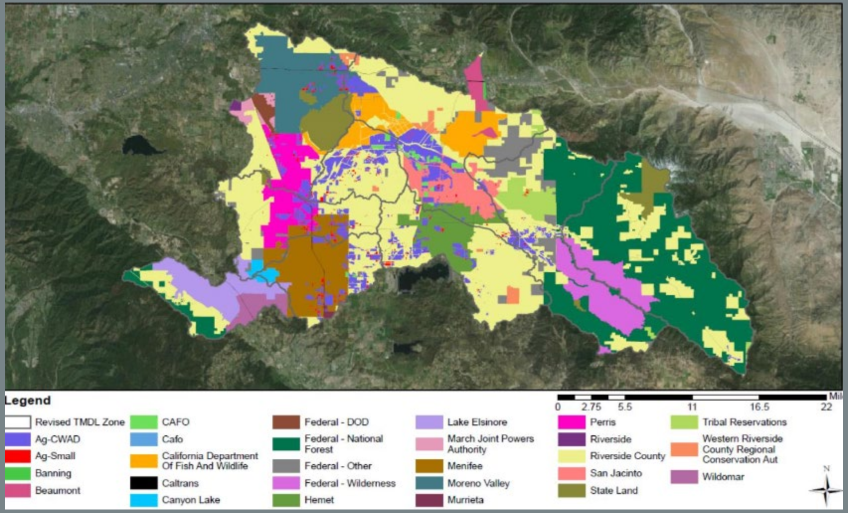
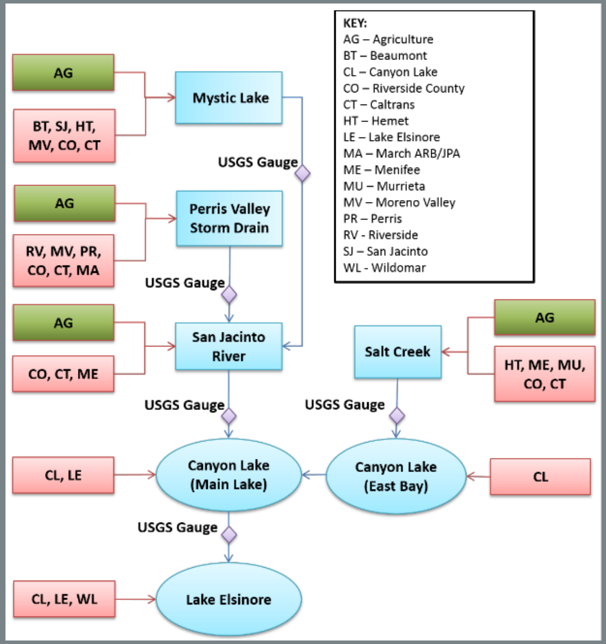
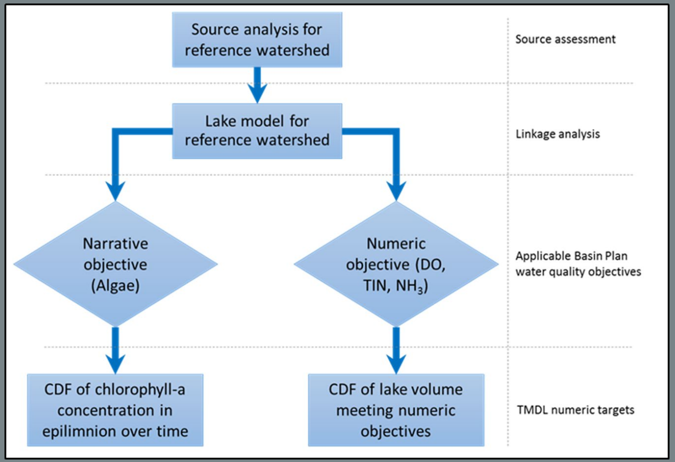
LECL TMDL Task Force Update to TMDL Revision

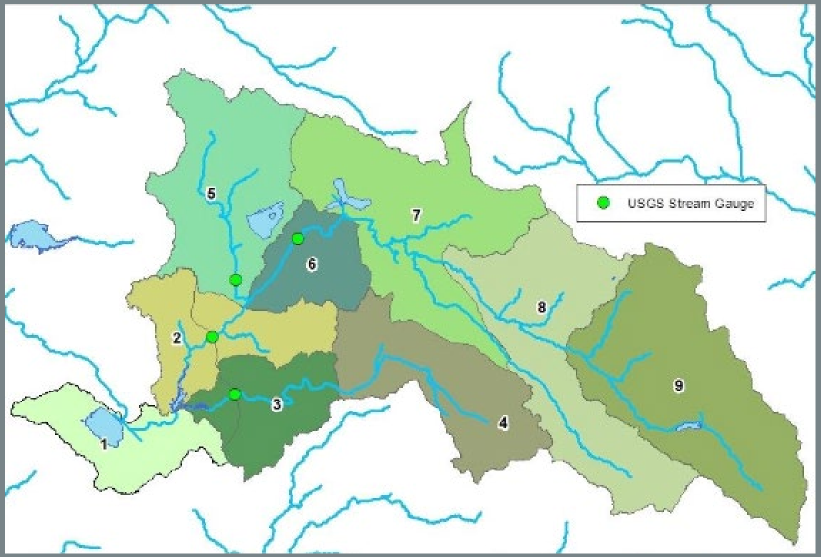


Presentation by Steve Wolosoff, GEI
and Paula Kulis, CDM Smith

April 25, 2023







Agenda

- Linkage Analysis within Reference Watershed Approach
- Lake Water Quality Models
- Numeric Target Derivation

Reference Watershed Approach

- Begin with allowable load
- Calibrated lake water models with current load and in-lake response
- Simulate lake water quality for a reference watershed condition scenario
- Convert time series results for historical hydrology into CDFs or reference curves

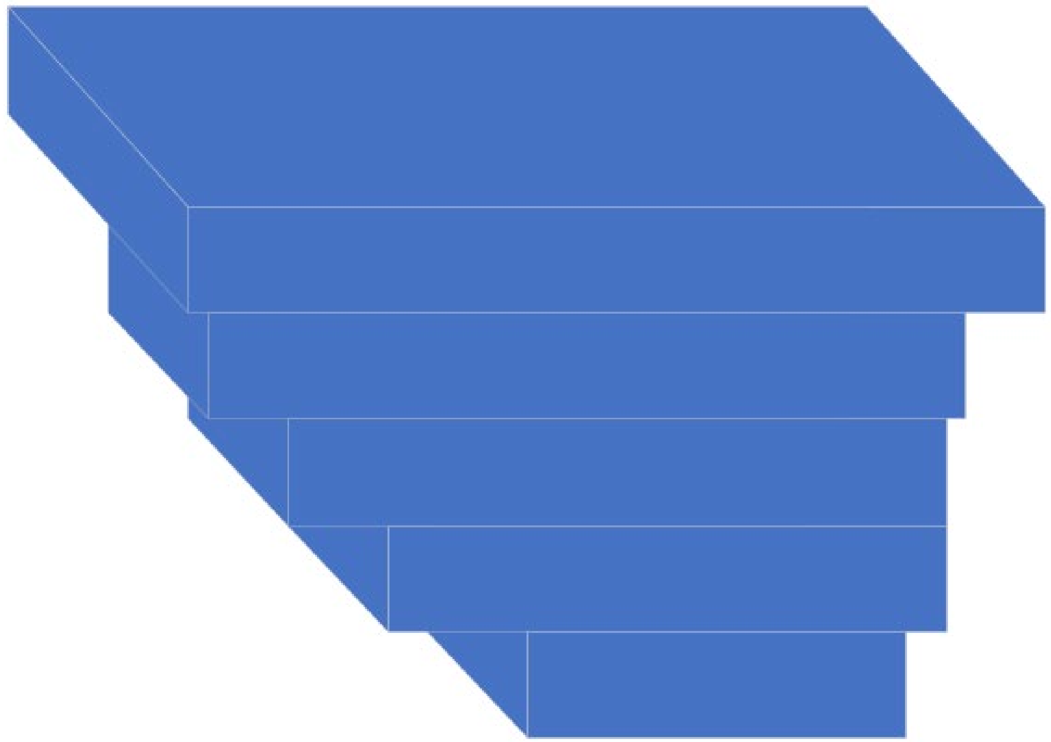
Water Quality Models

GLM for Lake Elsinore

- Description
- Key parameters
- Calibration results
- Reference scenario results
  - Nutrients, DO
  - Sediment flux
- Comparison
  - Calibration
  - Interim
  - Final

GLM for Lake Elsinore: Description

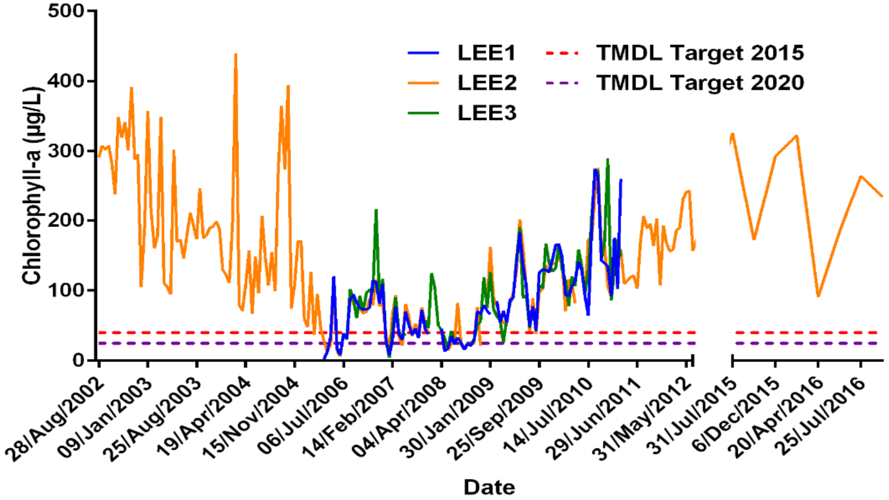
- 1D (modeling changes with depth)
- Water Balance
- Temperature
- Water Quality Model: AED2
    - Nutrients
    - Chlorophyll
    - DO
    - Sediment exchange

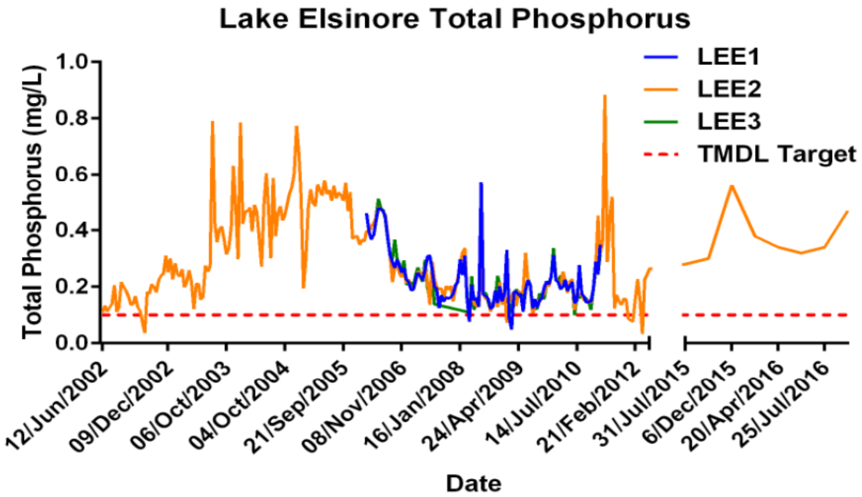


GLM for Lake Elsinore: Approach

- Model: horizontally averaged
- Observations: variability in-lake
  - Spatial within the lake
  - Temporal within a season

WQ Observations vary site to site and within a season by ~ 30-100%

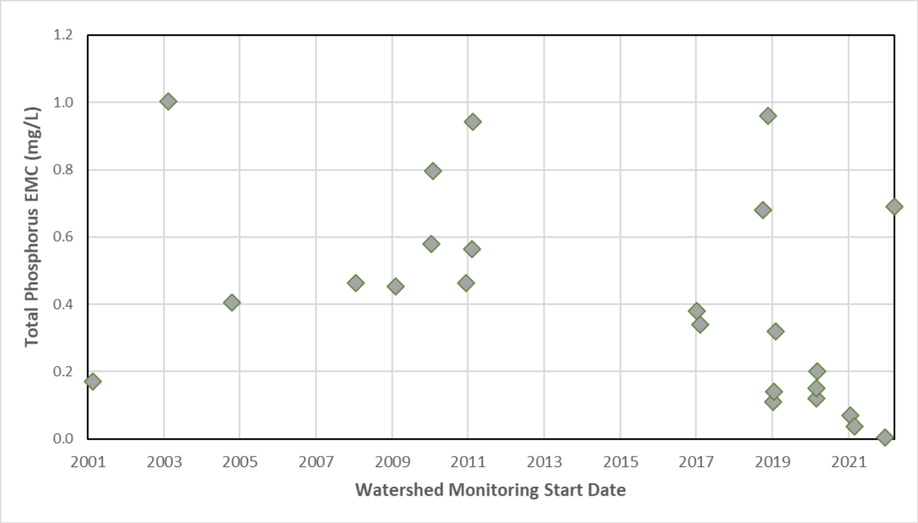


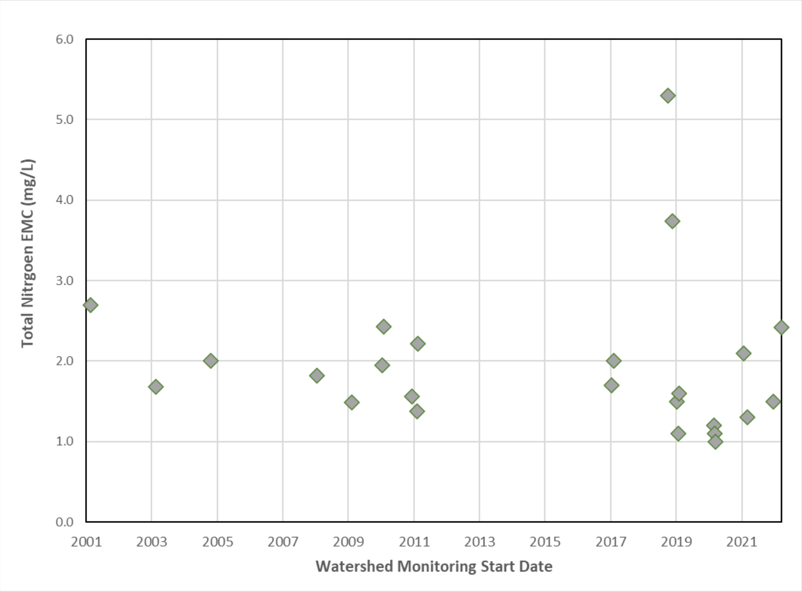


GLM for Lake Elsinore: Approach

- Model: inflow concentrations are constant
  - Smooths out sharp swings in time
- Observations: temporal variability

TP and TN EMCs vary over time





GLM for Lake Elsinore: Calibration Approach

- 1D (modeling changes with depth)
  - Model results are **averages** over the entire model at a given depth
- Assumptions → Model input concentrations are constant
  - Impossible to capture sharp swings
- Long-term reference simulation (100+ years) and calibration period (20 years)

Goals:

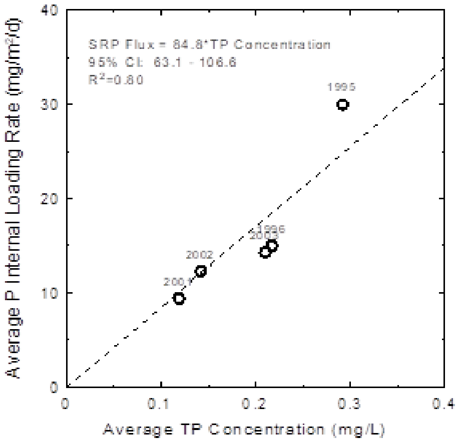
- capture long-term trends
- model-data comparisons matching on a similar level to **data variability**

