Memorandum

To: *Lake Elsinore and Canyon Lake Nutrient TMDL Task Force*

From: *Steve Wolosoff and Paula Kulis, CDM Smith*
Michael Anderson, University California Riverside

Date: *March 24, 2022*

Subject: *Supplemental lake water quality model application to evaluate potential alternative reference scenario for TMDL revision*

Introduction

The Lake Elsinore and Canyon Lake (LE/CL) nutrient TMDL was reopened in 2015 to incorporate data collected since the 2004 TMDL and to improve upon the preceding scientific basis with new data and modeling tools. Lake Elsinore and San Jacinto Watersheds Authority (LESJWA) submitted a technical report to support revisions to the Lake Elsinore and Canyon Lake (LECL) Nutrient TMDLs ("TMDL Technical Report") to the Santa Ana Regional Water Quality Control Board (Regional Board) in December 2018 (LESJWA 2018). The purpose of the TMDL Technical Report was to support the preparation of the Basin Plan Amendment (BPA) to formally revise the LECL TMDLs originally adopted by the Santa Ana Water Board in 2004. To support the Regional Board's BPA process the TMDL Technical Report was peer reviewed in 2019. Peer review comments were received from six water quality experts in the west and provided to the TMDL Task Force on November 6, 2019.

The CDM Smith led technical team provided 1) draft responses to peer review comments on February 20, 2020 and 2) supplemental documents to fulfill Regional Board requests for additional synthesis of supporting data and modeling in December 3, 2020. Following review of these documents, the Regional Board determined that further study in the form of lake water quality modeling analysis would be needed to effectively respond to the peer review and understand the sensitivity of assumptions that comprise the basis of the 2018 TMDL Technical Report. Specific review comments requiring further study included:

- Appropriateness of using the median of a wet weather nutrient concentration dataset from samples collected in the San Jacinto River at Cranston Guard Station (2001-2011; n=52) to represent total nitrogen (TN) and total phosphorus (TP) washoff from typical undeveloped lands. Regional Board staff requested that the 25th percentile of this dataset be considered to provide additional conservatism in the estimation of allowable loads

- Assumption of a pre-levee bathymetry within Lake Elsinore as part of the reference condition for development of numeric targets. The Task Force had made a case that the levee project was implemented to improve water quality and should not be assumed to exist in a reference pre-development condition. Peer reviewers and the Regional Board staff pose the question of how impactful the assumption of a larger lake basin is to the resulting numeric targets. Figure 1 portrays the lake footprint with and without the presence of the levee.

Figure 1. Lake Elsinore surface area with and without levee

- Lack of sensitivity analysis. The peer review and Regional Board noted that the technical report and other supporting documentation did not provide any sensitivity analysis with regard to the lake water quality models used to create numeric targets. While the February 20, 2020 response to peer review referenced numerous published CAEDYM applications that incorporated sensitivity analyses, new model runs were developed to provide additional information to the Regional Board specific to Canyon Lake and Lake Elsinore. The focus of the sensitivity simulations involved parameterization of sediment nutrient flux and hydrologic inflows under the reference condition.

This technical memorandum documents lake water quality model simulations that were conducted to provide the requested information to the Regional Board staff to support their decision whether to require the Task Force to refine the basis of the TMDL revision. Changes to the underlying data and assumptions made through Task Force's collaboration in 2015-2018 would significantly impact allocations, linkage analysis, and numeric targets, and likely require large substantive changes to the 2018 TMDL Technical Report. Table 1 presents the supplemental lake water quality simulations that were conducted in collaboration[1] with Regional Board staff in 2021.

Table 1. Lake Water Quality Modeling Scenarios Conducted in 2021

Scenario	Canyon Lake	Lake Elsinore
1. Alternative reference condition: 25th percentile of Cranston Guard Sta nutrient concentration, add levee to Lake Elsinore	2001-2016	1916-2016
2. Sensitivity for sediment flux parameter for NH4 and SRP	2007-2011	1916-2016
3. Sensitivity for hydrologic inflows	2007-2011	1964-2016

This memorandum is broken into three sections as follows:

- Model Overview
- Sensitivity Analyses
- Results of Alternative Reference Scenario

Model Overview

Hydrodynamic and water quality models of Lake Elsinore used to support the 2018 TMDL Technical Report involved DYRESM-CAEDYM, a one-dimensional lake model that is ideal for lake systems where vertical mixing and transport dominates over lateral circulation. For Canyon Lake, the linkage analysis involved a three dimensional hydrodynamic model ELCOM (Estuary, Lake and Coastal Ocean Model), which was also coupled with the CAEDYM water quality platform. In this way, both lakes were modeled with the same water quality equations.

Since the development of the 2018 TMDL Technical Report, water quality models used for the linkage analysis in both Lake Elsinore and Canyon Lake have been migrated from sunsetted platforms to currently supported software. The Canyon Lake ELCOM-CAEDYM model framework was transposed over to the Aquatic Ecosystem Model 3D (AEM3D)[2] and the Lake Elsinore DYRESM-CAEDYM was transposed into the now widely used open source model platform GLM[3] (General Lake Model). While CAEDYM's structure was migrated to AEM3D, many aspects of it were also used to develop the Aquatic Ecodynamics (AED2[4]) modelling library, which is the water quality module of GLM. AED2 is not a continuation of CAEDYM; it contains many shared approaches, but also

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[1] A series of workshops were held between Regional Board staff, Task Force administrators, and CDM Smith modeling team on 3/18/2021, 3/26/2021, 4/6/2021, 4/14/2021, 5/4/21, and 5/12/2021. The meetings focused on decisions regarding the characteristics of the 2018 TMDL Technical Report reference watershed condition, benchmarking with other TMDLs in the US, review of the physical and biogeochemical characteristics of Canyon Lake and Lake Elsinore, and model sensitivity to several lake configuration and nutrient loadings.

[2] https://www.hydronumerics.com.au/software/aquatic-ecosystem-model-3d

[3] https://aed.see.uwa.edu.au/research/models/glm/

[4] https://aed.see.uwa.edu.au/research/models/aed/

incorporates some insights from other water quality models. Figure 2 shows a simple depiction of the model migration process.

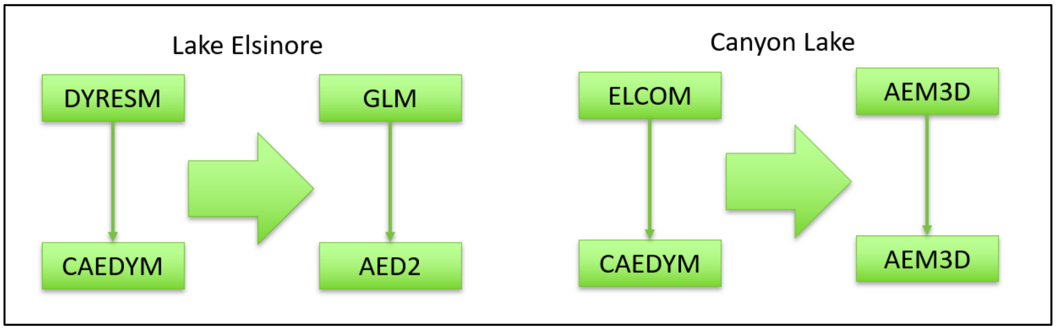

Figure 2. Model migration summary for Lake Elsinore and Canyon Lake

The migrated models are appropriate new tools for use in assessing model sensitivity and serving as linkage analysis for potential modifications to the LECL TMDL revision. Table 2 compares mean modeled results in GLM-AED2 with DYRESM-CAEDYM for Lake Elsinore and ELCOM-CAEDYM with AEM3D for Canyon Lake. Means of observed data are also shown in Table 2. Table 3 shows mean model results for Canyon Lake in ELCOM-CAEDYM and AEM3D. Tables 2 and 3 show that migration of the models yielded negligible differences in Canyon Lake and better overall model agreement for Lake Elsinore.

The 2018 Reference Scenario for Lake Elsinore simulated using DYRESM-CAEDYM had a very low frequency of reduced DO in the water column, which is not consistent with the high algal populations in the 2018 Reference Scenario simulation. The modeling team and the Regional Board agree that while the DO simulated in GLM-AED2 differs from the DO simulated in DYRESM-CAEDYM, the modeled DO characteristics and behavior in relation to algal kinetics in GLM-AED2 are an improvement in model representation.

Table 2. Mean Model Performance for Lake Elsinore in GLM-AED2 model and DYRESM-CAEDYM model (calibration simulation, 2000-2014).

Parameter	GLM-AED2 Mean	DYRESM-CAEDYM Mean
Lake Elevation (ft NAVD88)	1241.3	1241.5
Temperature (deg C)	25.0	24.1
TDS (mg/L)	1498	1731
DO (mg/L)	7.1	5.1
seasonal average TN (mg/L)	4.9	4.16
seasonal average TP (mg/L)	0.27	0.26
seasonal average ChlA (ug/L)	156	162

Table 3. Mean Model Performance for Canyon Lake in AEM3D model and ELCOM-CAEDYM model (calibration simulation, 2007-2009)

Parameter	AEM3D mean	ELCOM-CAEDYM Mean
Lake Level Below Crest (ft)	-3.63	-3.64
Temperature (deg C)	20.87	20.88
DO (mg/L)	7.91	7.91
TN (mg/L)	1.09	1.09
TP (mg/L)	0.58	0.553
ChlA (ug/L)	37.24	37.52

Sensitivity Analysis

A series of workshops were held between the Regional Board staff, Task Force administrators, and CDM Smith team to evaluate the sensitivity of key features of the reference condition in the 2018 TMDL Technical Report and help to familiarize multiple new Regional Board members with the key scientific assumptions and modeling approaches. This section documents sensitivity simulations conducted to support workshop discussions. Several simulations were run in both Lake Elsinore's GLM and Canyon Lake's AEM3D models to evaluate model sensitivity and response to changes in:

- Watershed inflow phosphorous and nitrogen concentrations;
- Internal phosphorous and nitrogen load from sediments;
- Lake Elsinore morphometry (presence/absence of the levee); and
- Watershed runoff volume inflow.

Watershed Nutrient Concentration

The reference watershed approach in the 2018 TMDL Technical Report involves simulation of in-lake water quality response to naturally occurring, or reference, external nutrient concentrations. In the 2018 TMDL Technical Report, the median of measured nutrient concentrations from the San Jacinto River at Cranston Guard Station was used to represent nutrient washoff from undeveloped land. The actual drainage area to the site is over 97 percent undeveloped and was sampled to support characterization of forested land nutrient loads in the 2004 TMDL. Multiple lines of evidence were presented to support the use of the median concentrations from the SJR at Cranston Guard Station site (0.32 mg/L TP; 0.92 mg/L TN) in the TMDL Technical Report and again in a December 3, 2020 technical memorandum[5]. The undeveloped watershed runoff concentrations associated with the median and 25th percentiles at Cranston Guard relative to other regional data are shown in Figure 3 for context. In addition, RCFC&WCD has conducted focused sampling downstream of recently burned natural areas and measured nutrient concentrations 1-2 orders of

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[5] CDM Smith 2020. Lake Elsinore and Canyon Lake TMDL Revision – Supplement to TMDL Technical Report, Technical Memorandum dated December 3, 2020.

magnitude greater than in the SJR at Cranston Guard Station (>5 mg/L TP and >10 mg/L TN in Ortega, Horsethief, and McVicker Canyons).

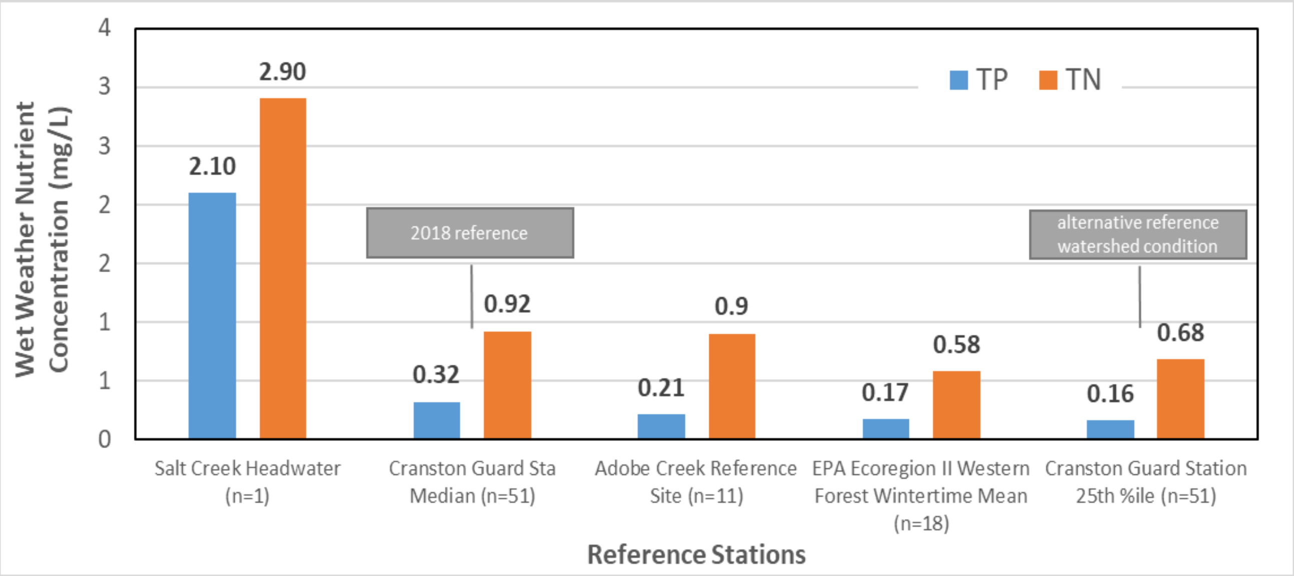

Figure 3. Nutrient Concentrations from reference streams within and nearby the SJR watershed (wet weather) and western forest ecoregion (winter season mean)

Regional Board staff sought to assess the potential impact to in-lake numeric targets from using an alternative statistical method involving use of the 25th percentile of the Cranston Guard Station to serve as a more conservative basis for allowable loads in TMDL revision. Models were run to evaluate in-lake water quality response at both median and 25th percentile inflow nutrient concentration levels. Model results from these simulations are reviewed in detail in the following sections of this memorandum.

