quality. The CDC Workplan is explicitly reliant upon this dataset, as described in §5.2. This appears inconsistent with the Investigative Order however; it thus seems then that CDC should be conducting an assessment within their portion of the lake watershed. It is my understanding that the results from the studies will then be used in a modeling assessment. I am not familiar with the details of the modeling study, but a properly calibrated and verified model should allow prediction of hydrology and water quality in the watershed, creek and lake under a range of rainfall conditions (e.g., El Nino and La Nina events). The model should also be to predict water quality in lake following implementation of various watershed BMPs and in-lake restoration alternatives. Close coordination will be required by all parties.

References

Anderson, M.A. and P. Pacheco. 2011. Characterization of bottom sediments in lakes using hydroacoustic methods and comparison with laboratory measurements. *Water Res.* 45:4399-4408.

Beutel, M.W. 2003. Hypolimnetic anoxia and sediment oxygen demand in California drinking water reservoirs. *Lake Reserv. Manage.* 19:208-221.

Holdren, G.C. and D.E. Armstrong. 1980. Factors affecting phosphorus release from intact lake sediment cores. *Environ. Sci. Technol.* 14:79-87.

Lurton, X. 2002. *An Introduction to Underwater Acoustics: Principles and Applications.* Praxis Publ., 347 pp.

Moss, B. 1988. *Ecology of Fresh Waters: Man and Medium, Past to Future.* 3rd ed. Blackwell Science, Ltd. 557 pp.

23 December 2011

California Regional Water Quality Control Board
San Diego Region
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Attn: Laurie Walsh

Re: Comments on Lake San Marcos Interim Investigation Work Plan

Dear Ms. Walsh,

After attending the December 21st presentation by CDC and Nautilus Environmental on the Lake San Marcos Interim Investigation Work Plan and reviewing Investigative Order No. R9-2011-0033, I would like to give you several comments based on my own experience.

By way of introduction, I've been involved in water quality projects for about 40 years, including long-term lake and watershed monitoring for nutrient management. I've published on nutrient loading and taught limnology for about 30 years. Currently I serve as science advisor for the Batiquitos Lagoon Foundation, which has a stake in this project. I also work informally with the volunteer monitoring group at Lake San Marcos.

In my opinion, the work plan submitted by Nautilus Environmental is reasonable in that it touches on all main aspects of the study. Since few specifics are included in the plan, it isn't possible to critique the actual methodology planned for all activities.

I think it is important, however, to focus on one of the most critical aspects of the proposed work where I have major concerns - the validity of the nutrient loading model. The proposed quarterly sampling for lake phosphorus and related parameters is clearly inadequate to develop a valid nutrient loading model for management purposes.

A reservoir such as Lake San Marcos is not the typical "well-behaved" dimictic lake found in textbooks. Stratification develops and breaks down in fits and starts, depending on weather conditions. This is especially true in the fall, where deep water may circulate upward on a cool, windy day, and then re-stabilize for a while during hot, quiet weather. Dr. Anderson's profile taken in September 2009 suggests the beginning of de-stratification. But this process can extend over weeks. Meanwhile, the surface water may develop sulfide, ammonia, and low oxygen problems that impact beneficial uses. Internal nutrient loading, which Dr. Anderson estimates to be the bulk of the loading, occurs in pulses as the surface water circulates and changes temperature.

Nautilus proposes to sample quarterly, once per season. Since each season is unique in a lake, single grab samples taken in, say, July and then October, will give no information on variability or extremes of water quality. They will most likely miss the main event (fall overturn). Any weather-related events will also be overlooked. There will be no estimate of within-season variability and, ultimately, no way to express confidence levels on the nutrient loading model.

We know from work on many lakes that conditions in the mixed layer typically vary weekly during the summer and early fall. Algal blooms can grow and die off within days to weeks. Oxygen profiles vary quite a bit as well, especially in a eutrophic reservoir with a large ratio of epilimnion to hypolimnion volume. Consequently, many monitoring programs recommend bi-weekly sampling (for example EPA's Volunteer Lake Monitoring Manual).

For the Nautilus project, I recommend monthly sampling (T-DO profiles, nutrient sampling, chlorophyll, and Secchi) in winter and spring, when stream and storm water flows tend to be the dominant processes. But in summer and fall, I would urge them to do bi-weekly sampling. If need be, they could contract out the actual collections to a local firm or university and then analyze the collected samples as usual. That would provide the statistical power needed. It would also give everyone a much clearer understanding of the overall behavior of the lake and its low-oxygen episodes.

Let me emphasize the following: a key result of this project should be to develop the water and nutrient loading model. Such a model will provide the planning tool needed to design any future clean up and, eventually, to evaluate the success of that clean-up. A large amount of effort rides on the data taken in 2012 and the accuracy and validity of the model.

The nutrient loading model requires measurements on stream flow and major discharges. USGS stream flow records are taken daily. Storm flow data give similar detail (if automated). But the most sensitive measurement used in a loading model is the total phosphorus concentration in the mixed layer of the lake (P). It is appears directly in the model and is also included indirectly to estimate internal loading and nutrient outflow at the dam. If that number is based on a single seasonal grab sample per site, the model will be very weak.

Considering the amount of effort needed to do this project and then to assess future management, it really is worth the time and expense to make that main phosphorus number in the model accurate and robust.

Sincerely,

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