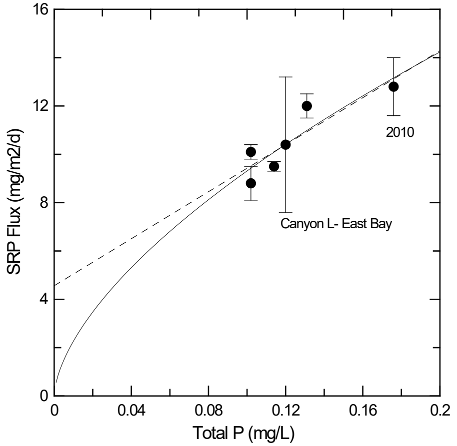
GLM for Lake Elsinore: Model Simulations

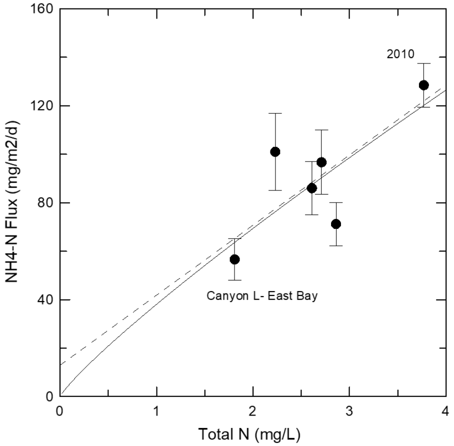
Parameter	Existing Conditions	2018 Reference Conditions (interim)	Reference Conditions
Description	Present-day lake characteristics	50^{th} percentile loadings	25^{th} percentile loadings with levee
Hypsography	With levee	Without levee	With levee
Inflow Total Phosphorous (mg/L) in Runoff	0.39	0.32	0.16
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		

Model-data comparisons

Reference Sediment Flux Estimates

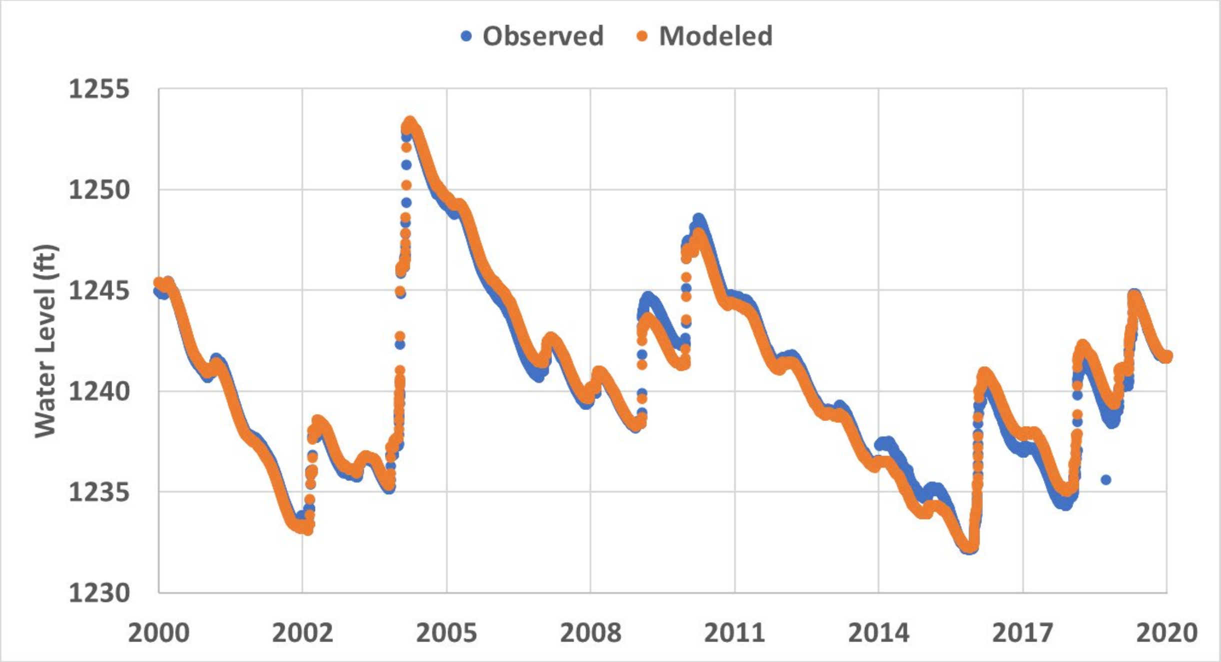


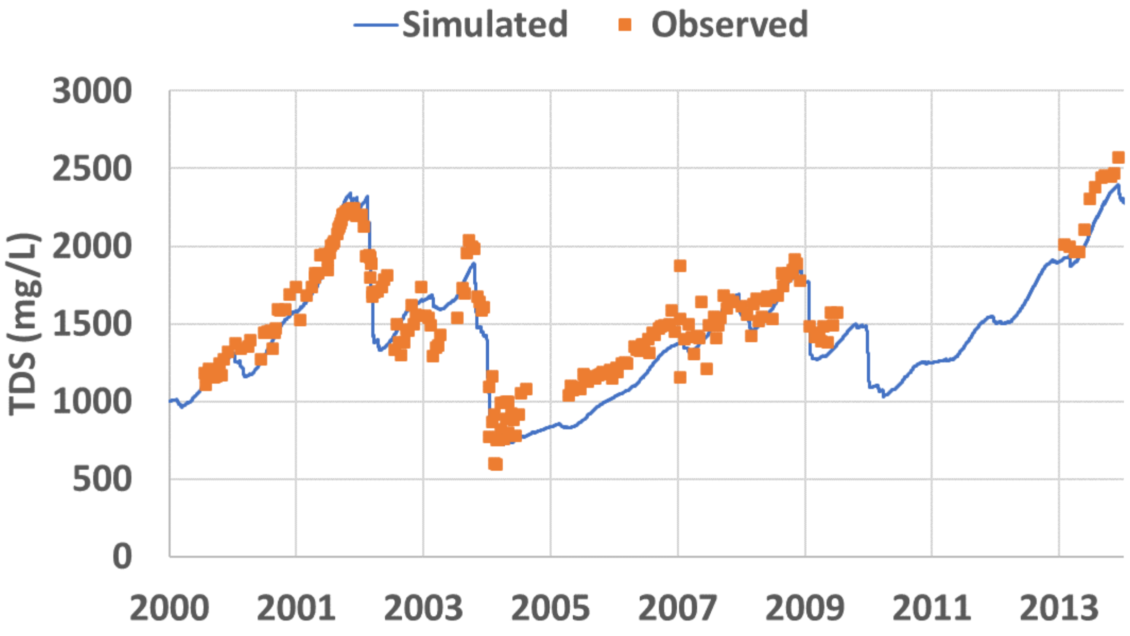




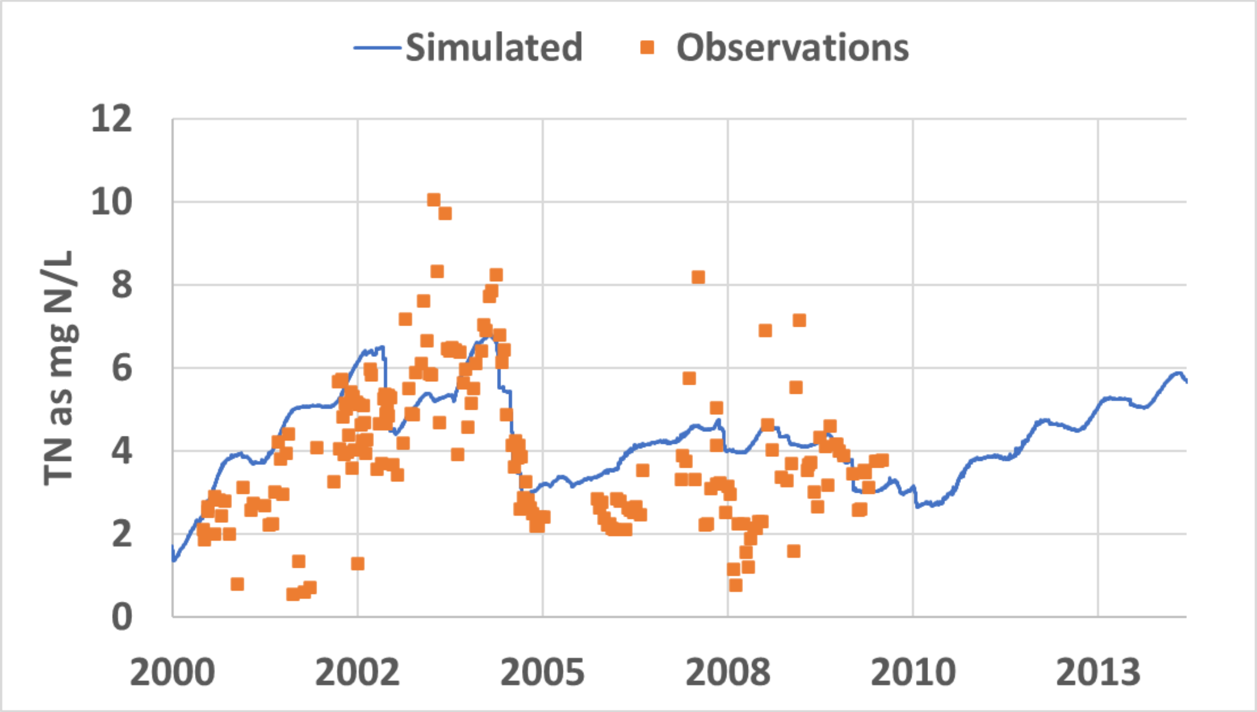
Parameter	Lake Elsinore		Canyon Lake	
	Phosphorus	Nitrogen	Phosphorus	Nitrogen
Existing Conditions	9.0	75.0	15.5	44.0
Median Values	5.4	37.0	7.8	22.0
Reference Scenario (25th percentile)	3.7	31.1	4.3	13.1

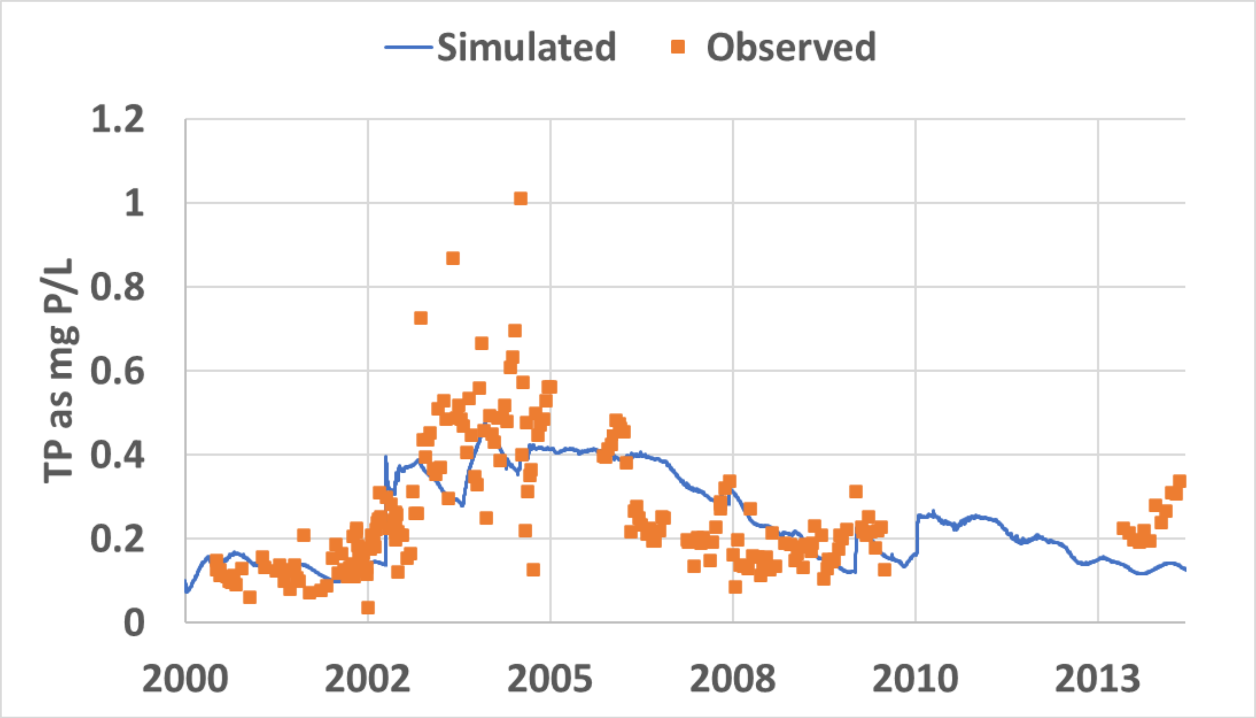
GLM for Lake Elsinore: Existing Conditions Physical Model





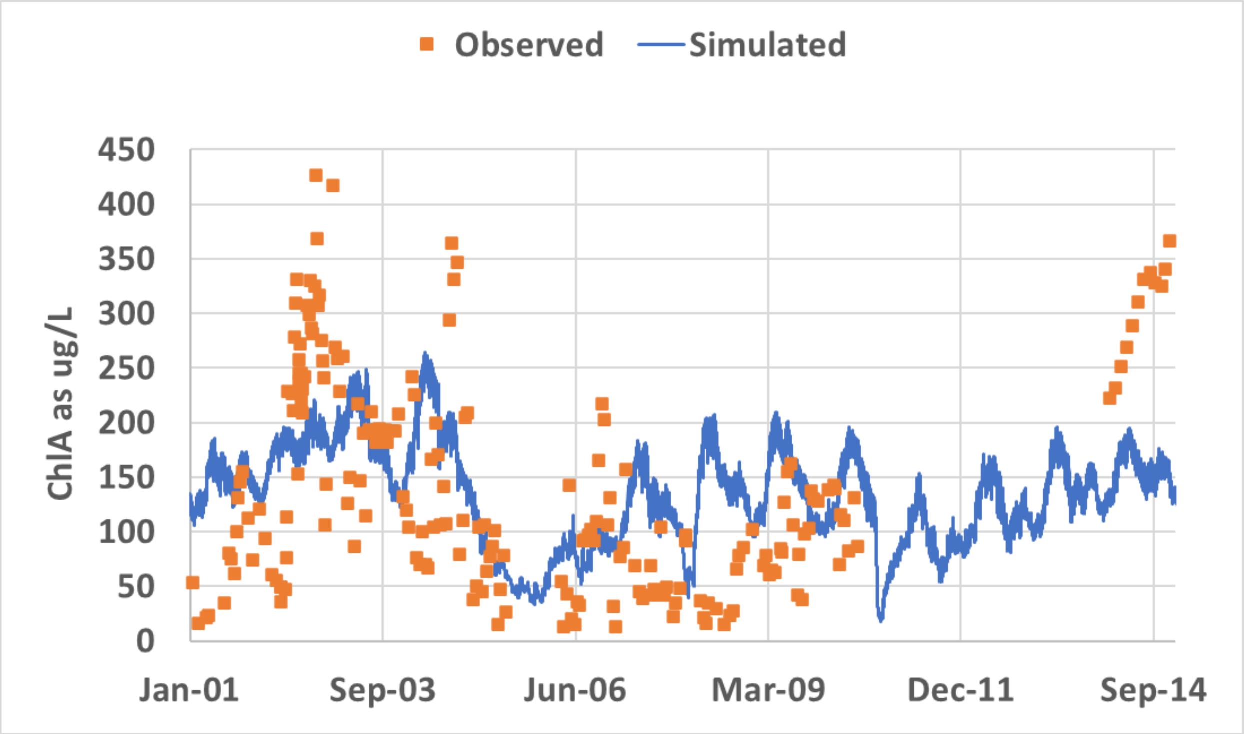
GLM for Lake Elsinore: Existing Conditions Nutrients