Following review by the Regional Board staff, use of the 25th percentile concentrations to represent the reference watershed condition was communicated to the Task Force as an important change to the scientific basis for the TMDL revision in order to satisfy the comments from the peer review.

Sediment Fluxes

Intermittent watershed nutrient loading during the wet season enriches sediments in the lake bottom through settling, indirectly increasing internal loads from the lake bottom over the course of the year. Historical data in both Canyon Lake and Lake Elsinore shows a clear correlation between water column nutrients and flux rates from sediment into the water column (Figure 4). As expected, no empirical data exists for internal flux rates prior to watershed development in the SJR watershed. Thus, an estimate of the change to internal load from a reduced external load associated with a reference watershed condition was critical to the linkage analysis for the LECL nutrient TMDL revision. The 2018 reference watershed TMDL involved downward extrapolation of correlations shown in Figure 4 to estimate an internal sediment flux rate to use for a reference watershed condition (Table 4). This same downward extrapolation was applied to appropriately parameterize internal sediment nutrient flux for the alternative reference watershed nutrient concentration at the 25th percentile of the Cranston Guard Station. Given that this extrapolation is based on relationships with considerable uncertainty, sensitivity analysis was conducted to assess the influence of changes to the sediment flux parameter upon overall lake water quality results.

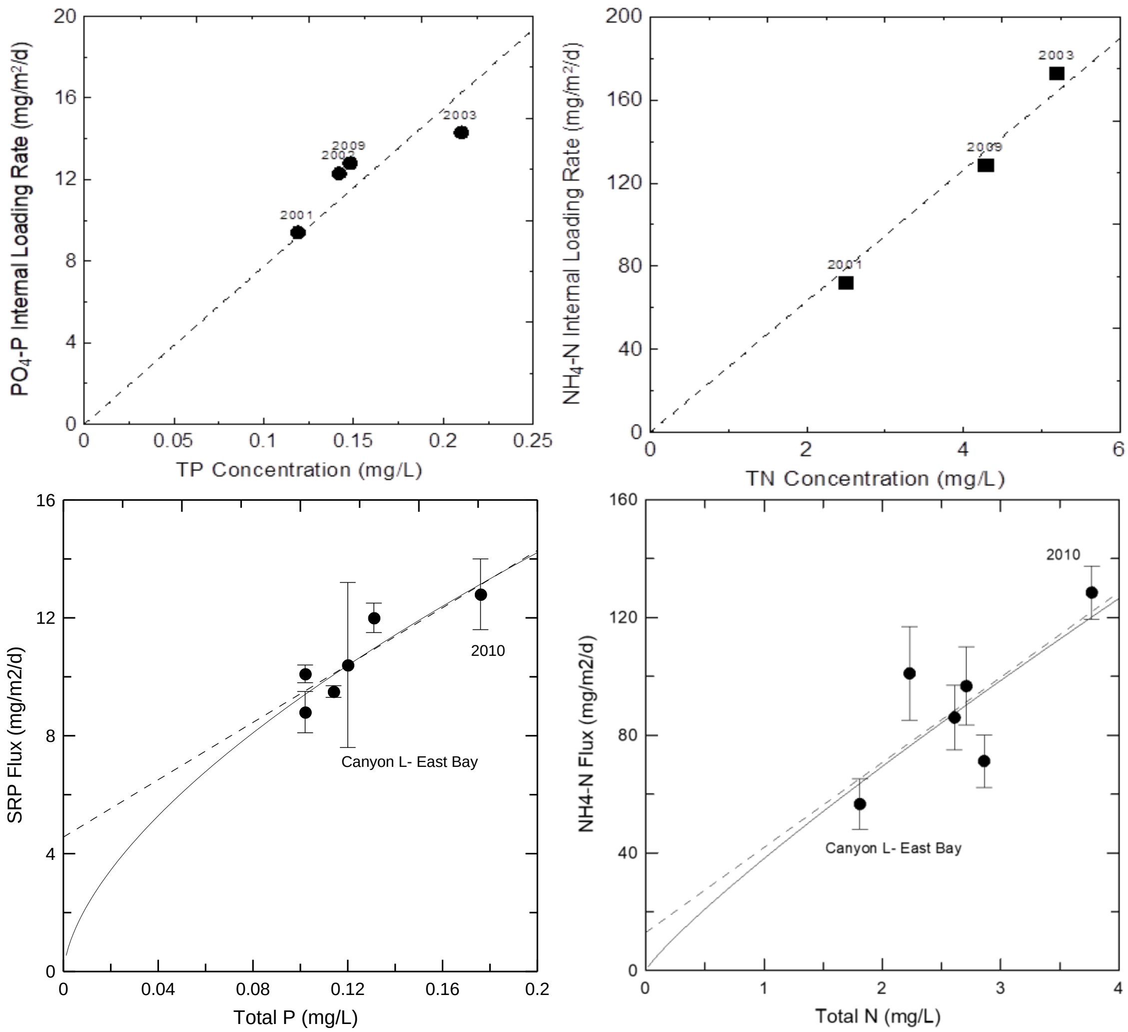

Figure 4. Sediment nutrient fluxes and water column nutrient concentrations in Lake Elsinore (top) and Canyon Lake (bottom) assessed from pore water samples collected by Anderson and others.

Table 4. Sediment Nutrient Flux Parameter as mg/m²/day for Current, 2018 Reference, and Alternative Reference Model Scenarios

Parameter	Lake Elsinore		Canyon Lake	
	Phosphorus	Nitrogen	Phosphorus	Nitrogen
Current	9.0	75.0	15.5	44.0
2018 Reference Scenario	5.4	37.0	7.8	22.0
Alternative Reference Scenario	3.7	31.1	4.3	13.1

The sensitivity of the AEM3D Canyon Lake model to sediment fluxes was quantitatively assessed by increasing nutrient sediment fluxes by 10%. Water column chlorophyll A, Total N and Total P are all moderately sensitive to sediment flux changes. The impact of this sensitivity test on the chlorophyll A distribution in the reference simulation is shown in Figure 5. This indicates that while incremental changes in sediment fluxes will have small impacts on these modeled water quality constituents, larger changes such as reducing watershed loadings to the 25th percentile from the 50th percentile are expected to have more significant influences on water column concentrations. Thus, the alternative reference is conservative enough to outweigh any sensitivity to associated parameter estimation in the median reference scenario.

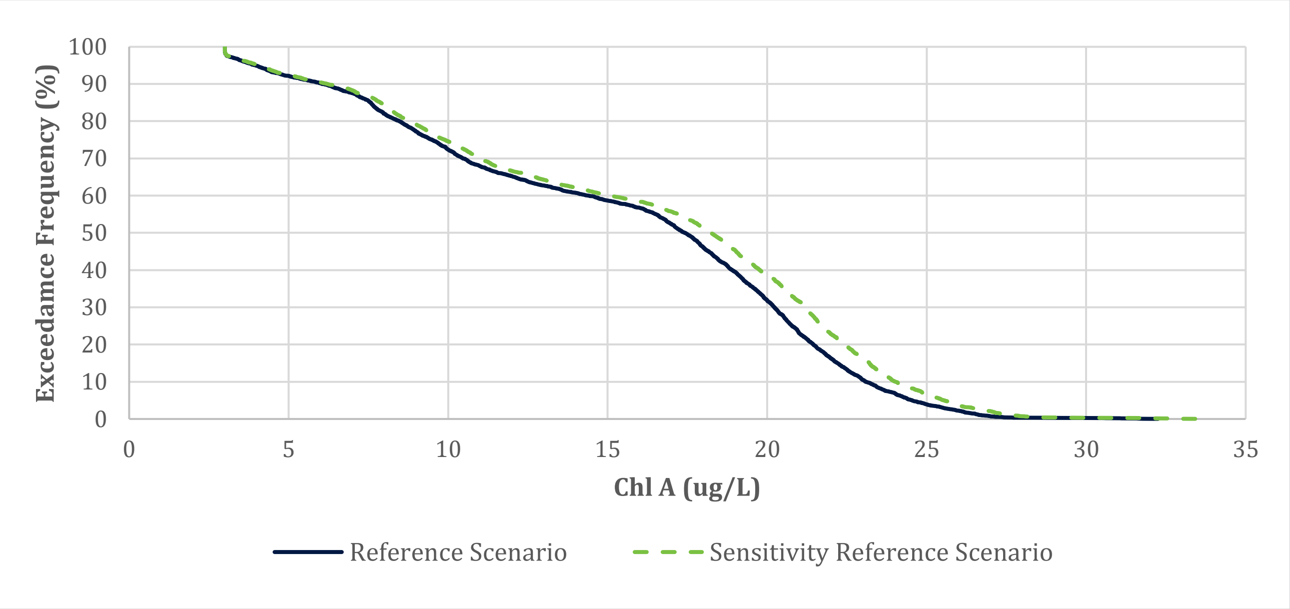

Figure 5. Simulated chlorophyll A distribution in Canyon Lake (Main Lake) with 25th percentile inflow concentrations and with a sensitivity test of adding an additional 10%

Levee

The Regional Board staff sought to assess the impact of the levee on Lake Elsinore water quality in the reference condition using the GLM model. Figure 6 shows the impact of including the levee in the reference simulation. water level is universally higher. The mean difference in elevation over the course of the reference simulation is 1.85 ft.

The lake elevation of 1234.4 ft has been identified as a critical elevation at which resuspension increases and has a negative impact on the lake’s water quality. Without the levee, 33.2% of the reference time period is simulated below this critical lake level. With the levee in place, 25.3% of the reference simulation is simulated below the critical elevation.

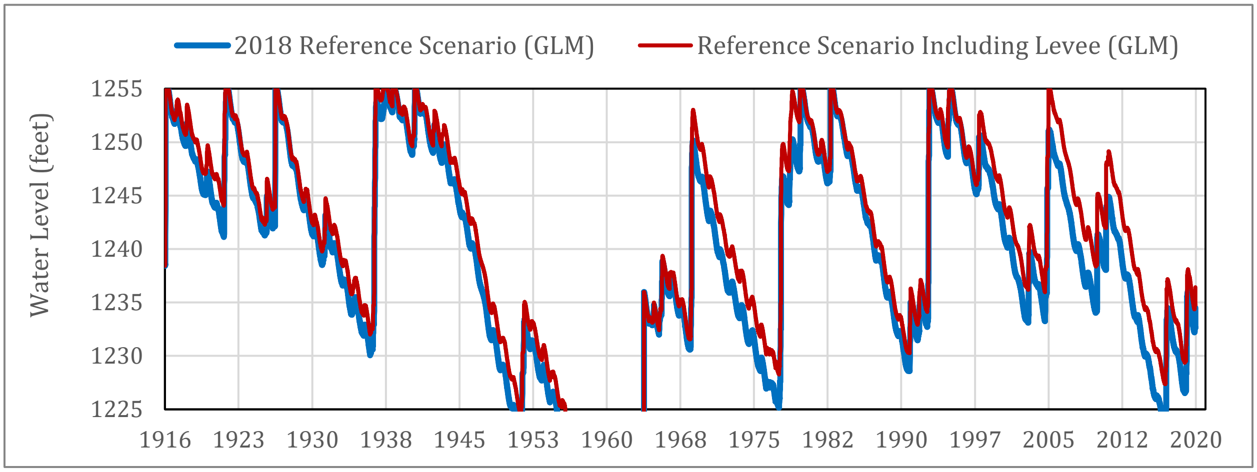

Figure 6. Lake level simulated in GLM with and without the levee for the reference period

Enhanced Watershed Retention

Development in the SJR watershed has led to an increase in imperviousness and thereby an increase in runoff volume and associated nutrient loads reaching the downstream lakes. On one hand, water quality within Lake Elsinore is improved with increased lake level (Figure 7). Reduction in volume that reaches Lake Elsinore leads to more frequent low water levels and dry lake beds; these dry conditions present their own host of threats to water quality in Lake Elsinore, as chlorophyll A is strongly connected to water level. On the other hand, the increased watershed runoff from development contains elevated nutrient loads that can increase eutrophication and negatively impact water quality. The Task Force used the calibrated GLM model to assess the net impact, positive or negative, of a watershed management scenario involving increased retention of runoff volume by 30% with nutrient concentrations at the 25th percentile of the Cranston Guard Station dataset.

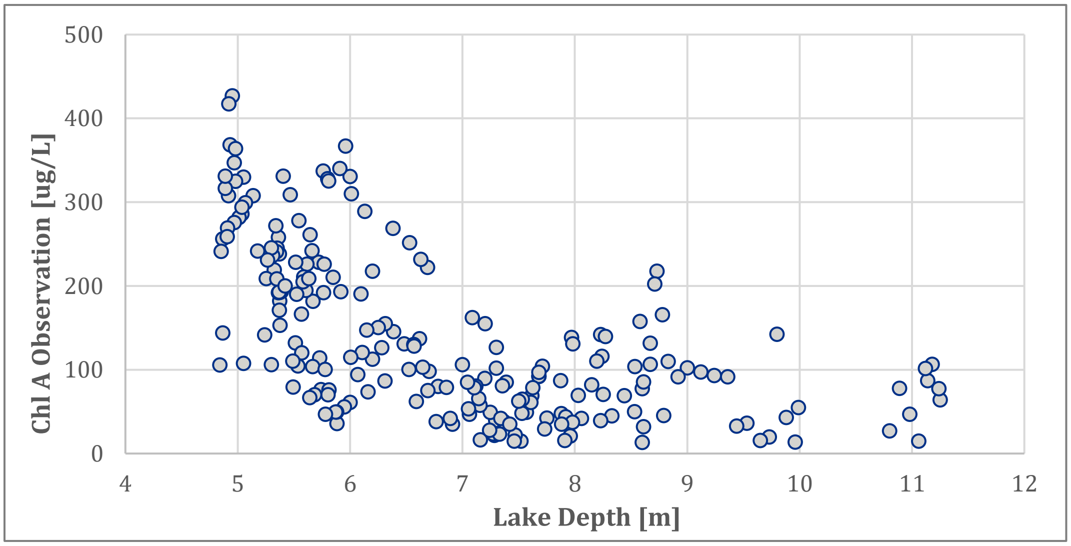

Figure 7. Chlorophyll A observations measured between 2000 and 2014 plotted against the corresponding water depth

The scientific findings from the enhanced runoff retention sensitivity analysis is instructive to support regional stormwater plans and permits by providing a demonstration of the unique relationship between receiving water quality in Lake Elsinore and watershed management practices in the SJR watershed. When compared to current lake inflows (the basis for reference scenarios), the increased runoff retention scenario resulted in additional dry bed periods in the 1930s and 1970s, and extended the dry bed periods modeled in other reference scenarios in the 1950s and 2010s. Moreover, higher seasonal peak chlorophyll A concentrations were simulated for the increased runoff retention scenario relative to historical gauged inflow volumes, followed by significantly more severe seasonal algae population crashes, as demonstrated in the 10-year period plotted in Figure 8.

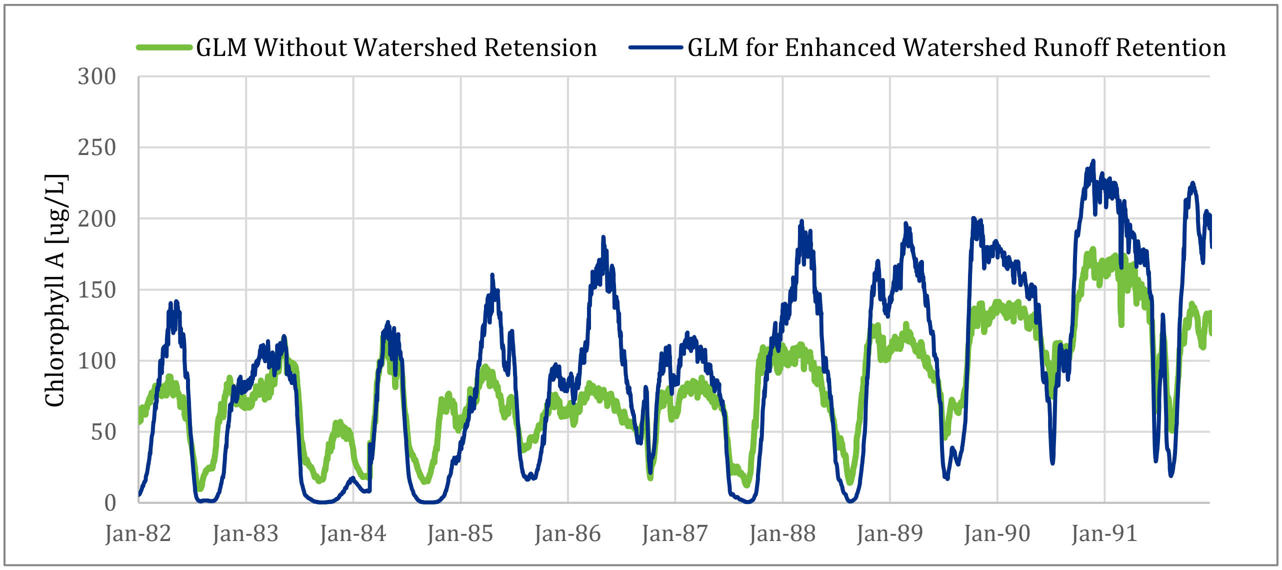

Figure 8. Simulated chlorophyll concentrations for 1982-1991 from reference scenarios with and without enhanced watershed runoff retention, both simulated in GLM

The overall distribution of chlorophyll A in the modelled 100-year scenarios are compared with and without watershed retention in Figure 9, where a larger tail of extreme high chlorophyll concentrations is clearly present in the enhanced watershed retention scenario. Thus, the benefits of increased runoff volume outweigh the impacts of increased nutrient loading, when comparing two scenarios of equal reference nutrient concentration for runoff inflows. This finding suggests that use of in-lake controls to reduce internal loads to offset a portion of excess external watershed nutrient loading will achieve a greater lake water quality condition by allowing for increased runoff volume to reach Lake Elsinore than an alternative watershed management strategy that strives to return to a predevelopment hydrologic condition.

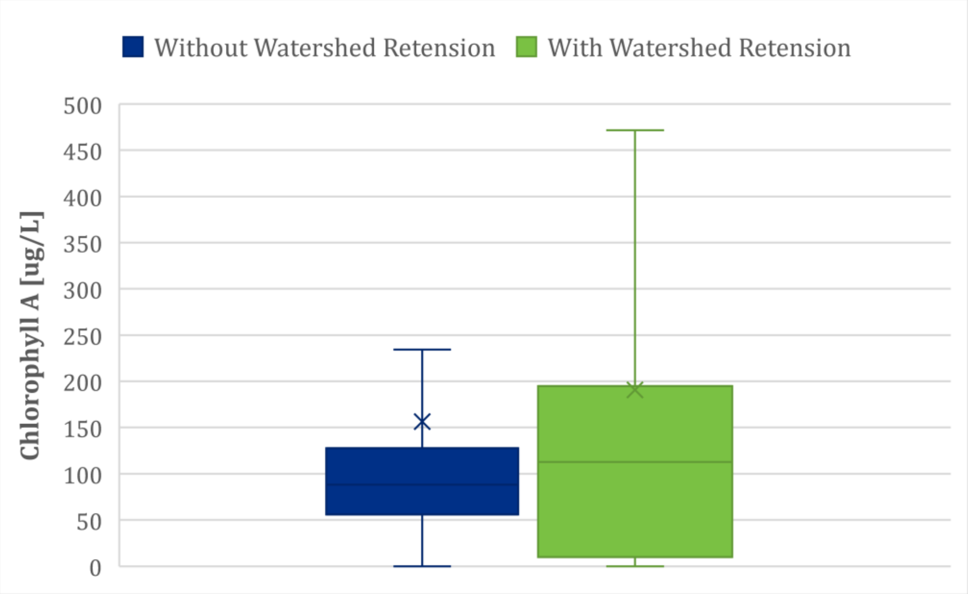

Figure 9. Box and whisker plot demonstrating simulated Chl A distributions with and without enhanced watershed retention. Colored boxes indicate 25-75% range, horizontal lines within colored boxes indicate median values, and brackets indicate 5-95% ranges. The "X" symbols indicate sample means (with outliers excluded)

Alternative reference scenario configuration and comparison

Lake water quality models were applied with runoff inflow nutrient concentrations for the reference watershed, and associated internal sediment flux parameters, set to the median and 25 percentile of the Cranston Guard Station to allow for comparison of potential numeric targets at both levels using AEM3D in Canyon Lake and GLM in Lake Elsinore. Tables 5 and 6 summarize select key model parameters for the 2018 and alternative reference watershed condition in Canyon Lake and Lake Elsinore, respectively. In both tables, existing present-day conditions used in calibrated models are included for comparison. Tables 5 and 6 correspond to model scenario 1 listed in Table 1 earlier in this memorandum.

The following sections detail changes between the 2018 reference scenario and the alternative reference scenario. The alternate reference scenario represents a more conservative assumption with regard to nutrient washoff from undeveloped lands. Attachment A presents the full suite of alternate reference scenario model results for potential use in construction of final numeric target in a future TMDL revision analysis and technical report.

Table 5. Parameter values evaluated in Canyon Lake for Alternative Reference Condition

Parameter	Existing Conditions	2018 Reference Conditions	Alternative Reference Conditions
Description	Recent watershed nutrient medians	50th percentile	25th percentile
San Jacinto River Total Phosphorous (mg/L)	0.69	0.32	0.16
San Jacinto River Total Nitrogen (mg/L	2.16	0.92	0.68
Salt Creek Total Phosphorous (mg/L)	0.46	0.32	0.16
Salt Creek Total Nitrogen (mg/L)	2.40	0.92	0.68
Sediment Phosphorous Flux (mg/m^2/d)	15.5	7.8	4.3
Sediment Nitrogen Flux (mg/m^2/d)	44.0	22.0	13.1
Runoff Flow	USGS gauge + local runoff		

Table 6. Parameter values evaluated in Lake Elsinore for Alternative Reference Condition

Parameter	Existing Conditions	2018 Reference Conditions	Alternative Reference Conditions
Description	Present-day lake characteristics	50th percentile loadings	25th percentile loadings with levee
Hypsography	With levee	Without levee	With levee
Inflow Total Phosphorous (mg/L) in Runoff	0.39	0.32	0.16
Inflow Total Nitrogen (mg/L) in Runoff	1.64	0.92	0.68
Internal Total Phosphorous Flux (mg/m^2/day)	9.0	5.4	3.7
Internal Total Nitrogen Flux (mg/m^2/day)	75.0	37.0	31.1
EVMWD discharge	Metered Inflows	None	None
Runoff Flow	USGS gauge + local runoff		

Canyon Lake Reference Scenario Comparison

The lower inflow nutrient concentrations and reduced internal recycling rates at the 25th percentile Cranston Guard Station yielded lower levels of chlorophyll-a in Canyon Lake compared with the 2018 reference scenario (Figure 10).

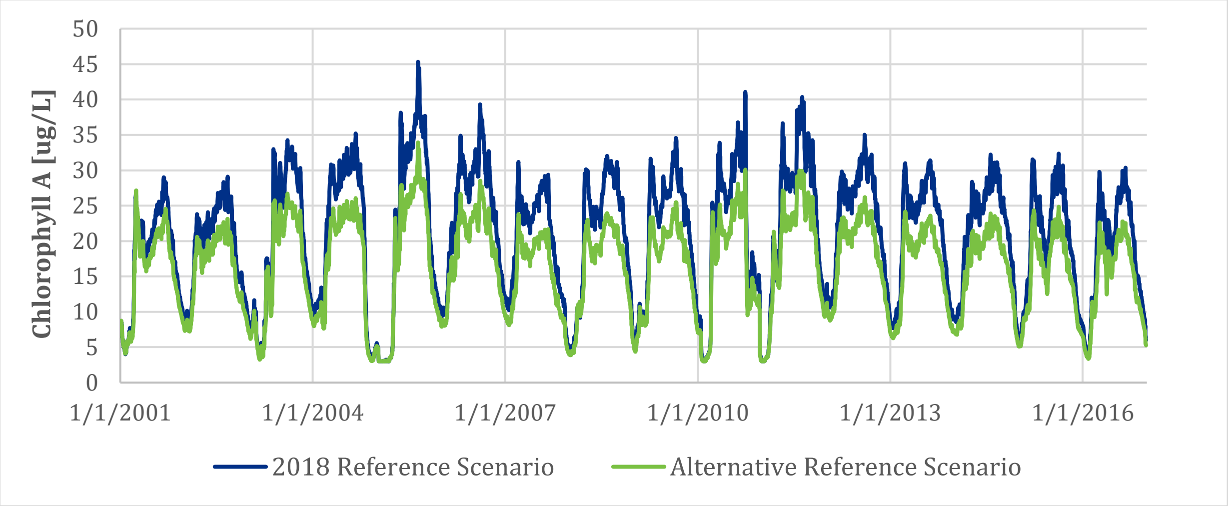

Figure 10. Simulated surface chlorophyll A concentrations in the Main Lake comparing with 2018 and Alternate Reference Scenarios

Like the timeseries plot, chlorophyll-a concentrations presented as a cumulative distribution function (CDF) shown in Figure 11 were also shifted to lower values using the alternate reference scenario compared with the 2018 reference scenario. Median chlorophyll-a concentrations decreased from 21.6 μg/L to 17.2 μg/L, corresponding to a 21% reduction, while maximum predicted concentrations decreased from 43.4 μg/L to 32.2 μg/L (representing a 26% reduction). Since inflow concentrations were reduced by 26-50% and nutrient recycling rates by 40-45%, the simulated chlorophyll-a response was not a simple linear function of inflow concentrations and nutrient recycling rates.