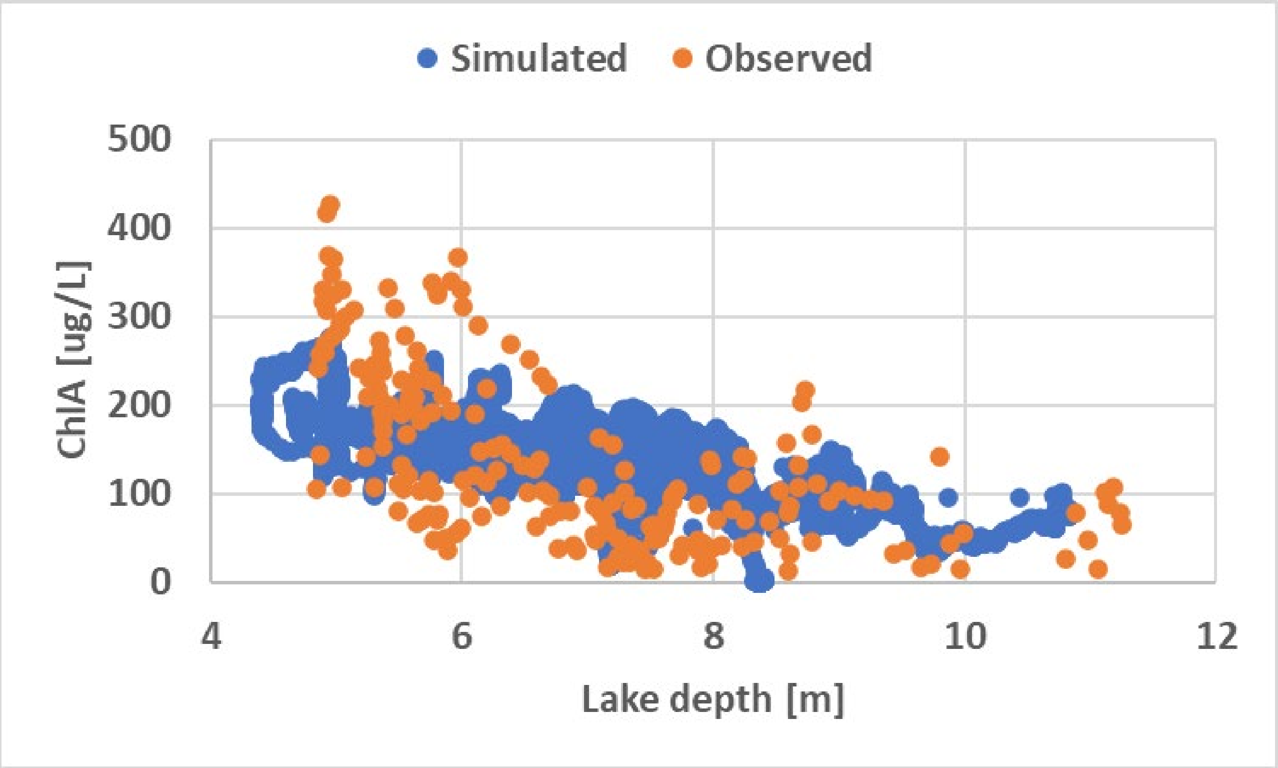




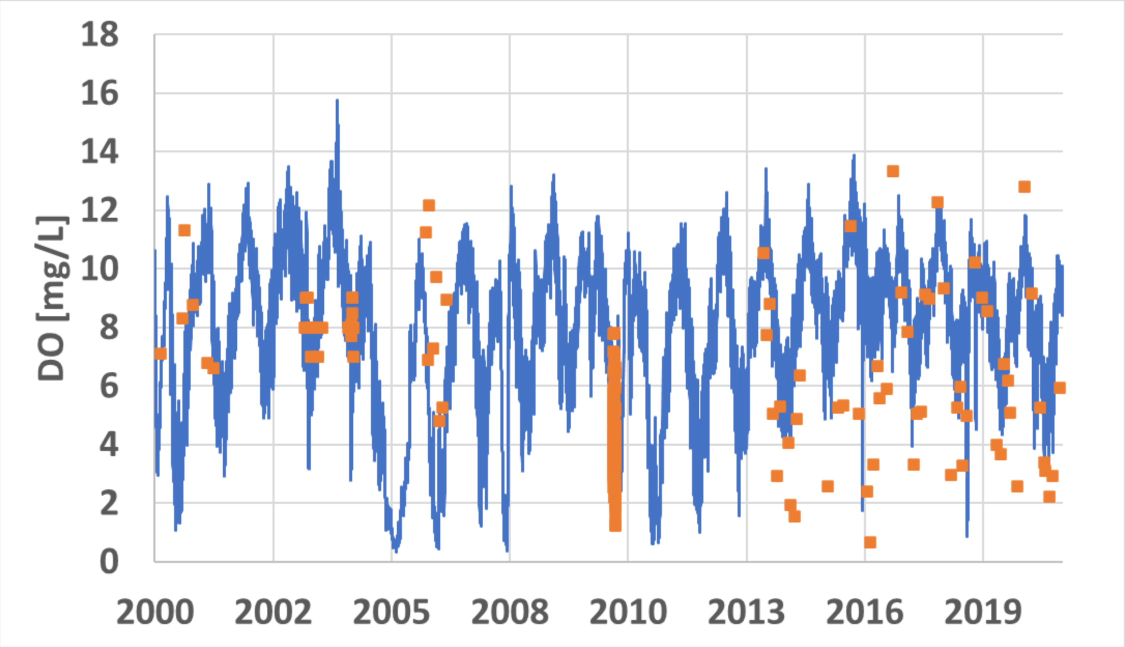
GLM for Lake Elsinore: Existing Conditions

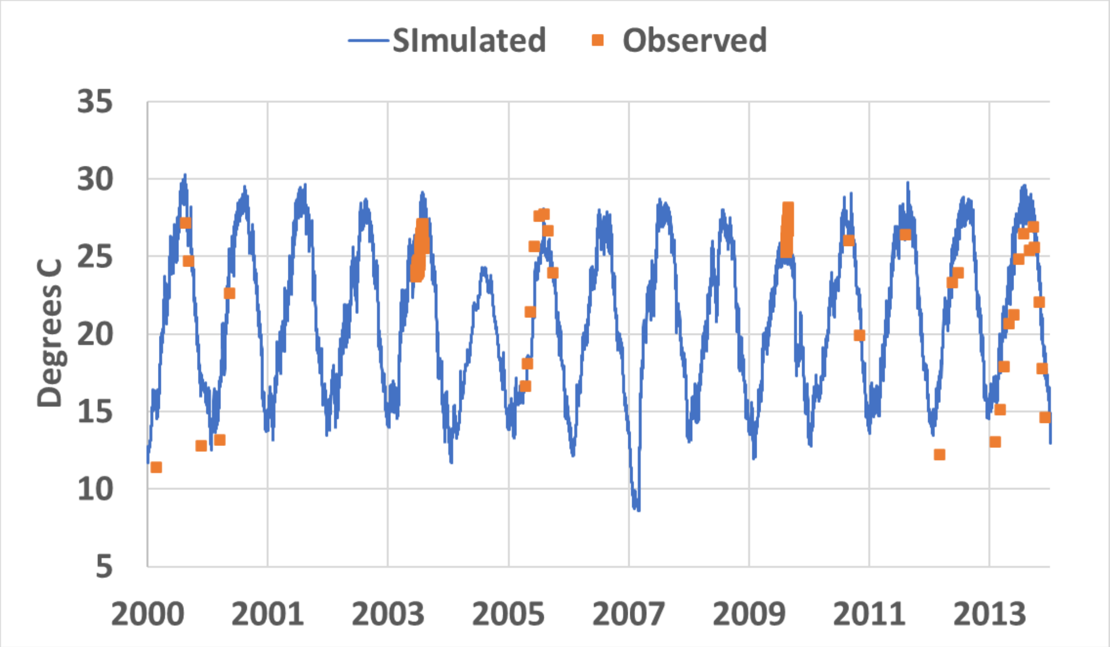
Surface Chlorophyll





GLM for Lake Elsinore: Existing Conditions
DO and Temperature





GLM for Lake Elsinore: Existing Conditions Summary Stats

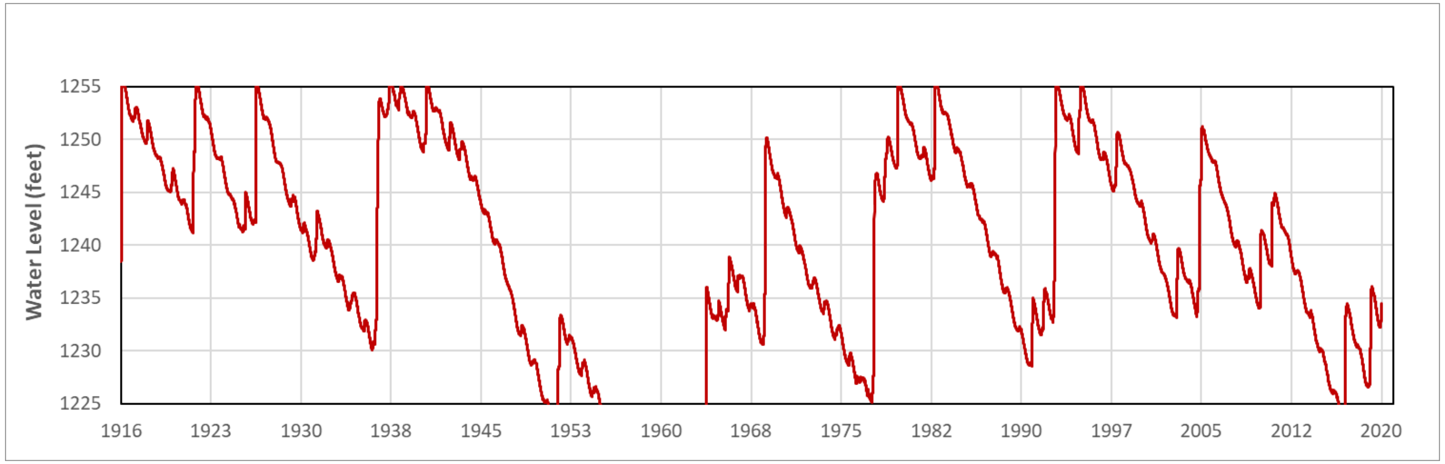
Parameter	Observed	Predicted	% Relative Error	N	RMSE	Standard Deviation of Observations
Lake Elevation (ft NAVD88)	1241.5	1241.3	2.6%	2,555	0.53	4.43
Temperature (deg C)	24.4	25.0	6.1%	63	2.30	2.42
TDS (mg/L)	1509	1498	12.3%	145	201	401
DO (mg/L)	8.1	7.1	22.8%	56	2.66	1.16
TN (mg/L)	4.2	4.9	32.7%	137	1.21	1.75
TP (mg/L)	0.30	0.27	29.5%	148	0.11	0.16
ChlA (ug/L)	155	156	50.7%	145	88	98

*Note: For TP, TN and ChlA statistics are calculated using a seasonal average approach for observations

GLM for Lake Elsinore: Reference Scenario

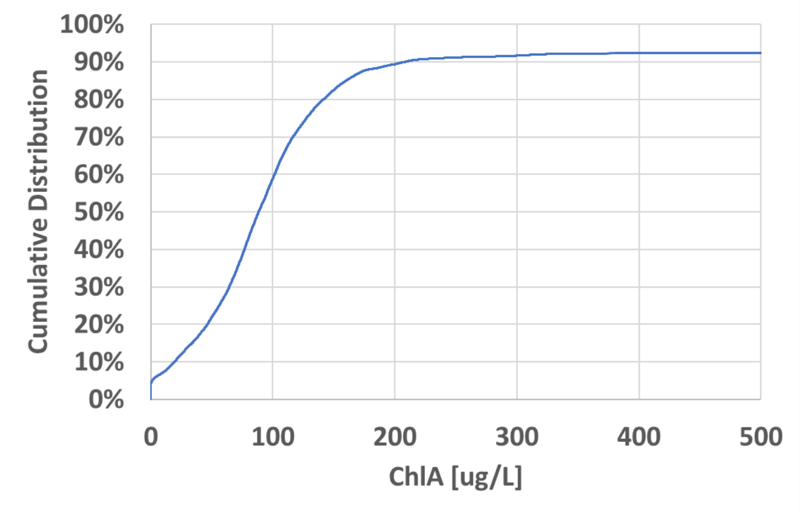
Hydrology

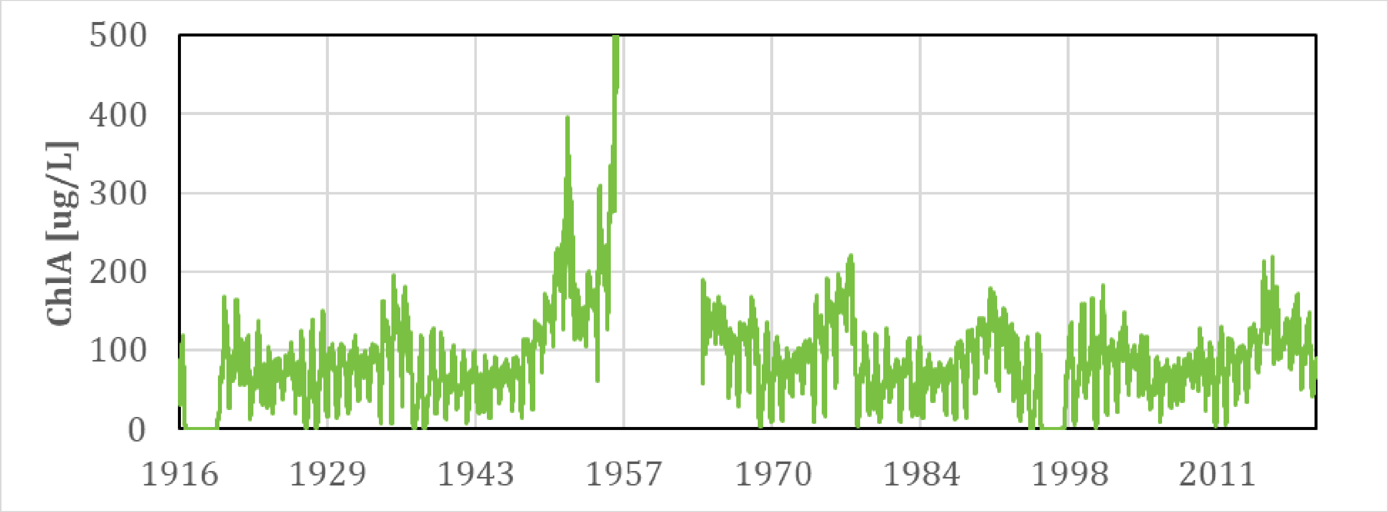
- 1916-2020
- 105 years
- Includes dry period