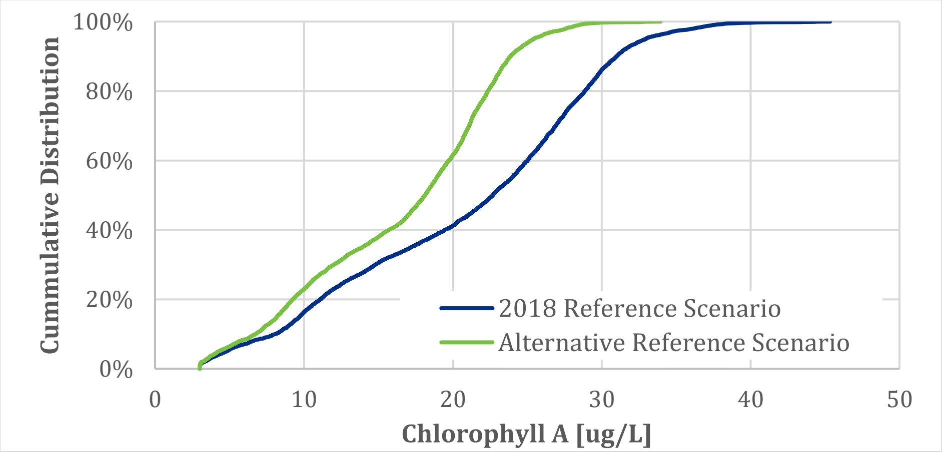

Figure 11. Cumulative distribution functions for predicted chlorophyll-a concentrations in main lake comparing the 2018 Reference Scenario with the Alternative Reference Scenario

Dissolved oxygen and ammonia also show an improvement in water quality with the Alternative Reference Condition. Figure 12 shows the CDF of both depth integrated ammonia and percentage of the lake volume where DO is greater than 5 mg/L. For parameters such as ammonia, distribution curves that show higher percentages at low concentrations on the x-axis indicate good water quality. However, for percentage of the lake volume where DO > 5 mg/L, higher values on the x-axis, indicating higher percentages of the lake volume, indicate good water quality.

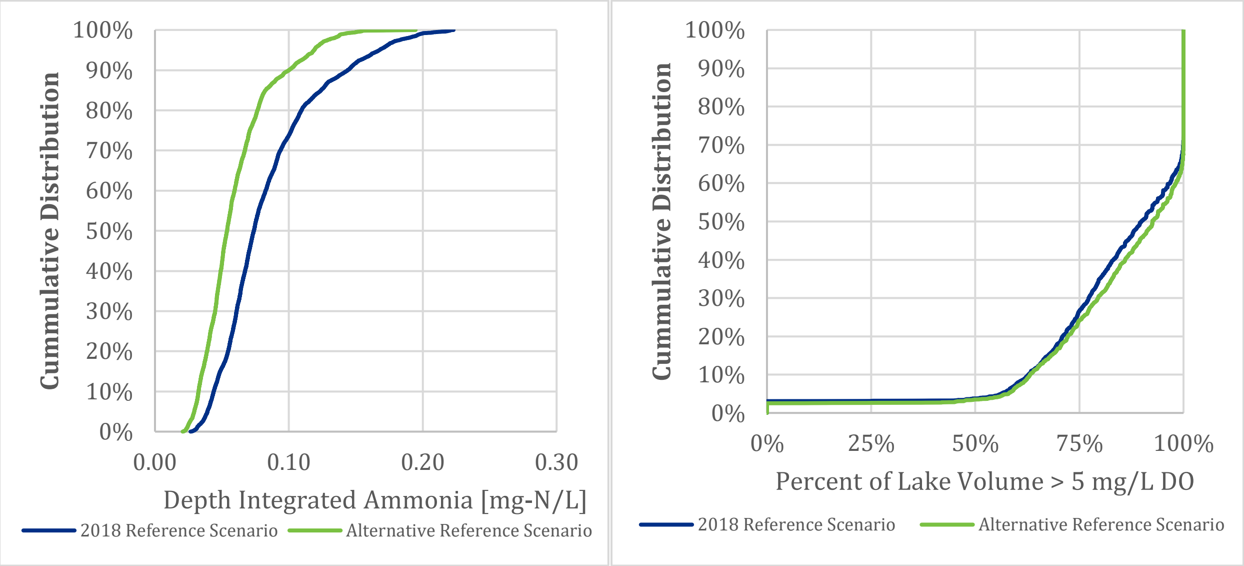

Figure 12. Cumulative distribution functions for a) depth-integrated ammonia and b) percentage of the lake volume where DO >5 mg/L in main lake comparing the 2018 Reference Scenario with the Alternate Reference Scenario

Lake Elsinore reference scenario comparison

As in Canyon Lake, for Lake Elsinore modeled chlorophyll A concentrations in the alternate reference scenario are lower than in the 2018 reference scenario, as expected. Figure 13 shows a timeseries of chlorophyll A concentrations over the course of the reference time period, 1916-2016. The timeseries shows frequent extreme blooms, followed by population crashes, in the 2018 Reference Scenario. This phenomena is less severe and less frequent in the alternate reference scenario.

The simulated surface chlorophyll A cumulative distribution from the Alternative Reference Scenario is plotted along with the distribution from the 2018 Reference Scenario simulated in GLM in Figure 14. The figure shows the cumulative distribution of chlorophyll A throughout the reference time period by concentration. The figure shows that 22% of model results throughout the reference time period had chlorophyll A concentrations less than or equal to 50 ug/L, simulated in the Alternative Reference condition. High percentages at low chlorophyll concentrations indicate that modeled chlorophyll concentrations are generally low. A distribution line on the plot that is *above* another line on the plot indicates *lower* overall modeled chlorophyll concentrations than the line below it, and hence better water quality. Figure 14 demonstrates that simulated chlorophyll concentrations are *overall* lower in the Alternative Reference Scenario than in the 2018 Reference Scenario. The higher percentage of time with less than 50 ug/L chlorophyll A concentrations in the 2018 Reference Scenario is a signature of sharp algal blooms and subsequent population crashes simulated in the 2018 Reference Scenario that are less frequent in the Alternate Reference Scenario.

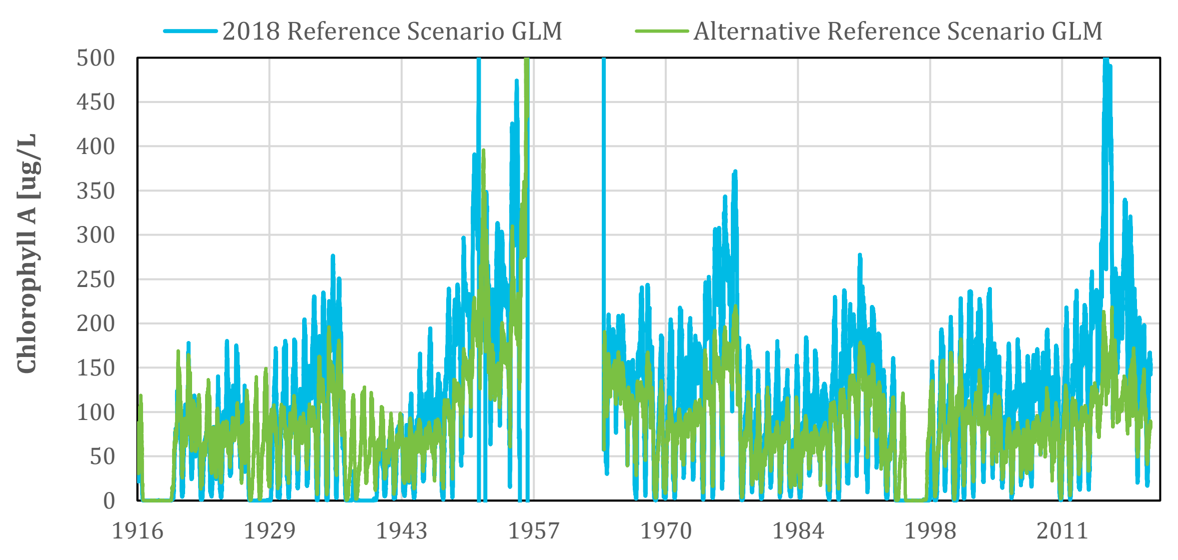

Figure 13. Modeled surface chlorophyll A concentrations in the alternate and 2018 reference scenarios for Lake Elsinore

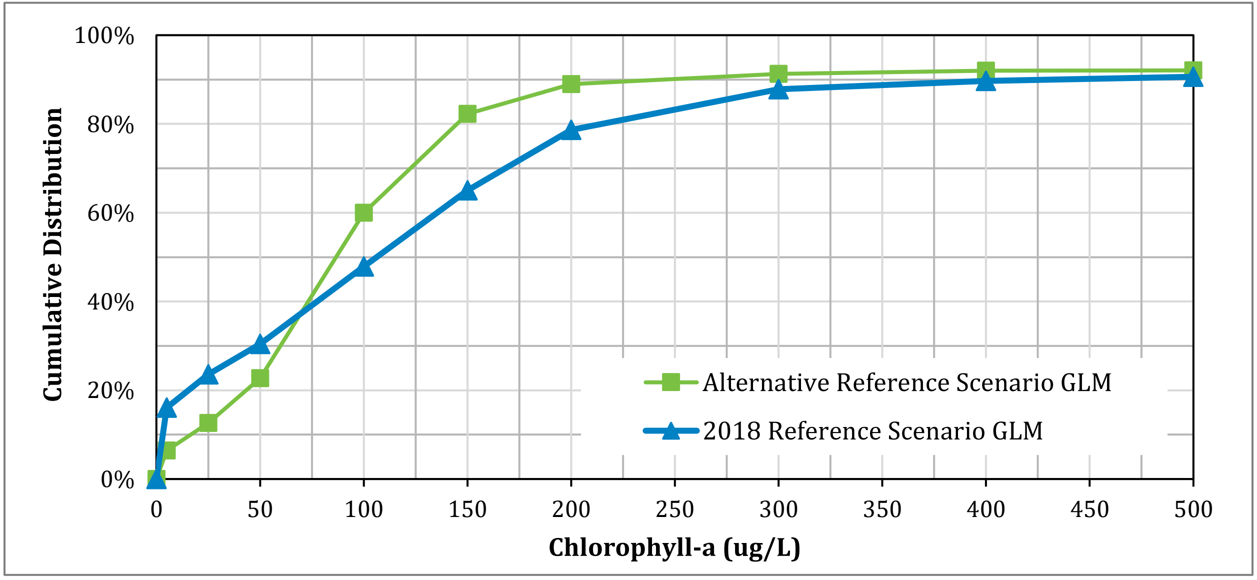

Figure 14. Reference scenario chlorophyll A concentration distributions

Similar CDF plots are included for DO, as fraction of the water column above 5 mg/L in Figure 14. In a healthy water body, 100% of the water column has a DO above 5 mg/L. Frequent low percentages indicate poor water quality. Figure 15 demonstrates that the Alternative Reference Scenario has slightly improved water quality over the 2018 Reference Scenario as modeled in GLM, consistent with the chlorophyll A results shown in Figure 13. The Alternative Reference scenario model results show a reduction in water column hypoxia from the 2018 simulated results.

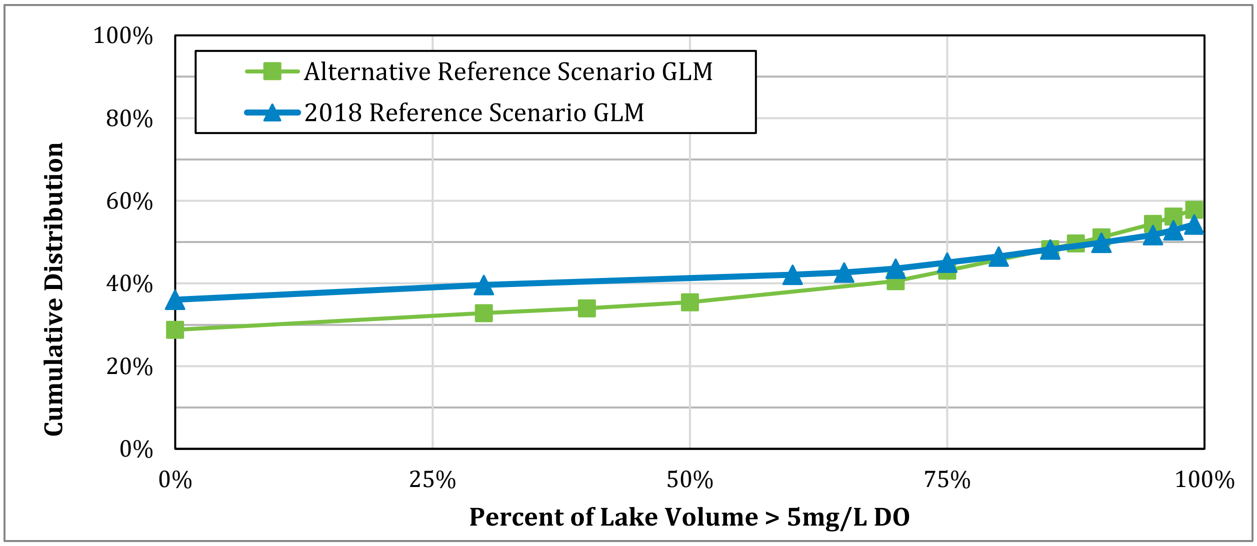

Figure 15. CDF of DO as a percentage of the water column where DO > 5mg/L

Water column ammonia distribution also changes slightly with the alternate reference scenario (Figure 16). The median concentration for the 2018 reference scenario and the alternate reference scenario is 0.07 mg/L. However, the 2018 Reference scenario has a higher frequency of high ammonia concentrations above 0.15 mg/L.

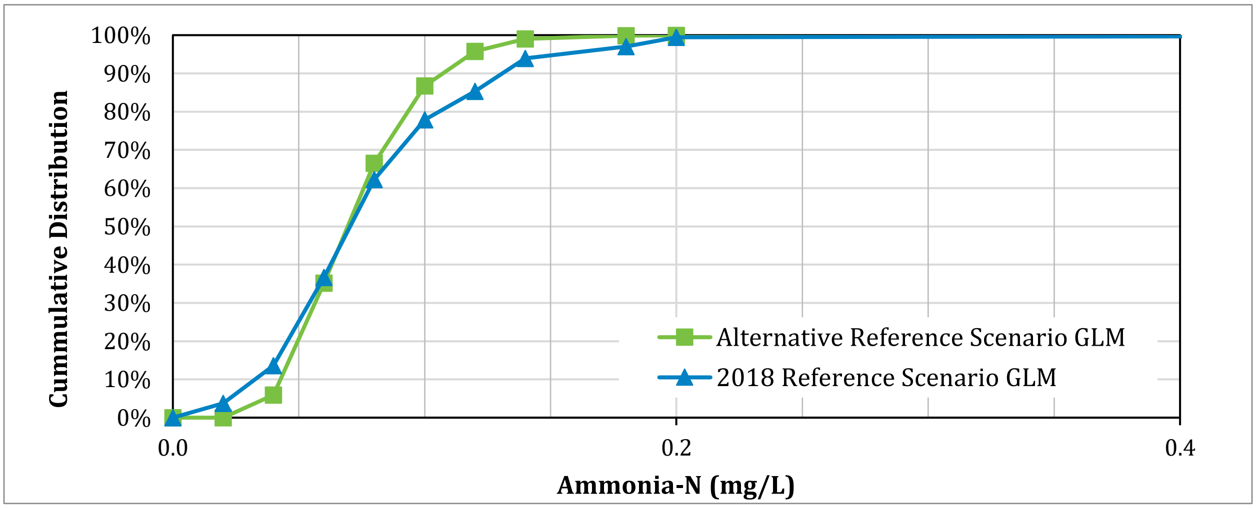

Figure 16. CDF of modeled depth-averaged ammonia.

Conclusion

The 2018 and alternate reference scenario results presented in this memorandum may be employed as numeric targets in a future TMDL revision for Lake Elsinore and Canyon Lake. The alternate reference scenario was developed to satisfy comments from the peer reviewers and was supported by the migrated lake water quality models. As expected, the alternate reference scenario produced lower nutrient levels and corresponding lower chlorophyll concentrations, and hence overall better water quality in both lakes when compared with the 2018 reference scenario. Model results are reasonable for both lakes under both the 2018 and alternative reference conditions.

Attachment A: Final Alternative Reference Scenario Model Results for Canyon Lake

Main Lake

CDF plots of surface chlorophyll A, depth-integrated ammonia and percentage of the water column where DO > 5 mg/L are plotted in Figures A.1 through A.3. These figures represent proposed revised numeric targets for Canyon Lake.

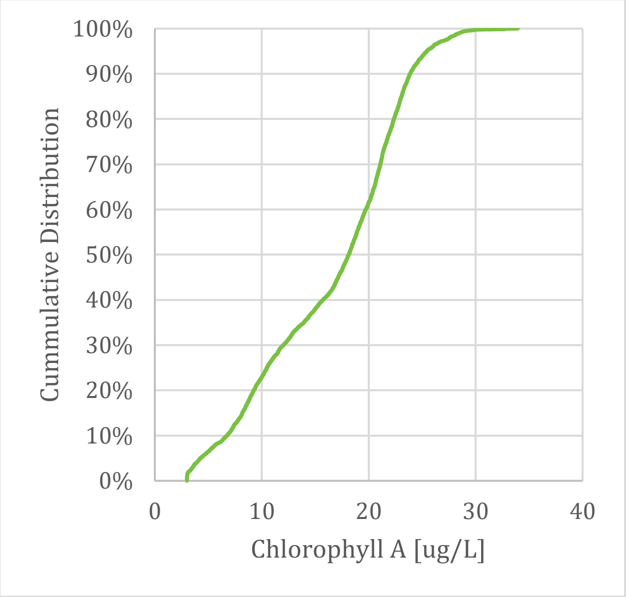

Figure A.1 Cumulative distribution for simulated average surface Chlorophyll A.

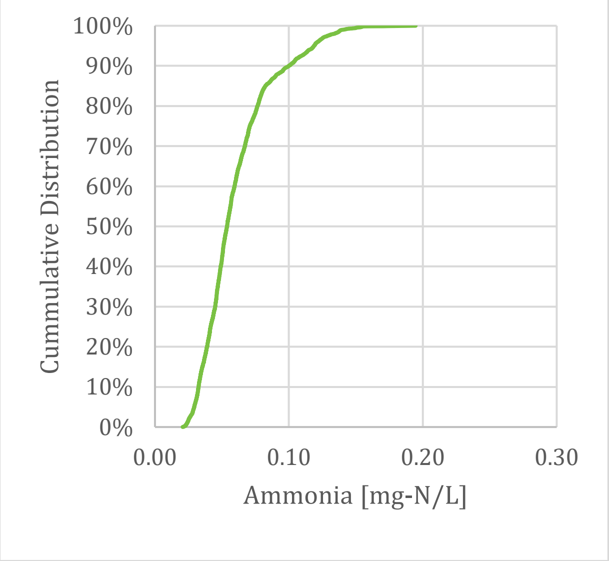

Figure A.2 Cumulative distribution simulated for depth integrated ammonia.

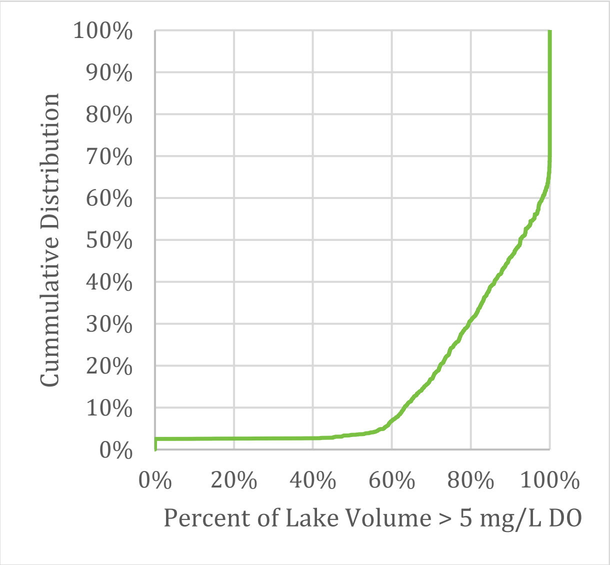

Figure A.3 Cumulative distribution for simulated percentage of the lake volume where DO > 5 mg/L.

The time history of various modeled parameters, including, DO at the surface and at depth, chlorophyl, total phosphorous and total nitrogen are all plotted for the alternate scenario in Figures A.4 through A.8.

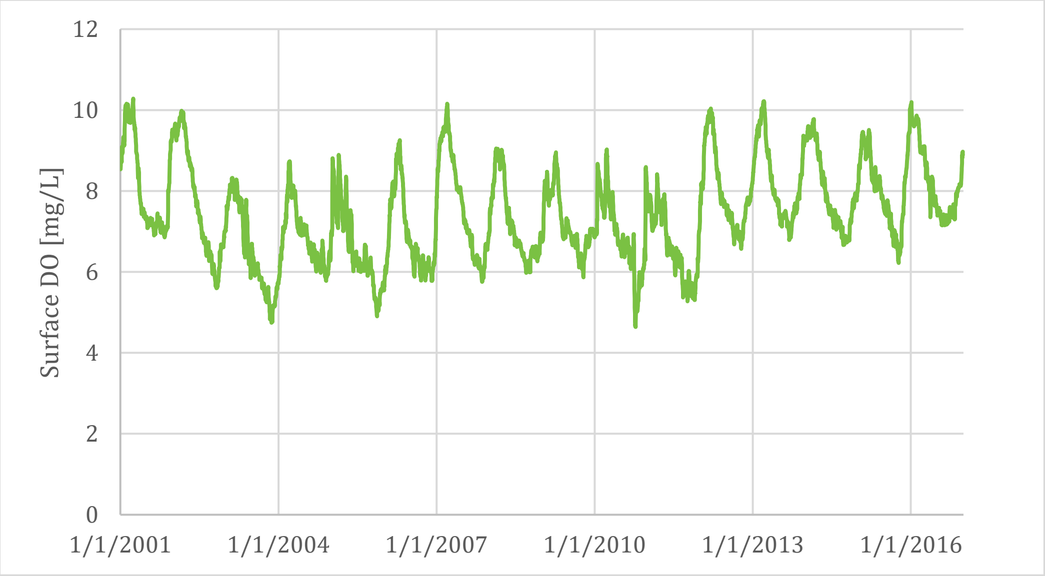

Figure A.4 Simulated average surface DO.

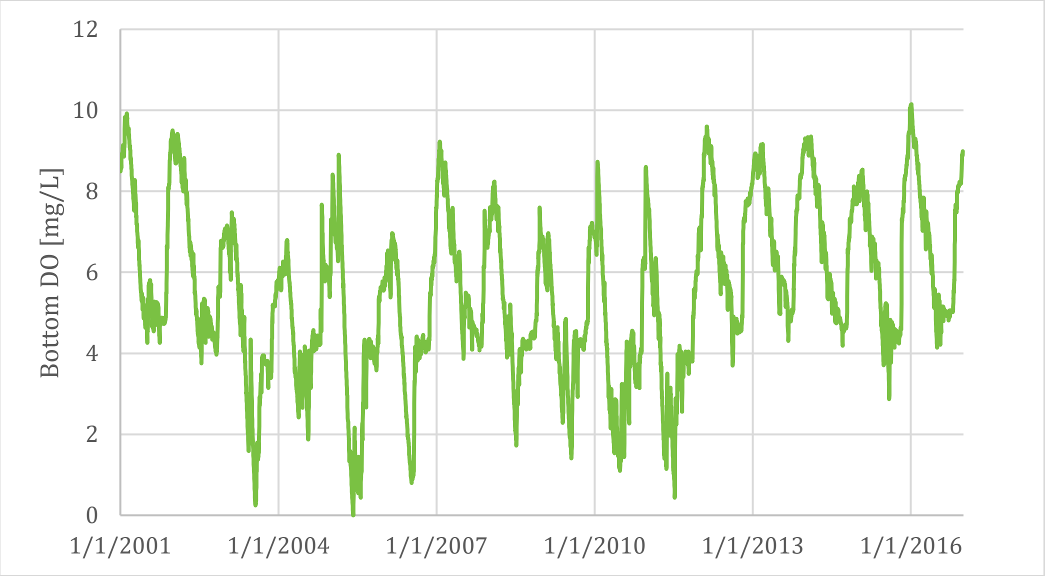

Figure A.5 Simulated average bottom DO.

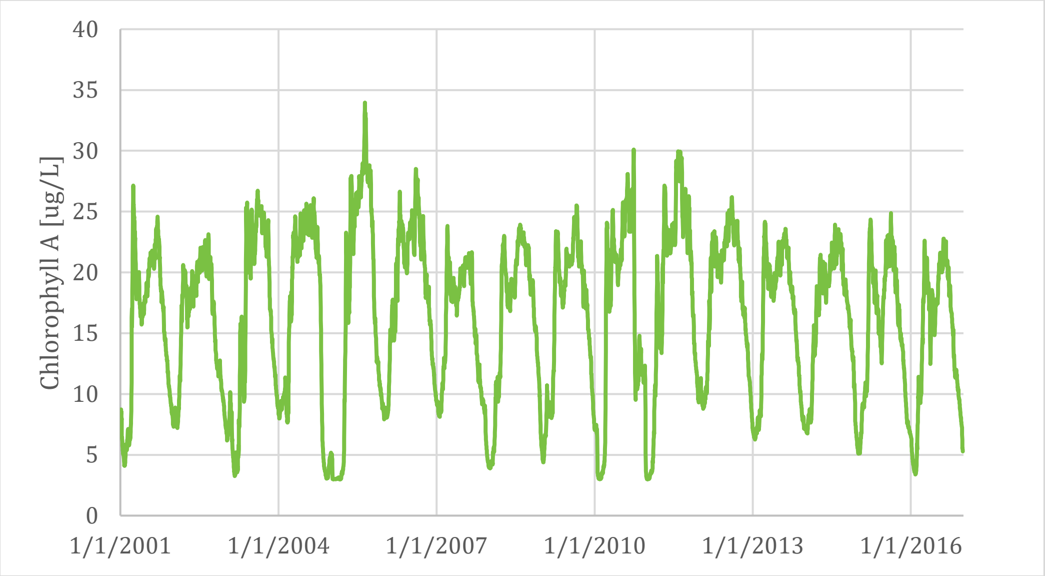

Figure A.6 Simulated average surface chlorophyll A.