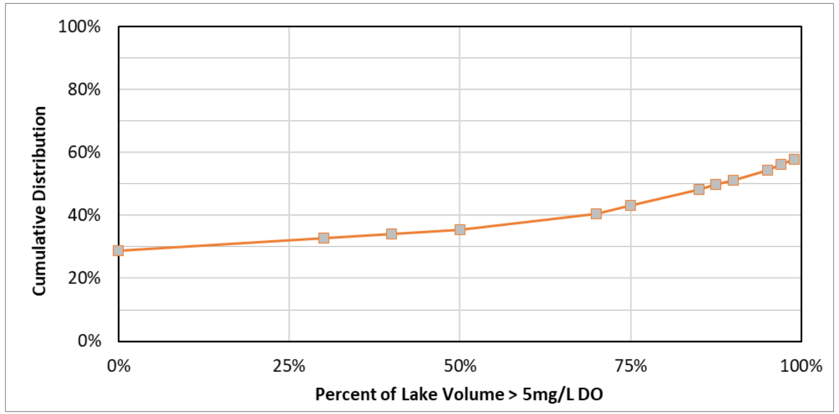


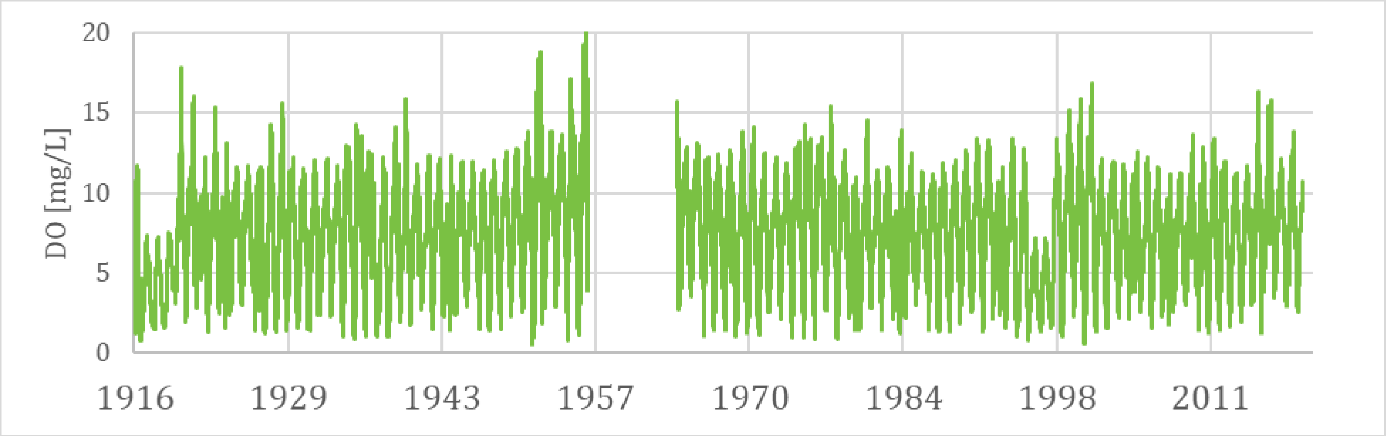
GLM for Lake Elsinore: Reference Scenario

Simulated Chlorophyll and DO

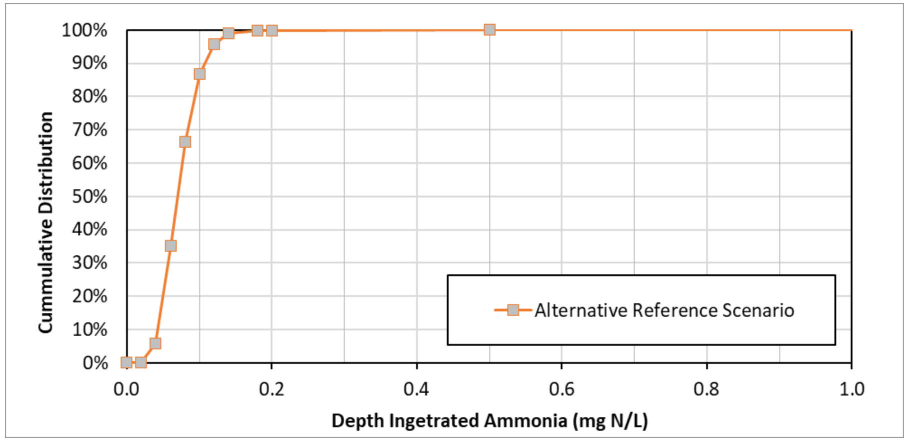


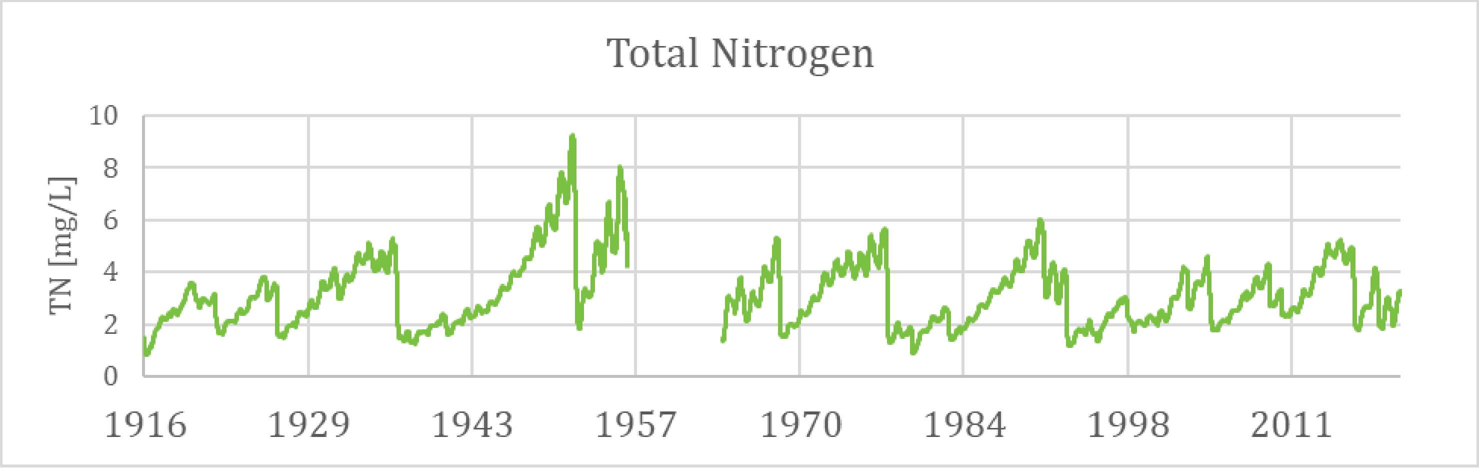






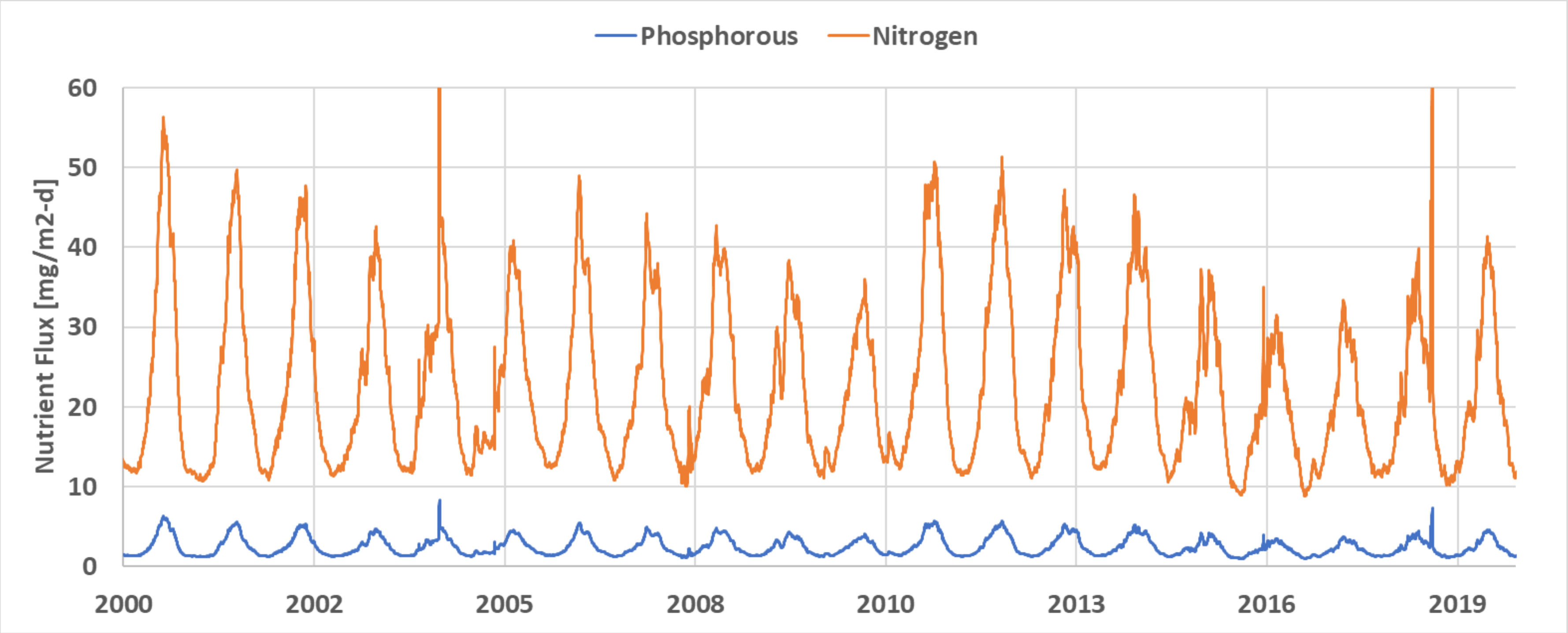
GLM for Lake Elsinore: Reference Scenario Simulated TP and TN





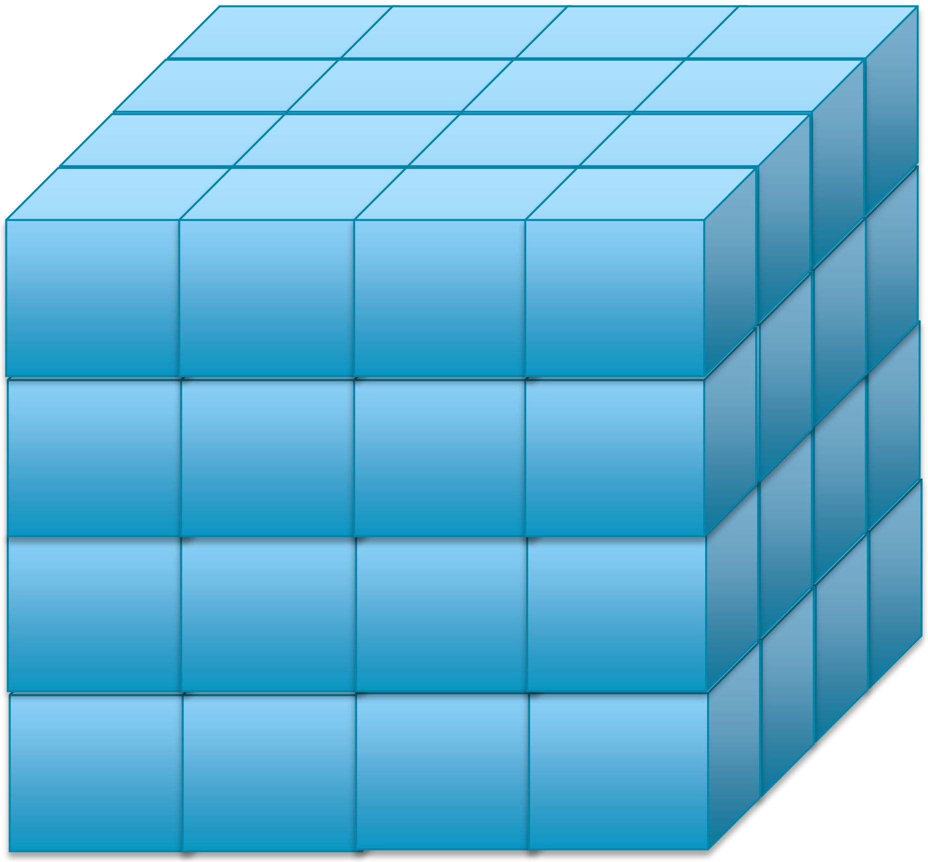
GLM for Lake Elsinore: Reference Modeled Sediment Flux

- Fluxes based on observations
- Adjusted for:
  - Temperature
  - Dissolved Oxygen



AEM3D for Canyon Lake

- 3D
- Water Balance
- Temperature
- Internal Water Quality Model
  - Nutrients
  - Chlorophyll
  - DO
  - Sediment exchange

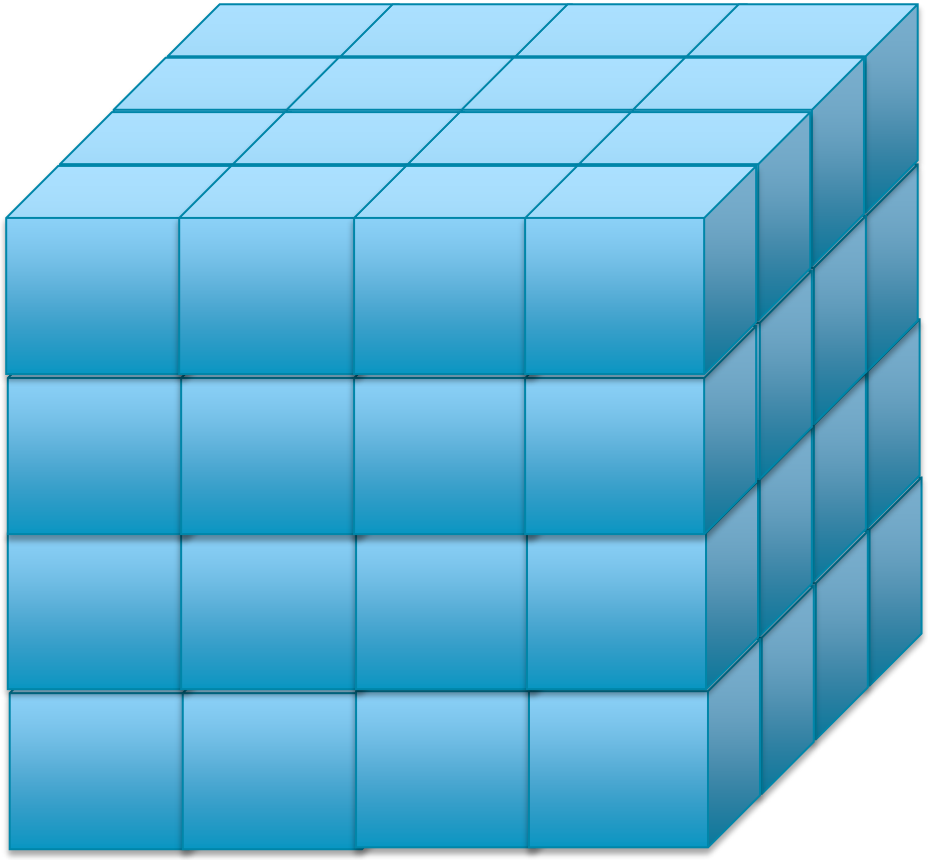


AEM3D for Canyon Lake: Approach

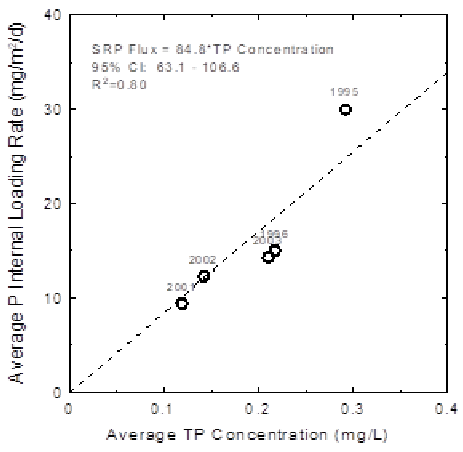
- Data variability lower than Lake Elsinore
- Calibration time period shorter than Lake Elsinore
- Spatially highly resolved

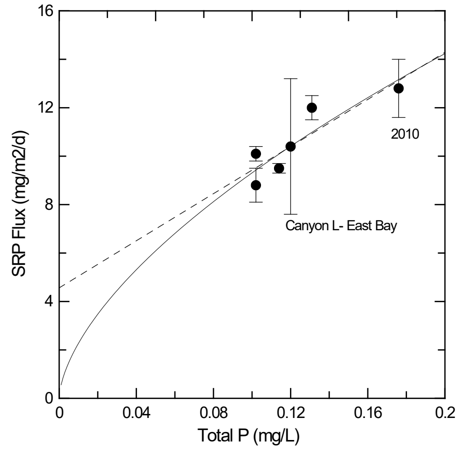
Calibration goals:

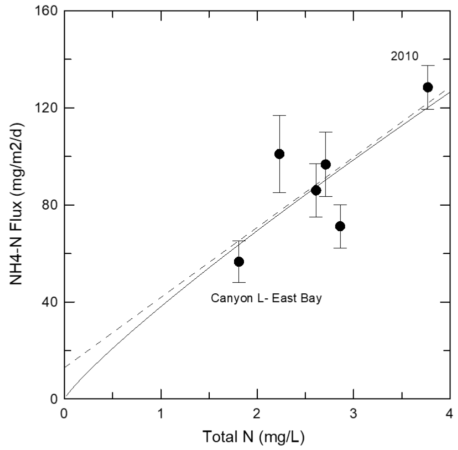
- Capture long term trends
- Seasonal trends



Reference Sediment Flux Estimates







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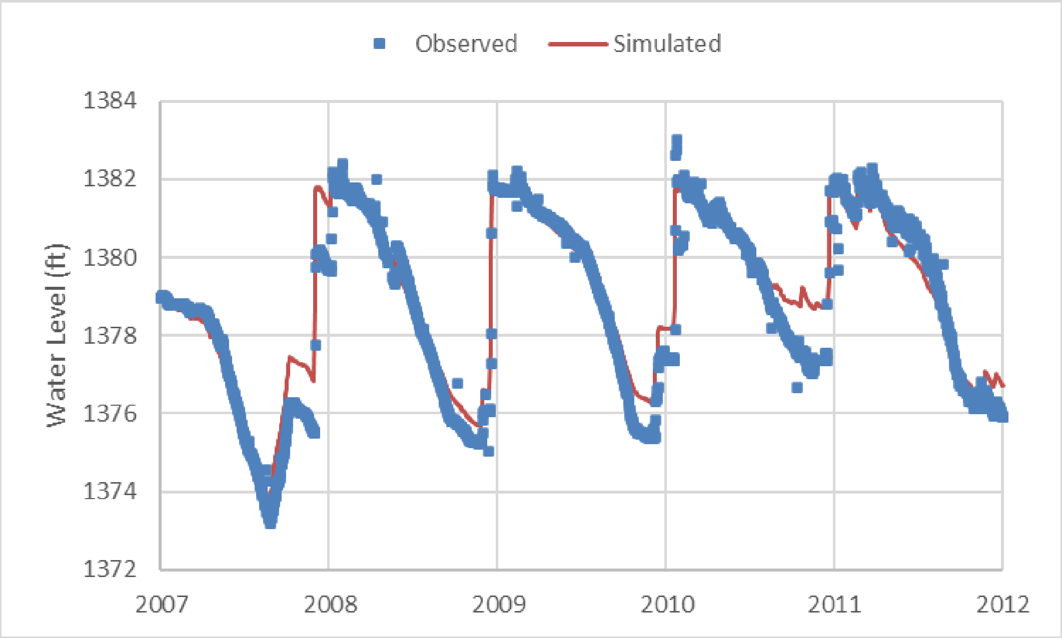
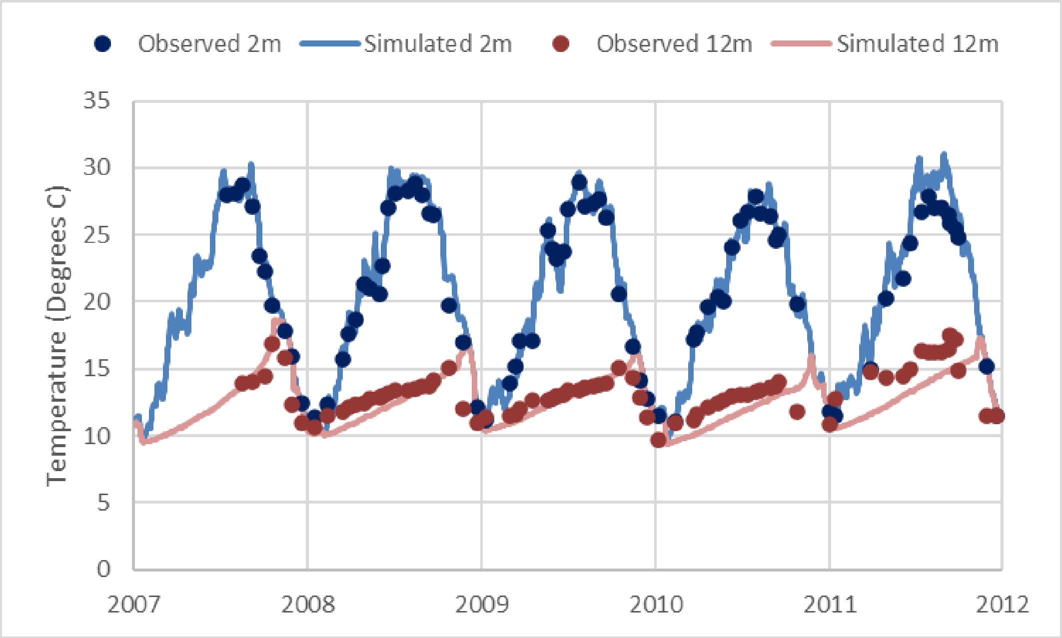
AEM3D for Canyon Lake: Main Lake Results