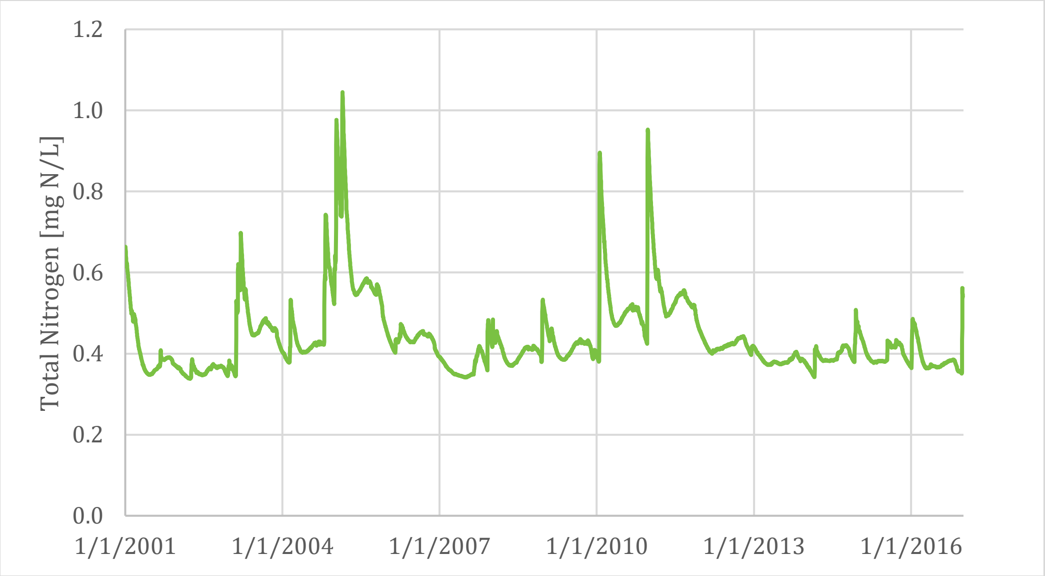

Figure A.7 Simulated depth-integrated total nitrogen.

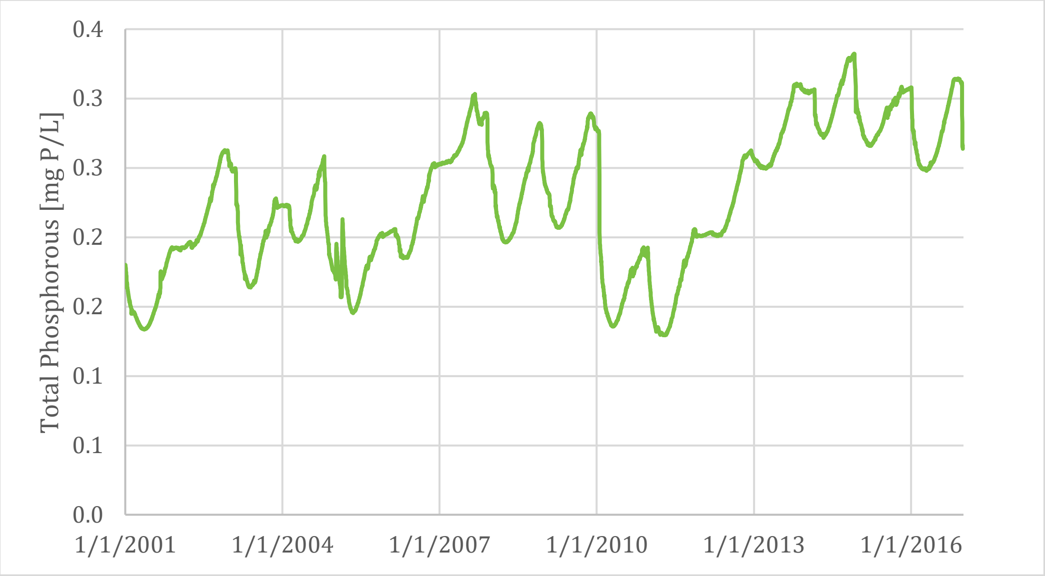

Figure A.8 Simulated depth-integrated total phosphorous.

East Bay

CDF plots of surface chlorophyll A, depth-integrated ammonia and percentage of the water column where DO > 5 mg/L are plotted in Figures A.9 through A.11. These figures represent proposed revised numeric targets for Canyon Lake.

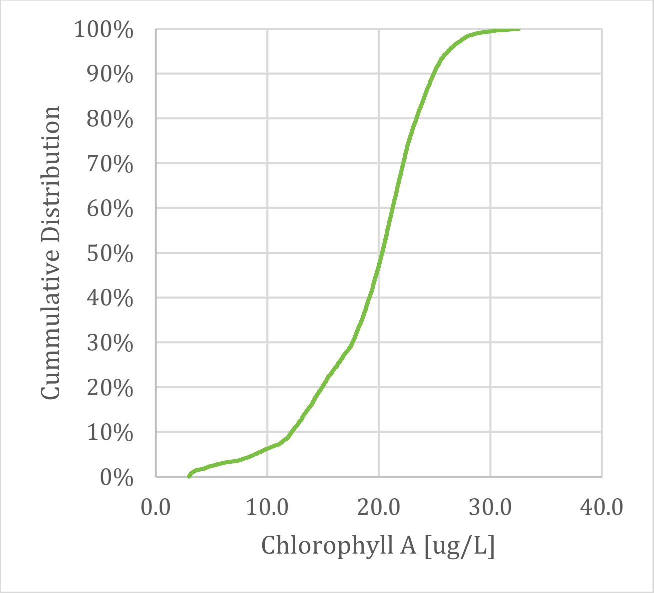

Figure A.9 Cumulative distribution for simulated average surface Chlorophyll A.

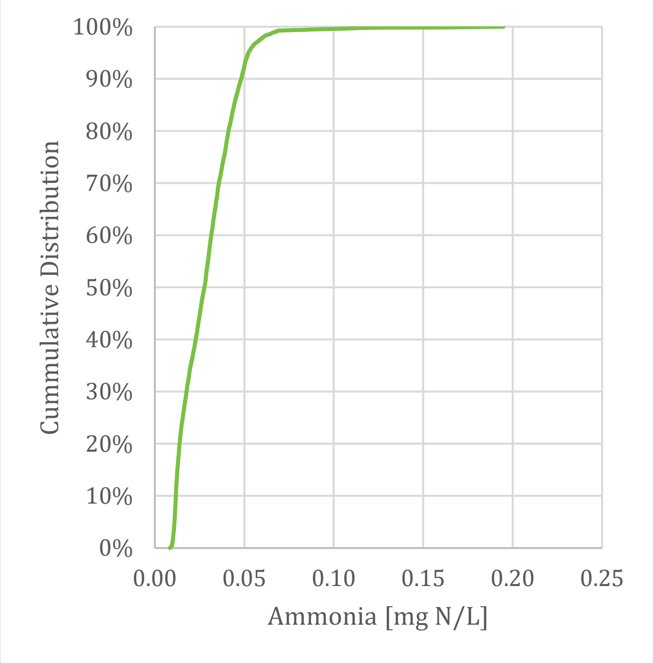

Figure A.10 Cumulative distribution for simulated depth integrated ammonia.

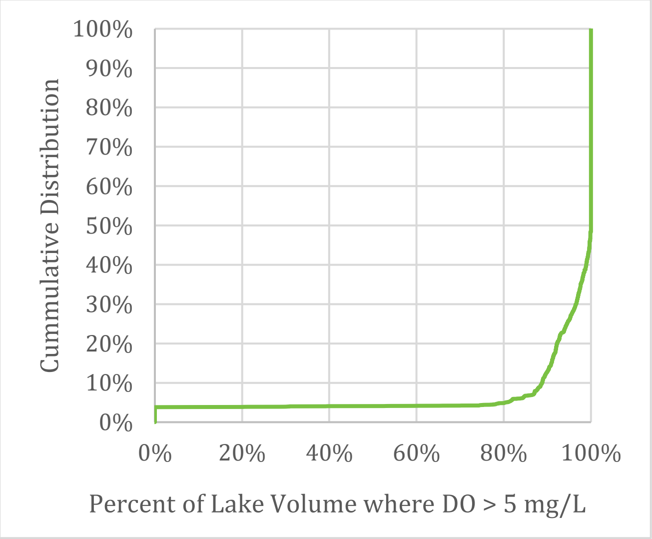

Figure A.11 Cumulative distribution for simulated percentage of the lake volume where DO > 5 mg/L.

The time history of various modeled parameters, including, DO at the surface and at depth, chlorophyl, total phosphorous and total nitrogen are all plotted for the alternate scenario in Figures A.12 through A.16.

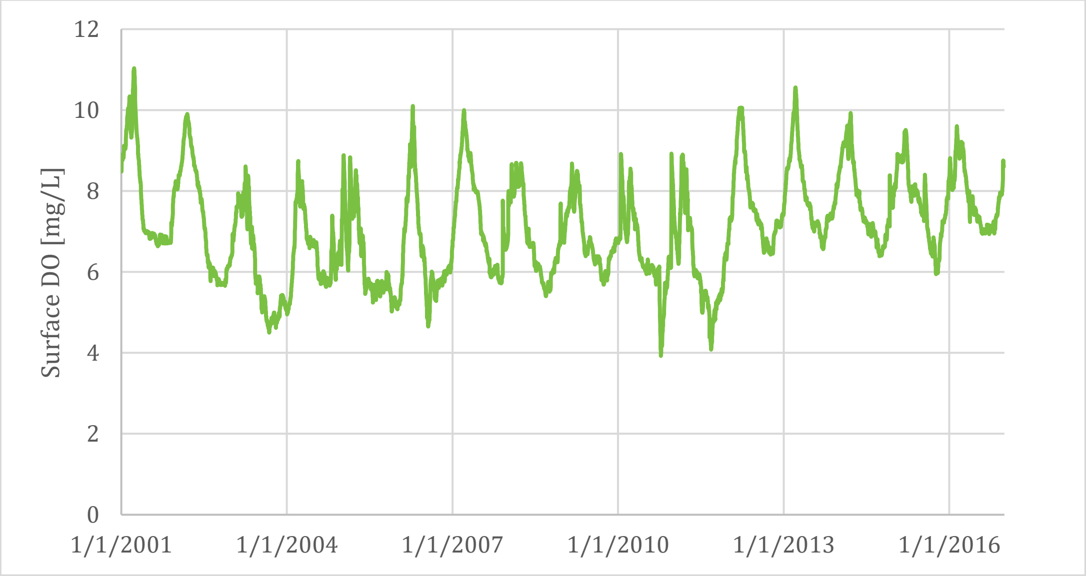

Figure A.12 Simulated average surface DO.

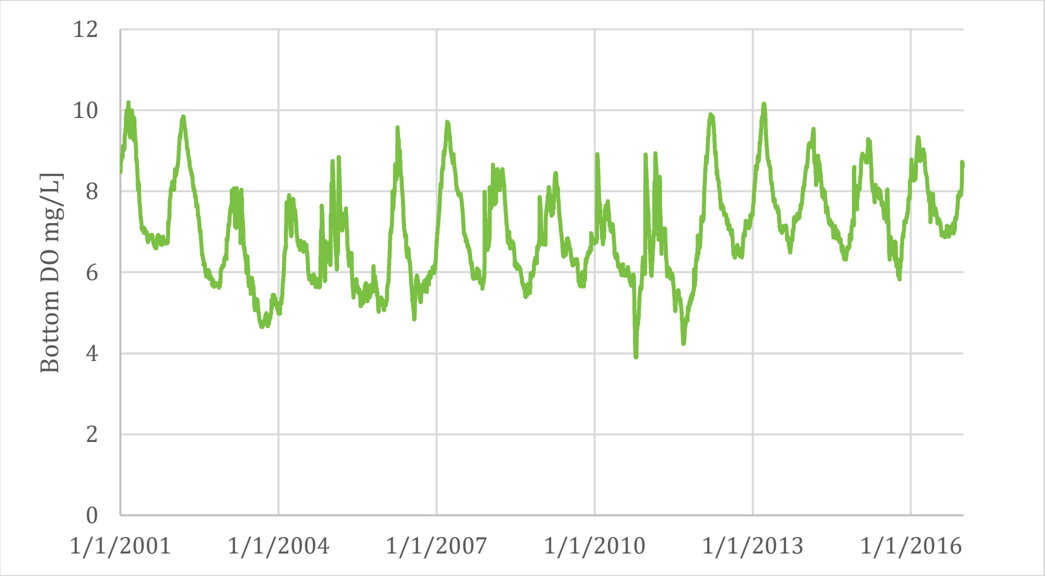

Figure A.13 Simulated average bottom DO.

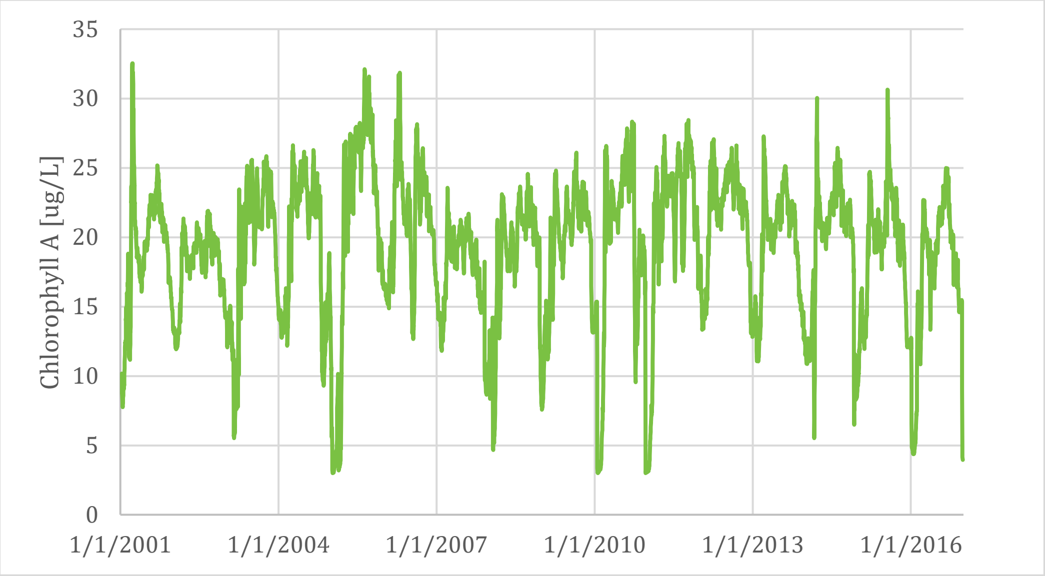

Figure A.14 Simulated average surface chlorophyll A.

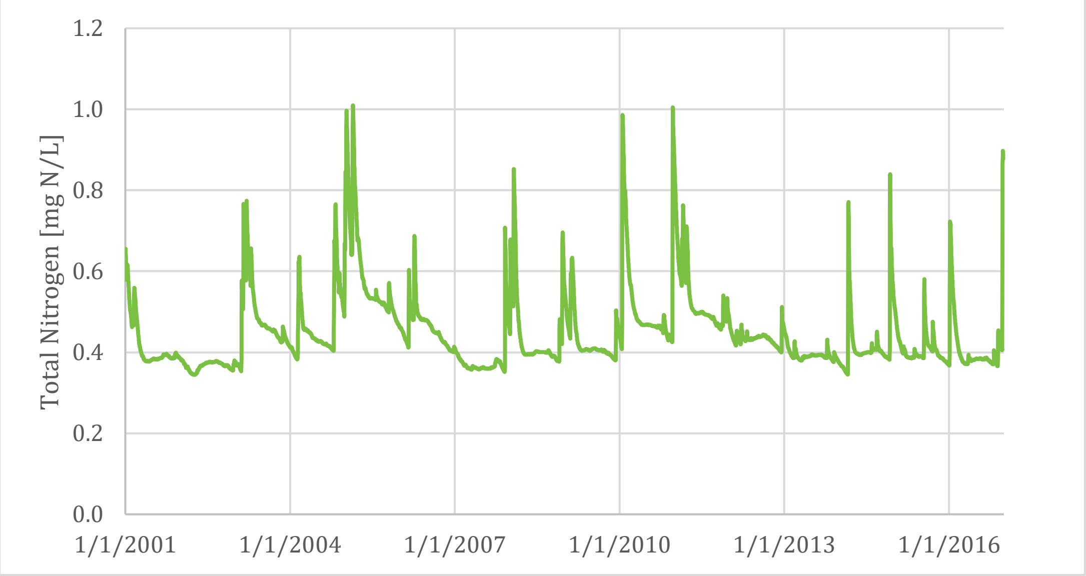

Figure A.15 Simulated depth-integrated total nitrogen.

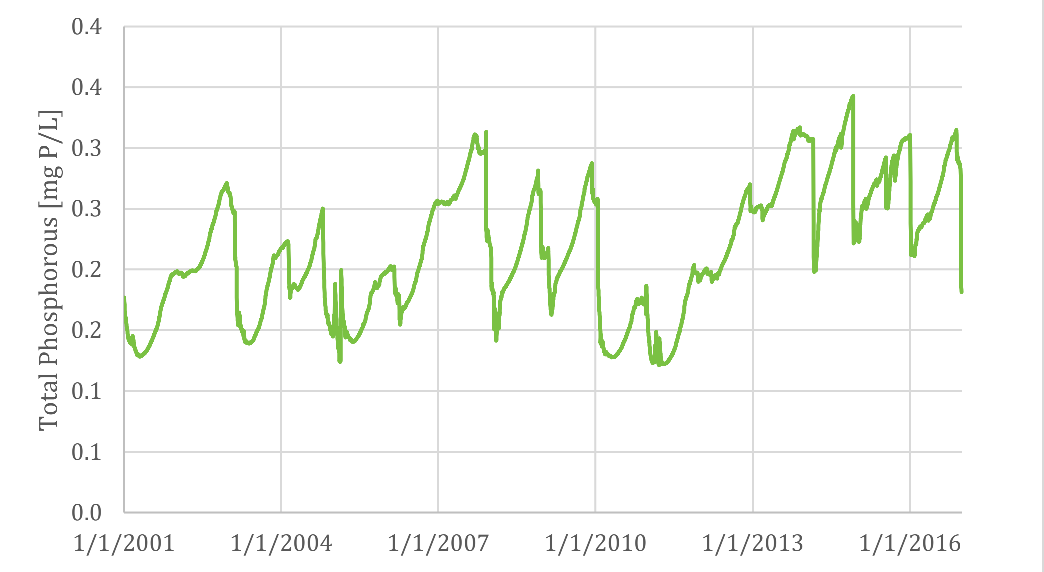

Figure A.16 Simulated depth-integrated total phosphorous.

Attachment B: Final Alternative Reference Scenario Model Results for Lake Elsinore

CDF plots of surface chlorophyll A, depth-integrated ammonia and percentage of the water column where DO > 5 mg/L are plots in Figures B.1 through B.3. These figures represent proposed revised numeric targets for Lake Elsinore.

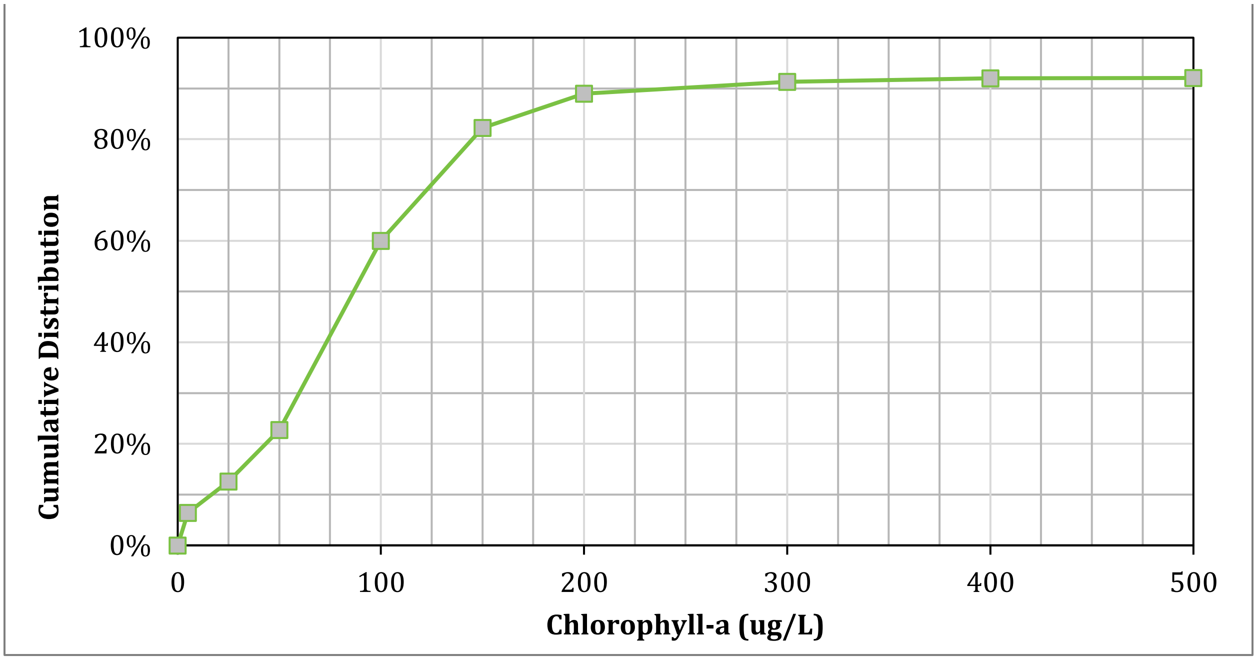

Figure B.1. Alternate reference scenario chlorophyl A concentration CDF.

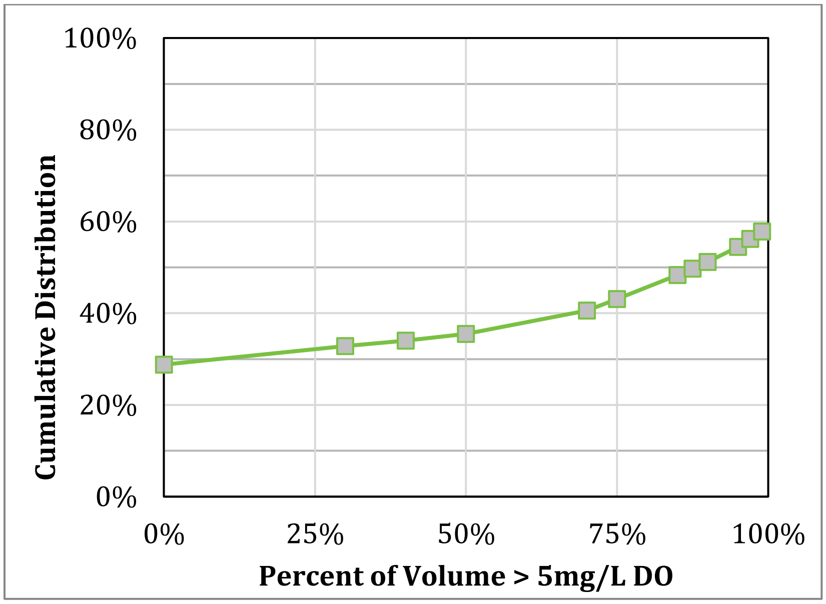

Figure B.2. Alternate reference scenario percentage of the lake volume where DO > 5mg/L CDF.

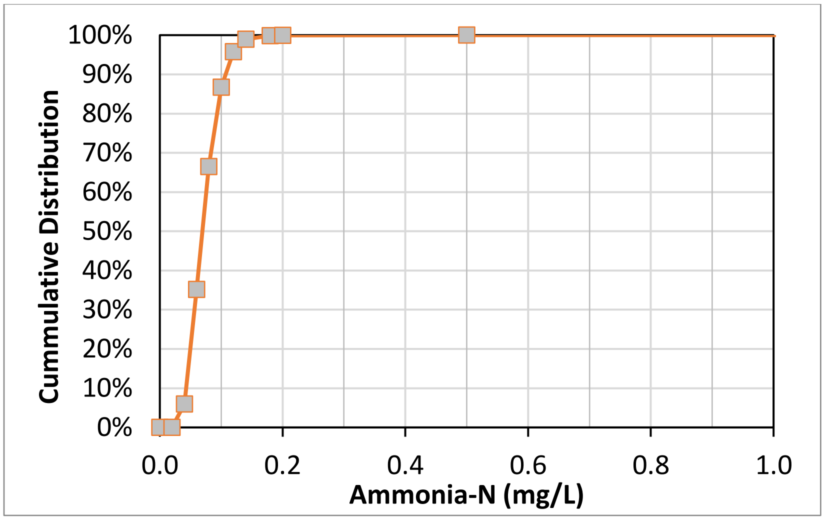

Figure B.3. Alternate reference scenario ammonia concentration CDF.

The time history of various modeled parameters, including water level, temperature, TDS, DO at the surface and at depth, chlorophyl, total phosphorous and total nitrogen are all plotted for the alternate scenario in Figures B.4 through B.11.