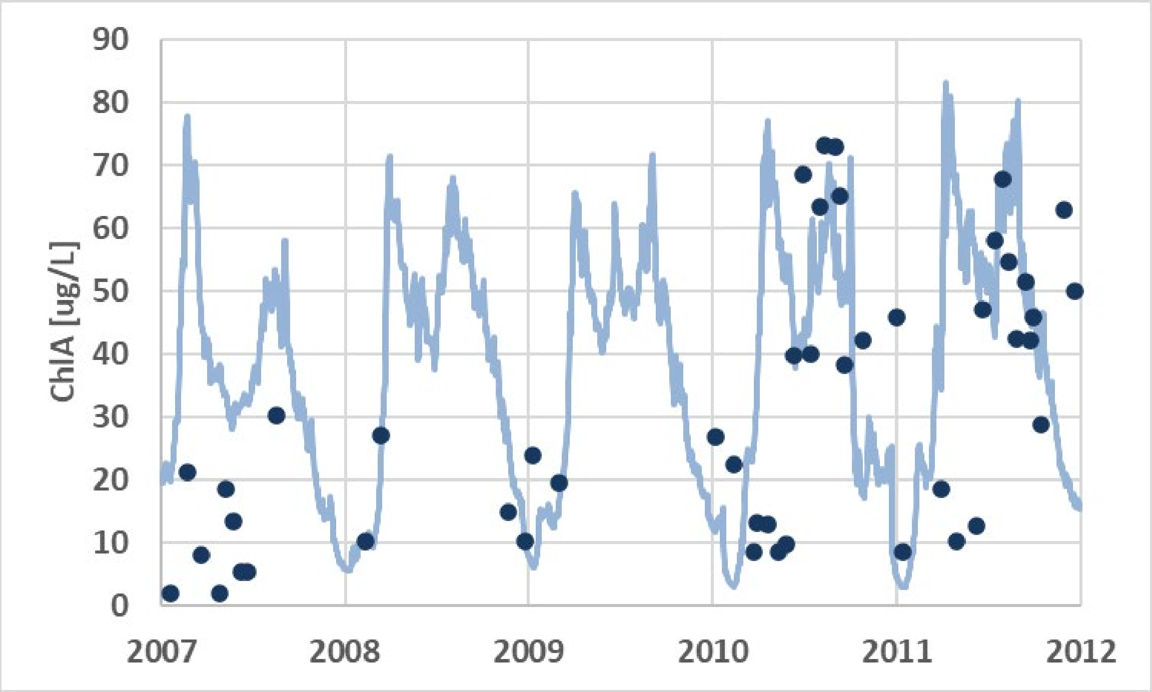
Existing Conditions

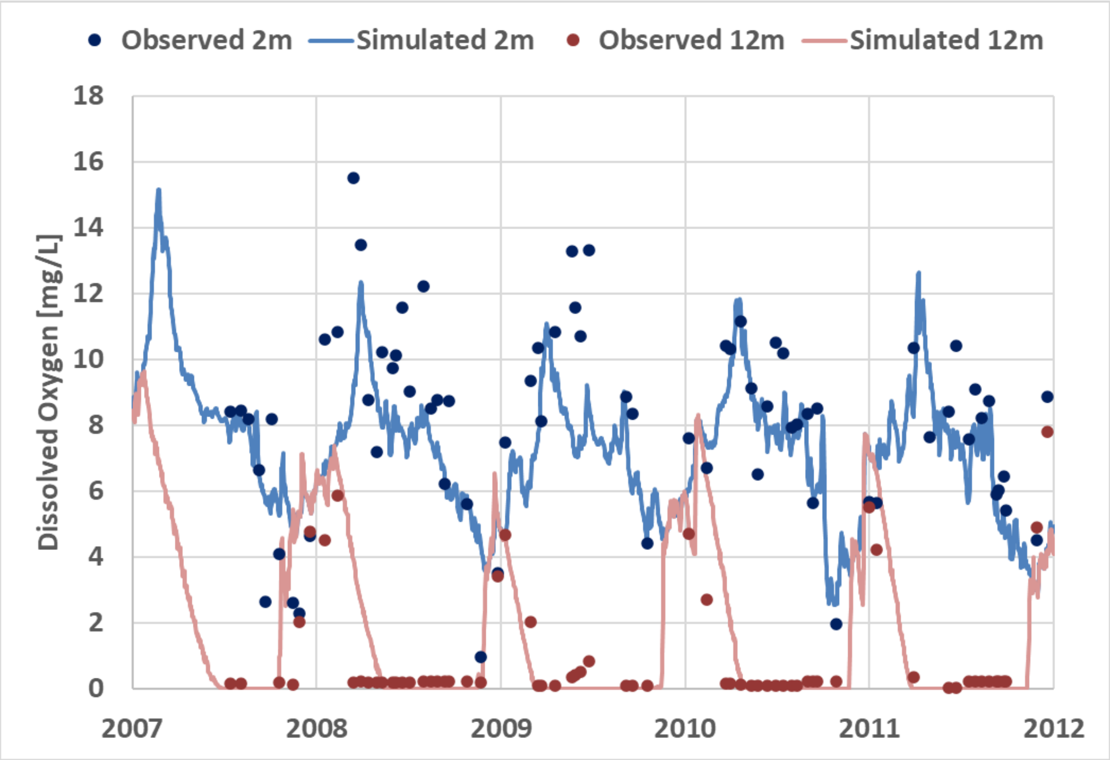




AEM3D for Canyon Lake: Main Lake Results

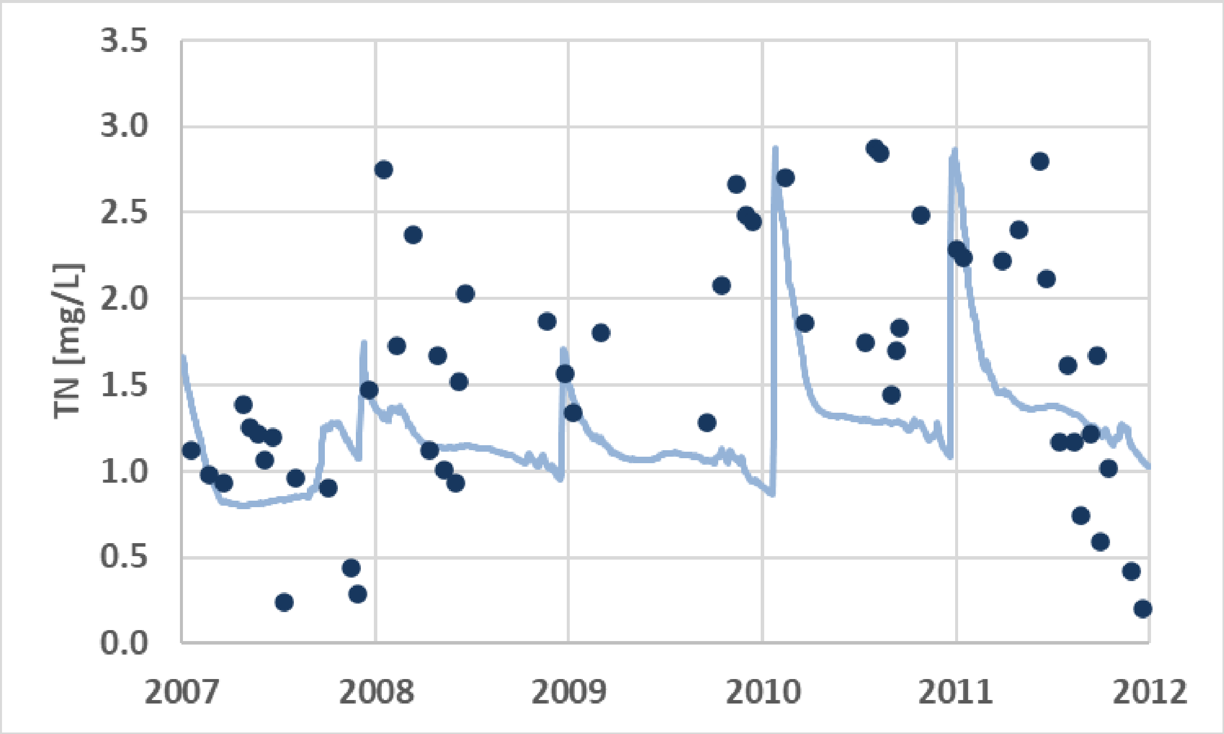
Existing Conditions

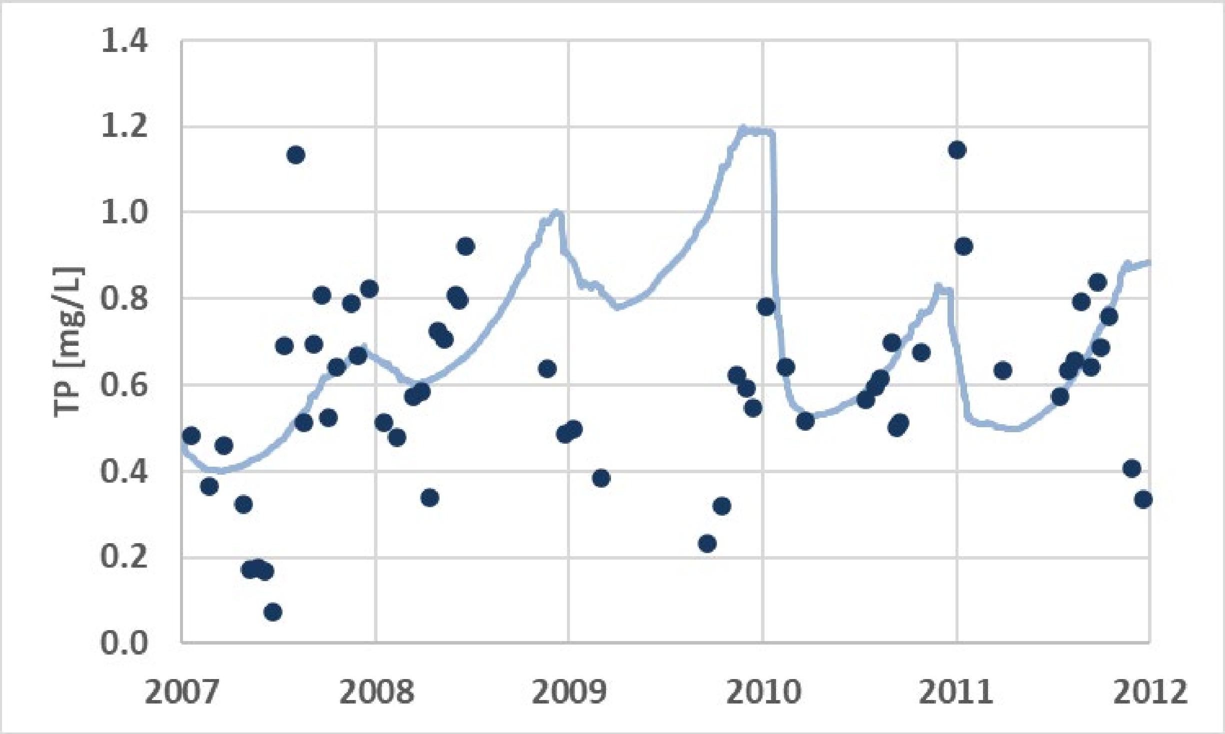




AEM3D for Canyon Lake: Main Lake Results

Existing Conditions





AEM3D for Canyon Lake: Main Lake Results Existing Conditions

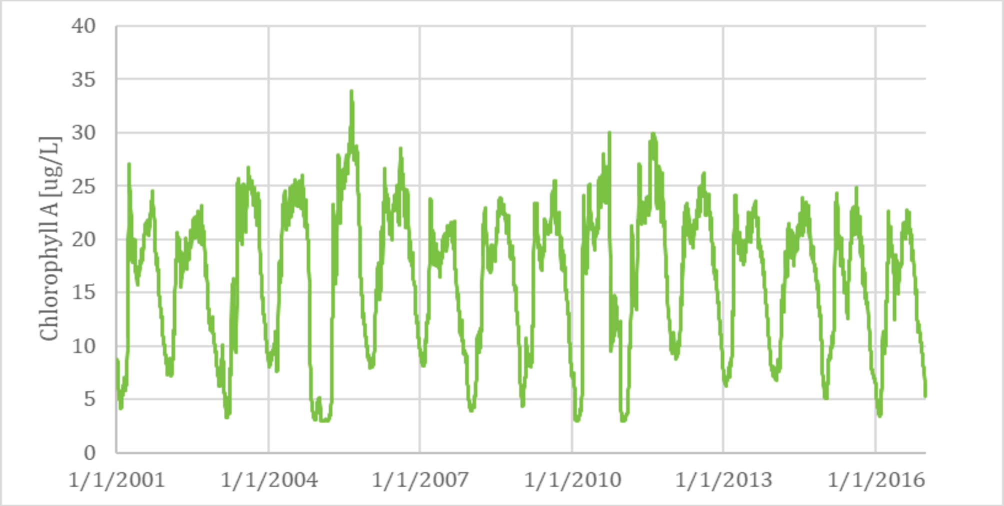
Mean Values for Observed and Predicted Water Quality Parameters in Canyon Lake (Observed/Predicted)

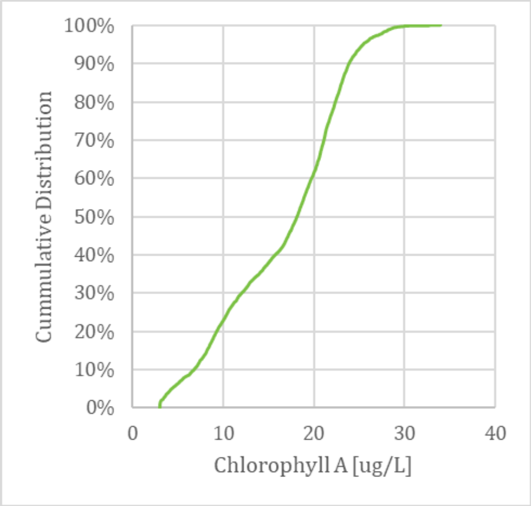
Site	Depth (m)	Temperature (°C)	DO (mg/L)	Chlorophyll-a (µg/L)	Total N (mg/L)	Total P (mg/L)
Main Lake (M1)	Epilimnion (2-m)	21.5 / 21.3	8.1 / 7.3	31.2 / 38.8	1.57 / 1.24	0.59 / 0.66
	Hypolimnion (12-m)	13.3 / 12.6	1.0 / 1.0	-	-	-
East Bay (E2)	Epilimnion (1-m)	-	-	50.8 / 53.7	1.80 / 1.35	0.50 / 0.64

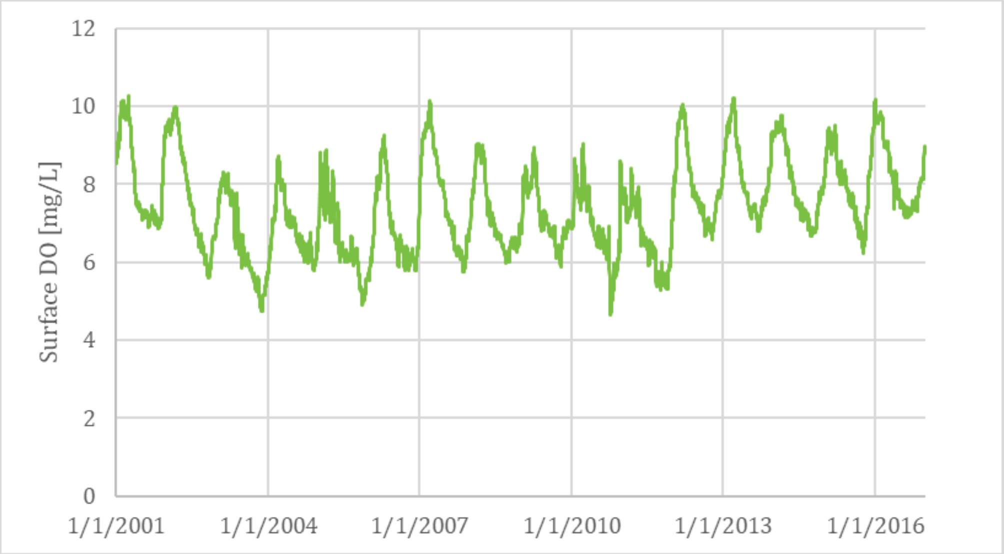
Average of Percent Relative Errors Between Discrete Pairs (Sampled Days) of Predicted and Observed Water Quality in Canyon Lake

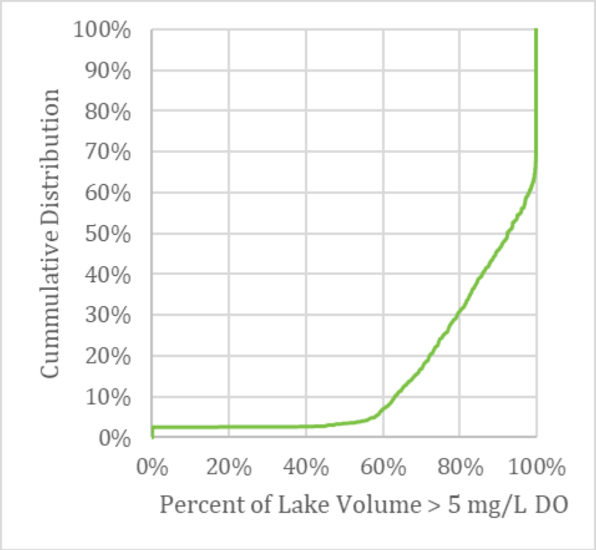
Site	Depth (m)	Temperature (% error)	DO (% error)	Chlorophyll-a (% error)	Total N (% error)	Total P (% error)
Main Lake (M1)	Epilimnion (2-m)	4.0 (N = 80)	22.7 (N = 73)	66.8 (N = 47)	36.8 (N = 57)	35.4 (N = 60)
	Hypolimnion (12-m)	8.7 (N = 77)	58.6 (M = 68)	-	-	-
East Bay (E2)	Epilimnion (1 m)	-	-	59.5 (N = 65)	37.8 (N = 72)	61.1 (N = 69)

AEM3D for Canyon Lake: Reference Simulation

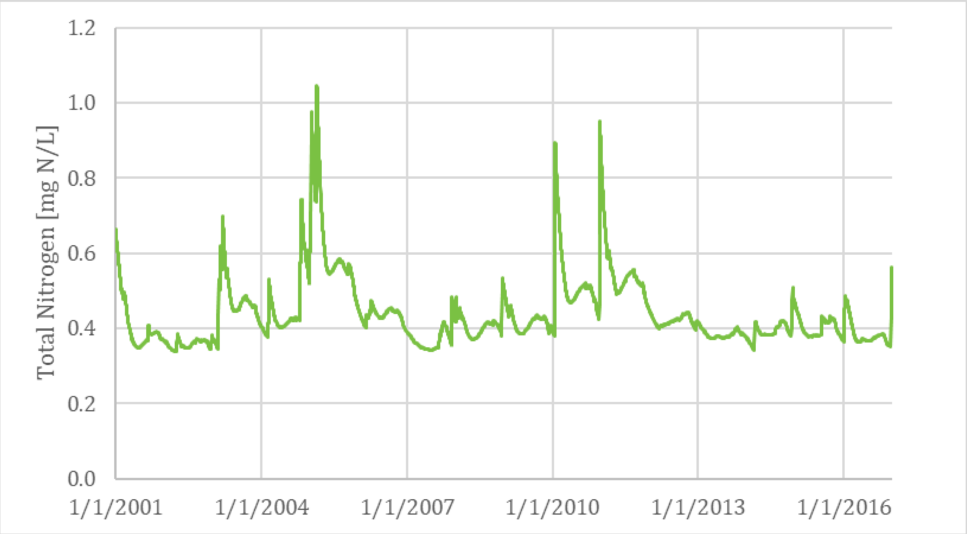


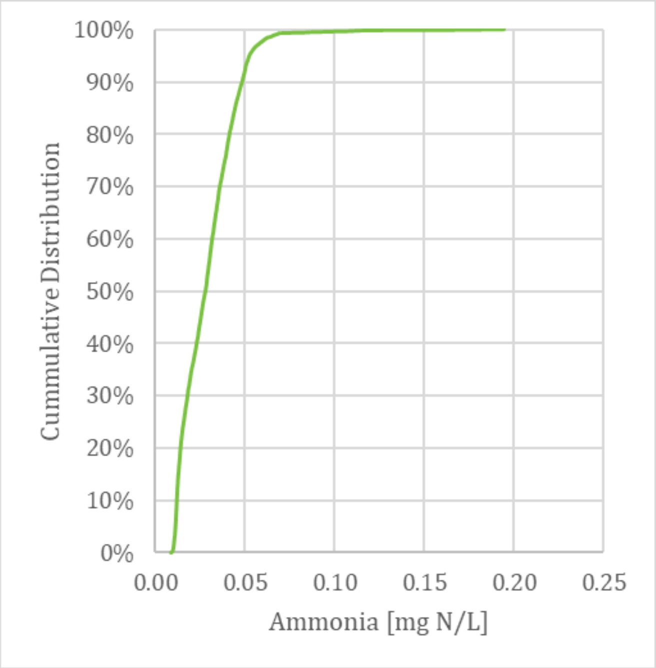






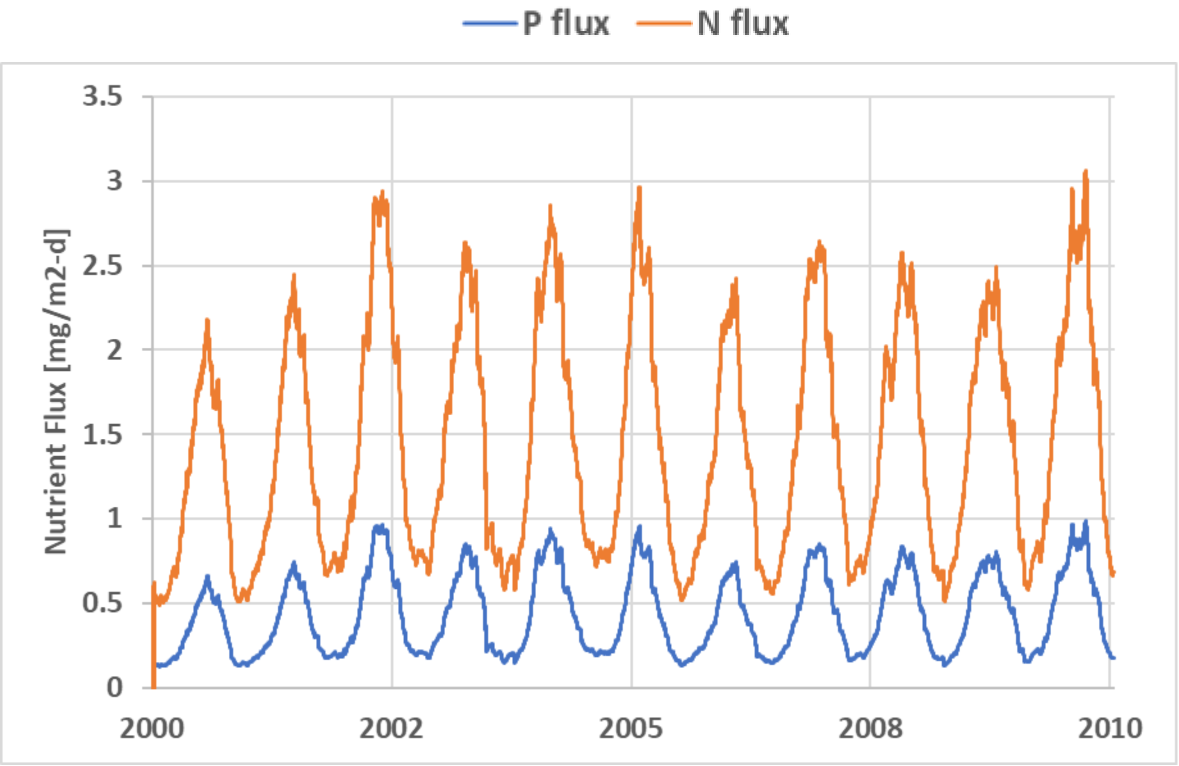
AEM3D for Canyon Lake: Reference Simulation





AEM3D for Canyon Lake: Reference Period Simulated Sediment Fluxes

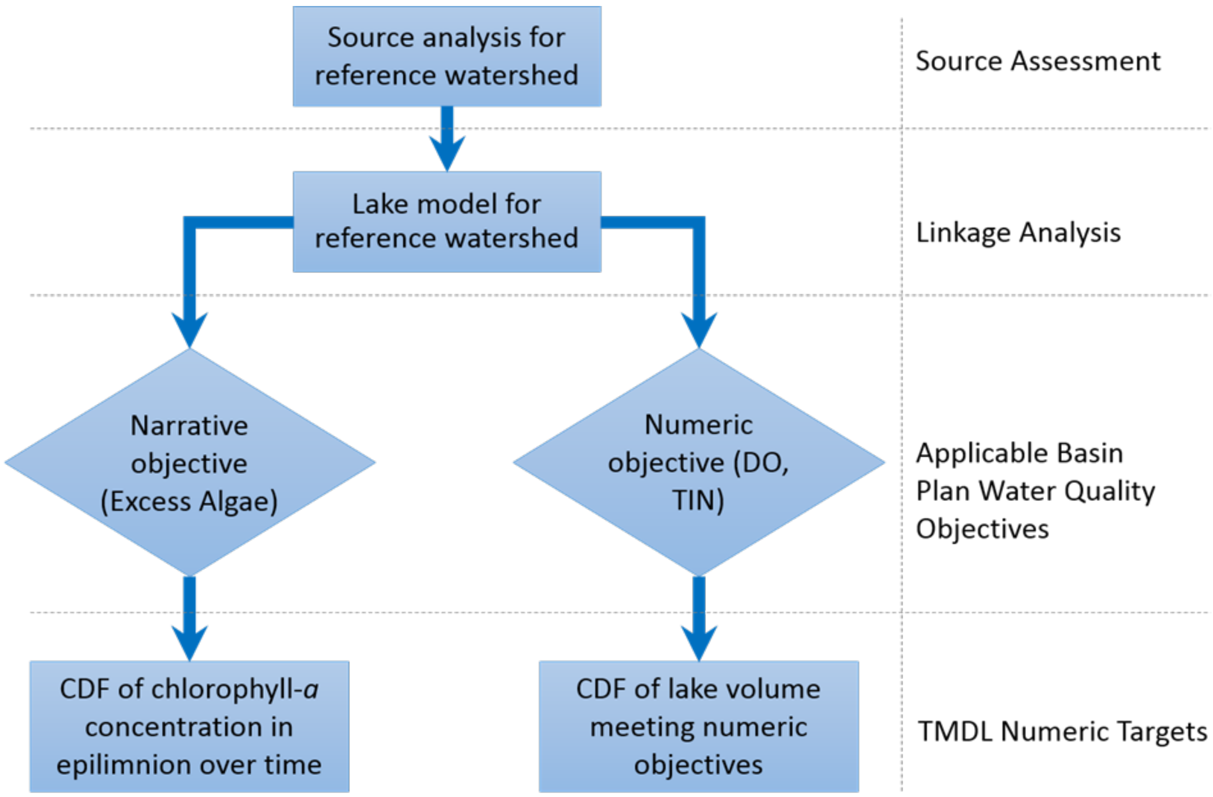
- Fluxes based on observations
- Adjusted for:
  - Temperature
  - Dissolved Oxygen



Numeric Targets

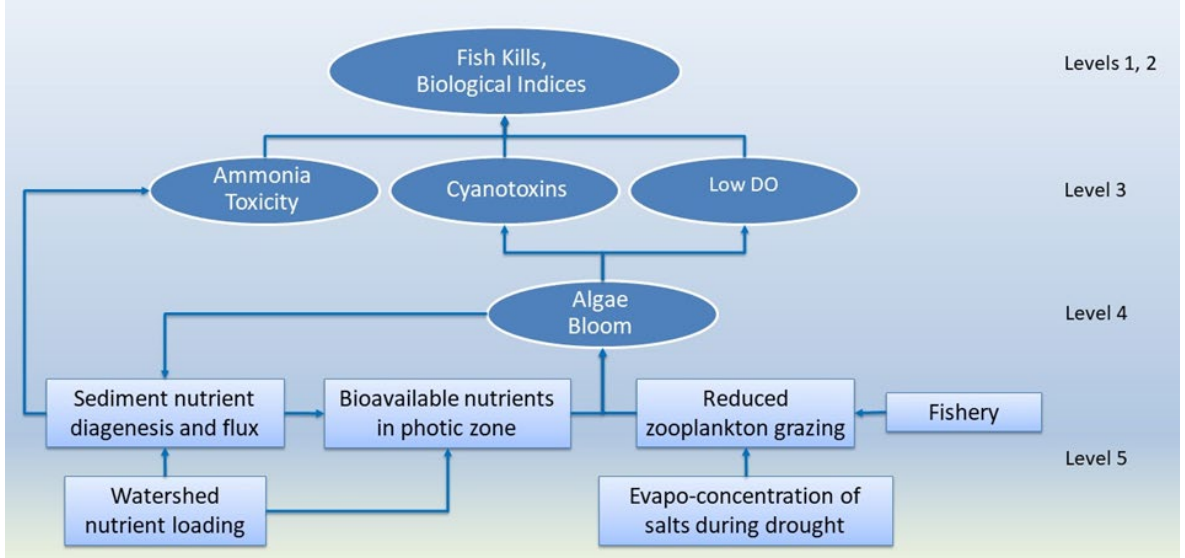
Reference Watershed

- Model simulation for reference watershed (allocated loading) achieves expected in lake response for a natural condition
- Different from stressor-response approach that begins with in-lake target and works upstream to allocations



Numeric Targets

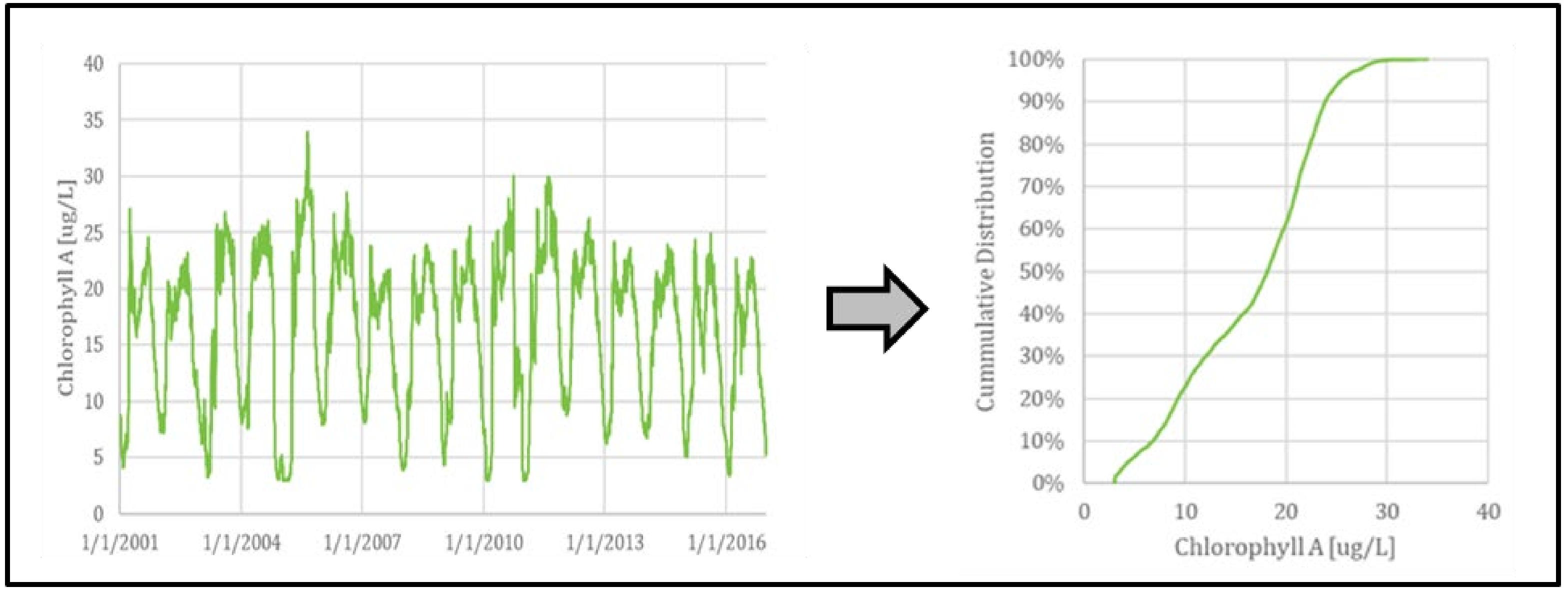
- Algae narrative WQO
  - *"Waste discharges shall not contribute to excessive algal growth in inland surface receiving waters"*
- *Dissolved Oxygen numeric WQO*
  - *"The dissolved oxygen content of surface waters shall not be depressed below 5 mg/L for waters designated WARM, or 6 mg/L for waters designated COLD, as a result of controllable water quality factors"*
- *Ammonia Toxicity*
  - *"The concentrations of toxic pollutants in the water column, sediments or biota shall not adversely affect beneficial uses."*

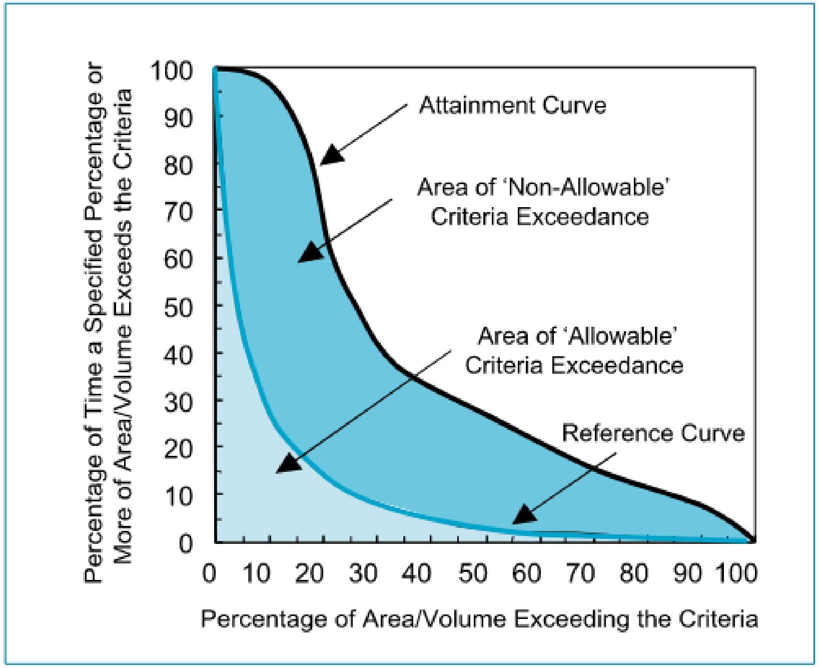


- Reference watershed approach for allocations eliminates need for in-lake nutrient targets

Cumulative Distribution Functions

- Reference model to CDF target for chlorophyll-a
- Based on top 1 meter of model output
  - GLM average across lake surface
  - AEM3D output for points in model corresponding to compliance monitoring locations (CL07 in Main Lake and CL10 in East Bay)

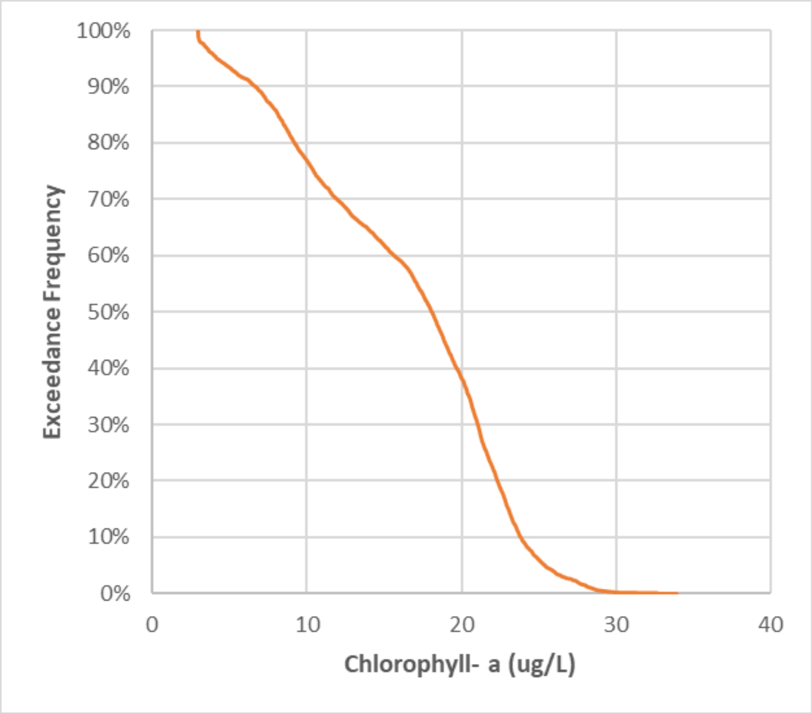


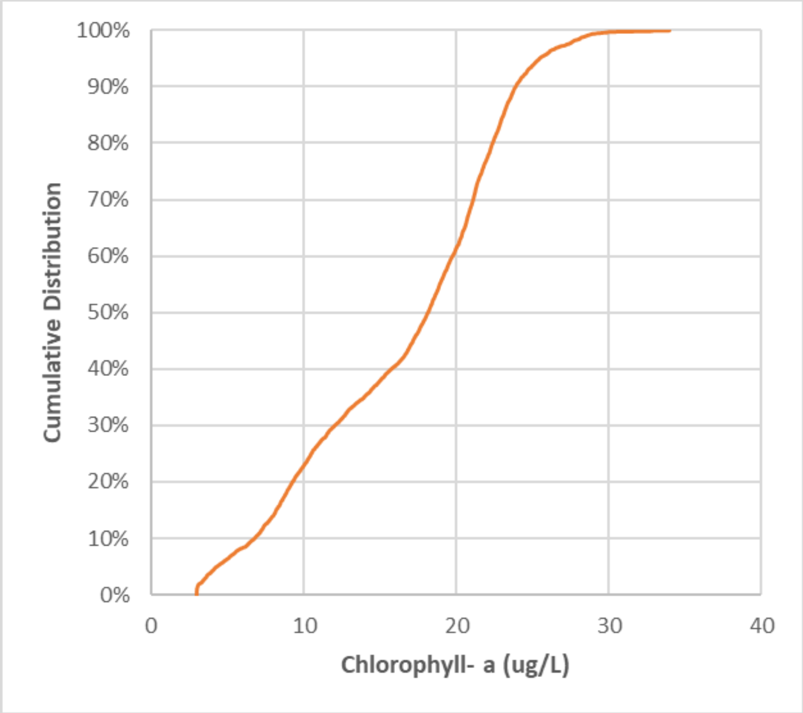


Criterion Reference Curve from Chesapeake Bay water quality standards. Source AmbientWaterCover.qxd (d38c6ppuviqmfp.cloudfront.net)

Cumulative Distribution Functions

- Numeric target as cumulative distribution function or exceedance frequency curve