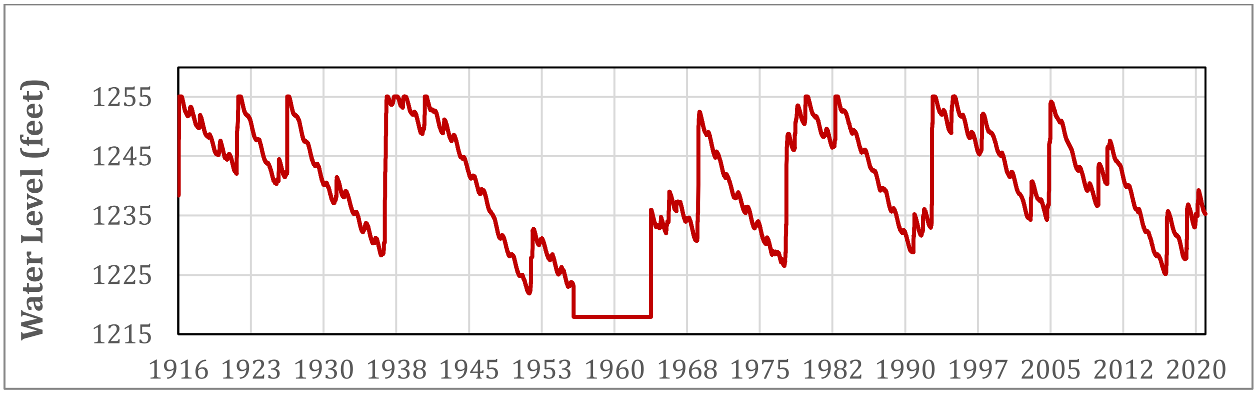

Figure B.4. Simulated water level in alternate reference scenario.

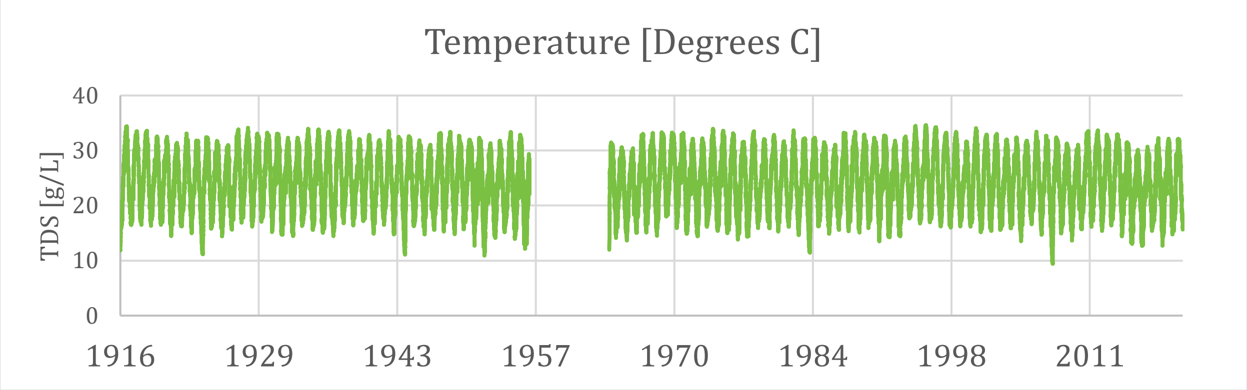

Figure B.5. Simulated temperature in alternate reference scenario.

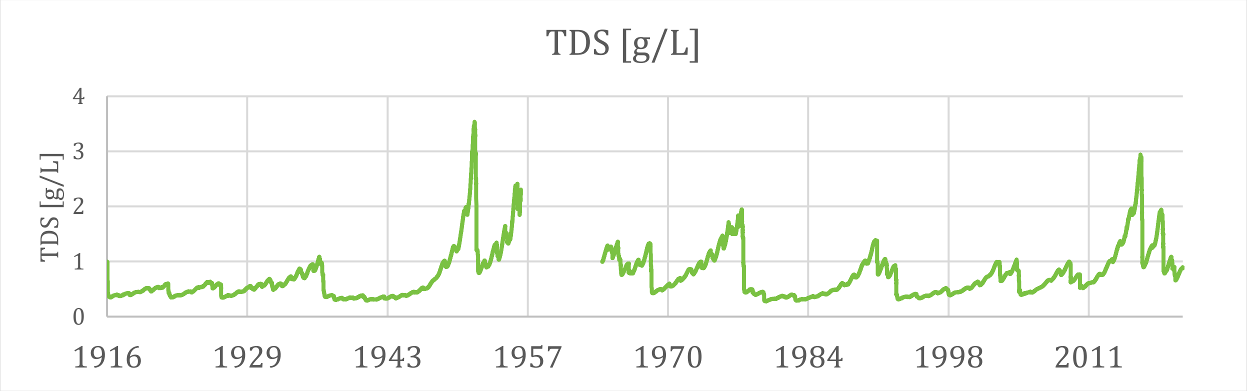

Figure B.6. Simulated TDS in alternate reference scenario.

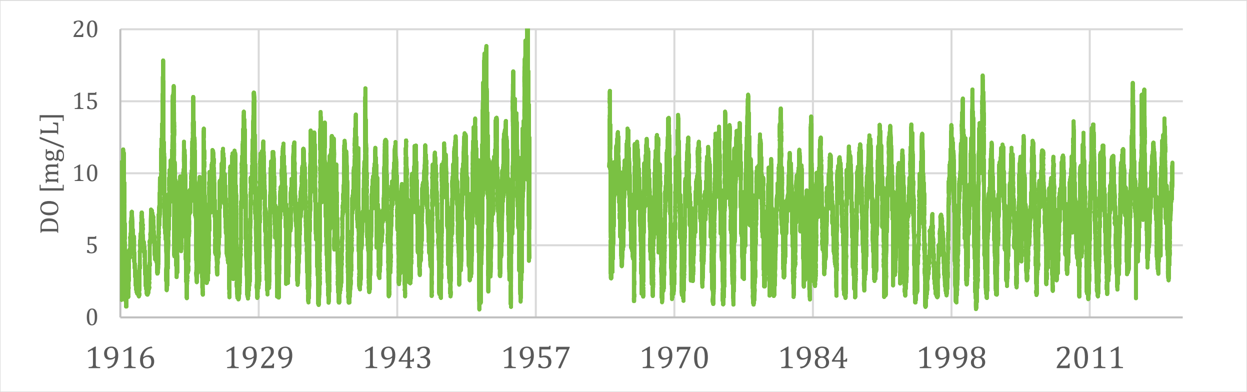

Figure B.7. Simulated DO at 2 meters depth in alternate reference scenario.

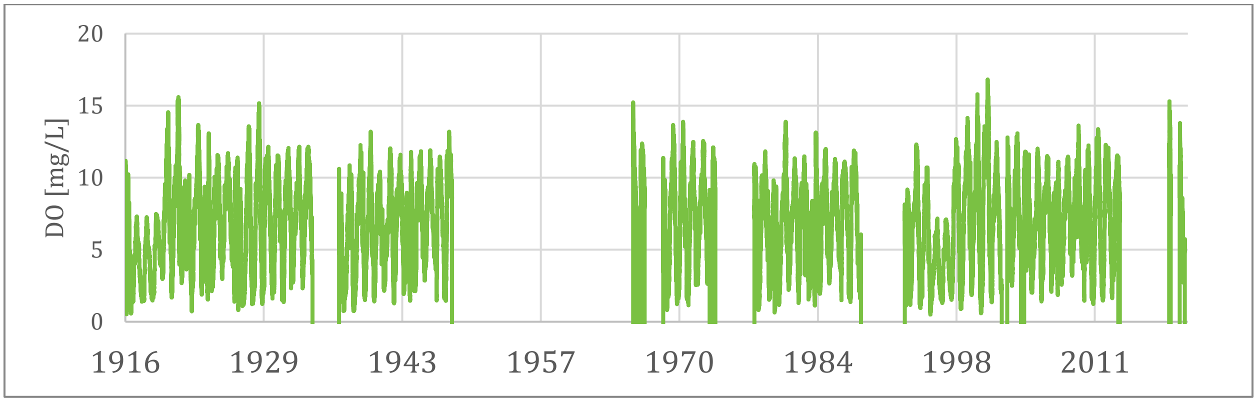

Figure B.8. Simulated DO at 6 meters depth in alternate reference scenario.

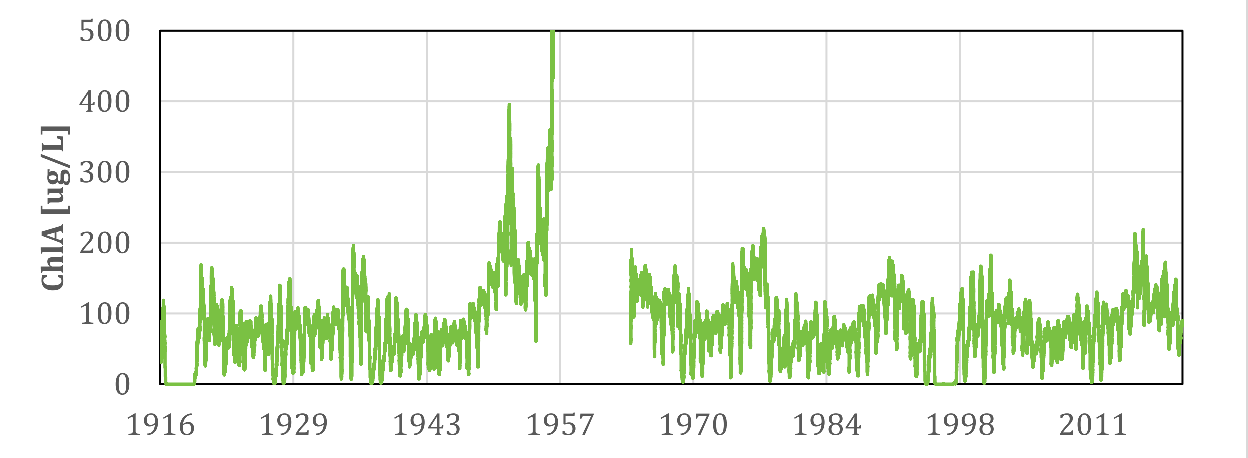

Figure B.9. Simulated surface chlorophyl A in alternate reference scenario.

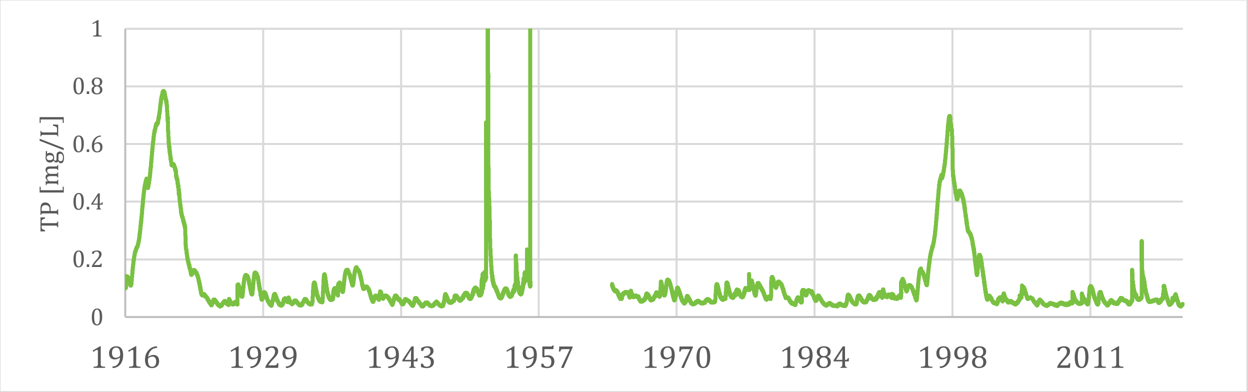

Figure B.10. Simulated surface total phosphorous in alternate reference scenario.

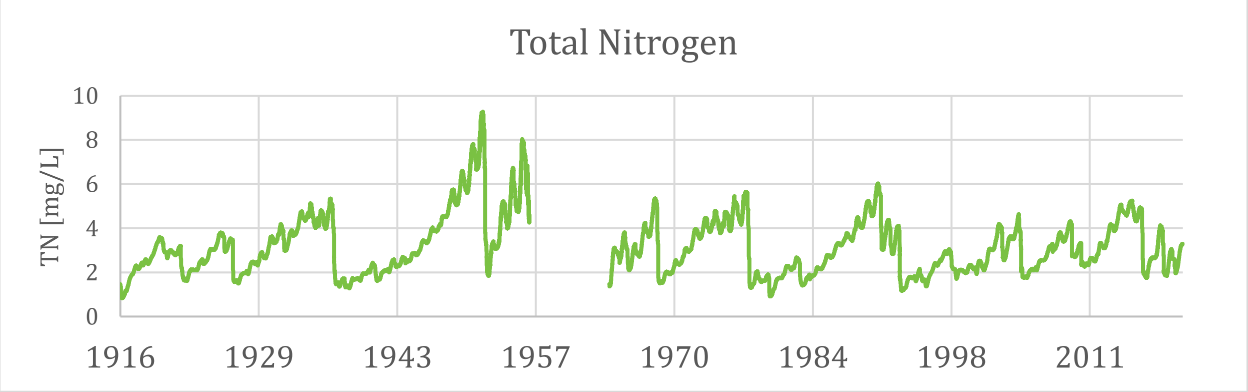

Figure B.11. Simulated surface total nitrogen in alternate reference scenario.