Cumulative Distribution Functions

- Dissolved Oxygen as percent of volume above 5 mg/L

Months →

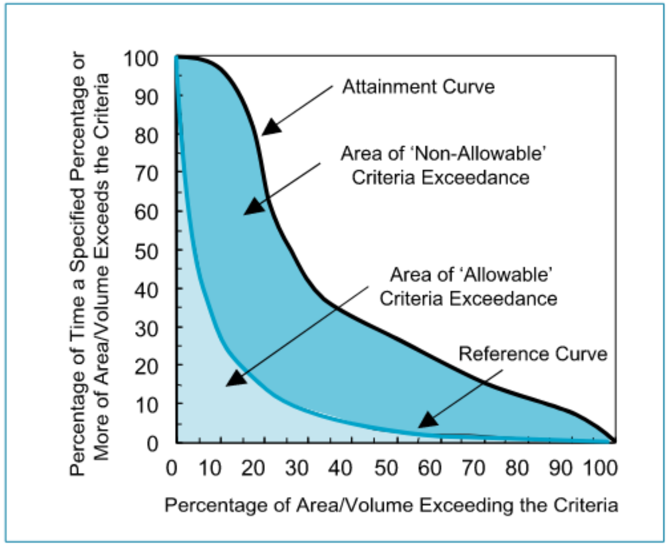
Depth Below Surface ↓

Depth (m)	Profile 1	Profile 2	Profile 3	Profile 4	Profile 5	Profile 6	Profile 7	Profile 8	Profile 9	Profile 10	Profile 11	Profile 12	Profile 13	Profile 14	Profile 15	Profile 16	Profile 17	Profile 18	Profile 19	Profile 20
1	8.5	11.1	8.7	7.6	7.1	6.7	7.0	8.6	7.6	6.9	6.3	6.5	6.5	7.6	7.8	7.3	7.0	6.7	7.4	7.7
2	8.5	11.1	8.7	7.6	7.1	6.7	7.0	8.6	7.6	6.9	6.3	6.5	6.6	7.6	7.8	7.3	7.1	6.7	7.4	7.7
3	8.5	11.1	8.7	7.6	7.1	6.7	7.0	8.6	7.6	6.9	6.4	6.5	6.6	7.5	7.8	7.3	7.1	6.7	7.4	7.7
4	8.5	11.2	8.7	7.6	7.1	6.7	7.0	8.3	7.6	7.0	6.4	6.6	6.5	7.3	7.8	7.3	7.1	6.7	7.4	7.7
5	8.5	11.2	8.7	7.6	7.0	6.7	7.0	8.2	7.6	7.0	6.4	6.6	6.5	7.2	7.8	6.6	6.6	6.7	7.4	7.6
6	8.5	11.1	8.6	7.5	6.6	6.7	7.0	8.1	6.9	6.2	6.4	6.6	6.5	6.9	7.4	7.6	6.0	6.7	7.4	6.9
7	8.5	10.8	8.4	6.4	6.4	6.7	7.0	7.4	5.9	6.0	6.3	6.6	6.6	6.6	6.5	6.0	6.8	6.7	7.4	7.7
8	8.5	9.0	7.7	6.2	6.1	6.7	7.1	6.5	4.0	5.5	6.4	6.6	6.5	6.4	6.5	6.0	6.5	6.7	7.4	7.4
9	8.5	7.7	6.5	5.5	6.4	6.6	7.0	6.3	3.5	1.0	6.0	6.4	6.4	7.4	6.5	5.8	6.3	6.6	7.4	7.3
10	8.5	7.9	6.9	3.9	1.6	6.4	7.0	6.4	4.1	0.5	1.0	6.6	6.4	5.7	6.0	0.2	6.2	6.4	7.2	7.5
11	8.5	7.7	5.9	2.7	0.3	6.4	7.0	6.3	3.6	0.5	0.5	3.1	6.5	4.5	5.0	0.0	0.0	6.4	7.2	7.3
12	8.5	7.6	5.4	2.3	0.2	6.1	7.0	6.2	3.1	0.1	0.5	0.3	6.5	4.2	1.2	0.0	0.0	6.9	7.2	7.2
13	8.5	7.6	6.2	2.9	0.4	3.6	7.0	6.1	3.4	0.2	0.0	0.0	6.5	4.5	1.4	0.0	0.0	0.6	4.0	7.1
14	8.5	7.0	5.7	1.8	0.1	0.2	7.0	7.4	2.8	0.0	0.0	0.0	6.4	3.9	0.7	0.0	0.0	0.0	4.0	6.7

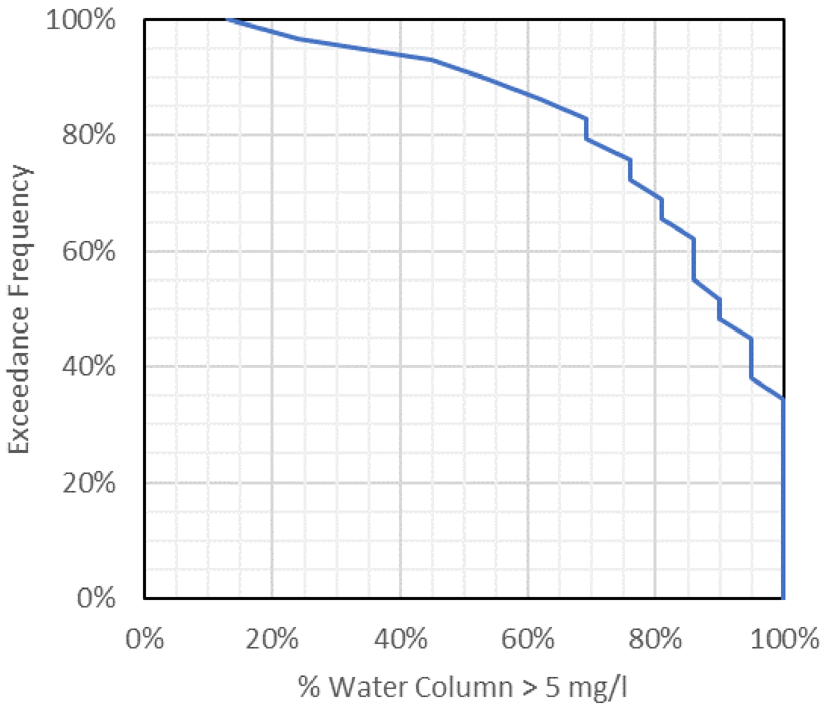
Depth (m)	Profile 21	Profile 22	Profile 23	Profile 24	Profile 25	Profile 26	Profile 27	Profile 28	Profile 29	Profile 30	Profile 31	Profile 32	Profile 33	Profile 34	Profile 35	Profile 36	Profile 37	Profile 38	Profile 39	Profile 40
1	7.4	6.5	6.2	6.5	7.6	7.9	7.2	6.4	7.5	7.1	8.7	11.4	8.9	7.8	7.3	6.9	7.1	8.9	7.8	7.1
2	7.4	6.5	6.1	6.5	7.6	7.9	7.2	6.4	7.5	7.1	8.7	11.4	8.9	7.8	7.2	6.9	7.1	8.9	7.8	7.1
3	7.5	6.6	6.2	6.5	7.6	7.9	7.2	6.4	7.6	7.1	8.7	11.4	8.9	7.8	7.2	6.9	7.1	8.8	7.8	7.1
4	7.4	6.5	6.2	6.5	7.6	7.9	7.2	6.4	7.6	7.2	8.7	11.4	8.9	7.8	7.2	6.9	7.1	8.5	7.8	7.1
5	7.4	6.5	6.2	6.5	7.6	7.8	7.2	6.4	7.6	7.2	8.7	11.4	8.9	7.8	7.1	6.9	7.1	8.4	7.8	7.1
6	4.9	6.2	6.2	6.5	7.6	7.8	6.9	7.2	7.5	7.2	8.7	11.4	8.8	7.7	6.7	6.9	7.2	8.3	7.1	6.4
7	4.0	6.0	6.2	6.5	7.6	7.8	6.9	7.1	6.4	7.1	8.7	11.1	8.6	6.6	6.5	6.9	7.2	7.5	6.1	6.2
8	1.6	3.9	5.8	6.5	7.6	7.4	6.3	7.0	5.0	7.1	8.7	9.2	7.9	6.4	6.3	6.9	7.3	6.7	4.1	5.6
9	0.8	3.5	5.7	6.3	7.6	7.3	6.2	4.0	4.9	6.8	8.7	7.9	6.6	5.6	6.6	6.8	7.2	6.4	3.6	1.0
10	1.3	3.0	0.0	5.3	7.4	4.2	3.0	3.5	4.8	6.1	8.7	8.0	7.1	4.0	1.7	6.6	7.1	6.6	4.2	0.5
11	1.1	0.0	0.0	2.7	7.4	3.9	2.9	3.2	4.0	3.2	8.7	7.9	6.0	2.8	0.3	6.6	7.2	6.4	3.7	0.5
12	1.0	0.0	0.0	0.0	7.4	3.8	2.2	0.0	3.2	0.1	8.7	7.7	5.5	2.4	0.2	6.3	7.2	6.3	3.2	0.2
13	1.5	0.0	0.0	0.0	7.4	3.8	0.0	0.0	0.0	0.0	8.7	7.8	6.4	3.0	0.4	3.7	7.2	6.3	3.5	0.2
14	0.9	0.0	0.0	0.0	7.4	3.6	0.0	0.0	0.0	0.0	8.7	7.2	5.8	1.9	0.1	0.2	7.2	7.6	2.9	0.0

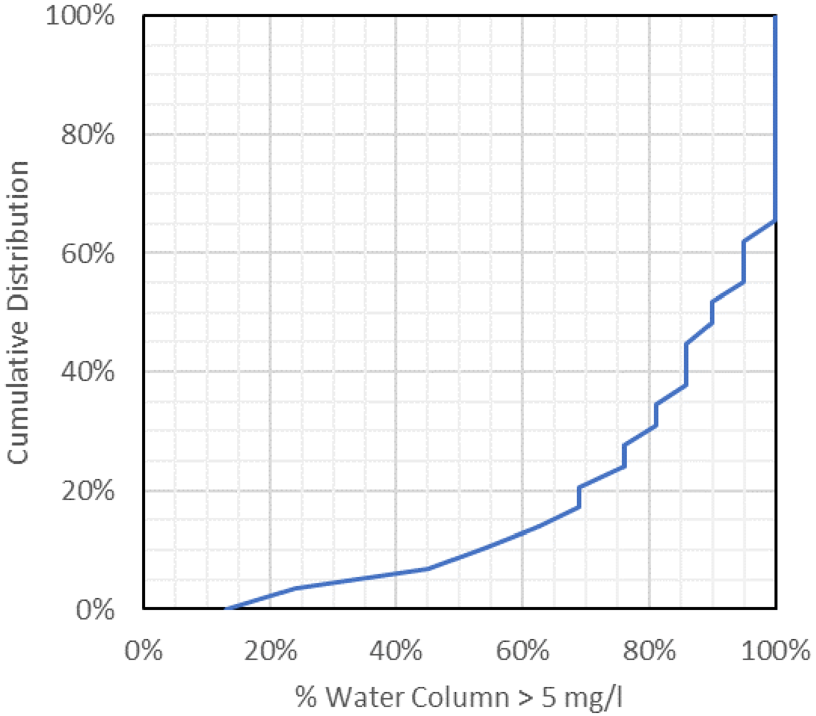
Depth (m)	Profile 41	Profile 42	Profile 43	Profile 44	Profile 45	Profile 46	Profile 47	Profile 48	Profile 49	Profile 50	Profile 51	Profile 52	Profile 53	Profile 54	Profile 55	Profile 56	Profile 57	Profile 58	Profile 59	Profile 60
1	6.5	6.7	6.7	7.8	8.0	7.5	7.2	6.8	7.6	7.9	7.6	6.7	6.3	6.6	7.8	8.1	7.4	6.5	7.7	7.3
2	6.5	6.7	6.7	7.7	8.0	7.5	7.2	6.9	7.6	7.9	7.6	6.7	6.3	6.7	7.8	8.1	7.4	6.5	7.7	7.3
3	6.5	6.7	6.7	7.7	8.0	7.5	7.2	6.9	7.6	7.9	7.6	6.7	6.3	6.7	7.8	8.1	7.3	6.5	7.8	7.3
4	6.6	6.7	6.7	7.5	8.0	7.5	7.2	6.9	7.6	7.9	7.6	6.7	6.4	6.7	7.8	8.1	7.3	6.5	7.8	7.3
5	6.6	6.7	6.7	7.4	8.0	6.8	6.8	6.9	7.6	7.8	7.6	6.7	6.3	6.7	7.8	8.0	7.4	6.6	7.8	7.3
6	6.6	6.7	6.7	7.1	7.6	7.8	6.2	6.9	7.6	7.0	5.0	6.3	6.3	6.7	7.8	8.0	7.0	7.4	7.7	7.3
7	6.5	6.7	6.7	6.7	6.7	6.2	7.0	6.9	7.6	7.9	4.1	6.2	6.3	6.7	7.8	8.0	7.1	7.3	6.6	7.3
8	6.5	6.7	6.7	6.5	6.7	6.2	6.7	6.9	7.6	7.6	1.6	4.0	5.9	6.7	7.8	7.6	6.5	7.2	5.1	7.3
9	6.2	6.6	6.6	7.6	6.7	5.9	6.5	6.7	7.5	7.5	0.8	3.6	5.8	6.4	7.7	7.5	6.4	4.1	5.0	7.0
10	1.0	6.8	6.6	5.9	6.2	0.2	6.4	6.6	7.4	7.7	1.3	3.1	0.0	5.4	7.6	4.3	3.1	3.6	4.9	6.2
11	0.5	3.2	6.6	4.6	5.1	0.0	0.0	6.5	7.4	7.5	1.1	0.0	0.0	2.7	7.6	4.0	3.0	3.3	4.1	3.3
12	0.5	0.3	6.6	4.3	1.2	0.0	0.0	7.1	7.4	7.3	1.0	0.0	0.0	0.0	7.6	3.9	2.3	0.0	3.3	0.1
13	0.0	0.0	6.6	4.6	1.4	0.0	0.0	0.7	4.1	7.3	1.5	0.0	0.0	0.0	7.6	3.9	0.0	0.0	0.0	0.0
14	0.0	0.0	6.6	4.0	0.7	0.0	0.0	0.0	4.1	6.9	0.9	0.0	0.0	0.0	7.6	3.6	0.0	0.0	0.0	0.0

Cumulative Distribution Functions



- Numeric target as cumulative distribution function or exceedance frequency curve





Compliance Assessment

- Dissolved Oxygen
- X-axis is percent of volume above 5 mg/L
- Y-axis is frequency
- More high-DO water at same frequency is better

Step 1. Calculate fraction of Main Lake volume with DO > 5mg/L

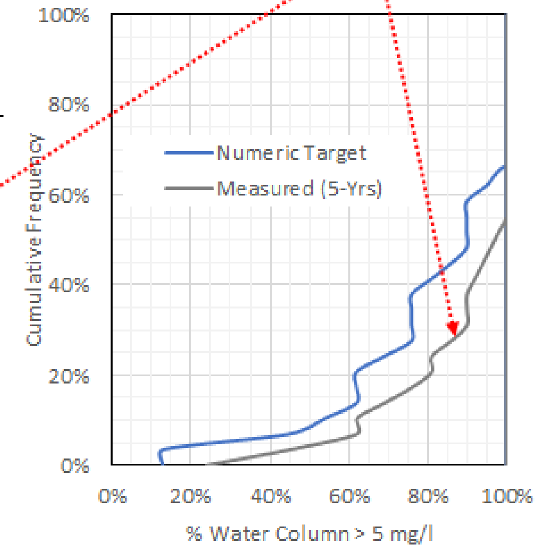
Example for Profile 1 of 30

Water Surface Elevation (ft msl)	Depth of Water (m)	Profile 1 DO Readings (mg/L)	Cumulative Volume (AF)	Incremental Volume (AF)	Volume with DO > 5 mg/L
1382	14.0	9.0	6,537	829	829
1379	13.0	8.5	5,709	766	766
1376	12.0	8.0	4,943	705	705
1373	11.0	8.0	4,238	645	645
1370	10.0	7.0	3,593	587	587
1367	9.0	7.0	3,007	530	530
1364	8.0	6.5	2,477	475	475
1361	7.0	6.0	2,002	421	421
1358	6.0	6.0	1,581	369	369
1355	5.0	5.5	1,212	318	318
1352	4.0	4.5	893	269	0
1349	3.0	4.0	624	221	0
1346	2.0	3.0	403	175	0
1343	1.0	2.5	227	227	0
			Volume (AF)	6,537	5,644
			Fraction above 5 mg/L DO	86%	

Step 2. Repeat step 1 for all 30 profiles

Step 3. Plot as CDF

Percentile	Fraction of Lake Volume with DO > 5 mg/L	Reference CDF (Numeric Target)
0%	24%	13%
3%	45%	13%
7%	62%	45%
10%	62%	54%
14%	69%	62%
17%	76%	62%
21%	81%	62%
24%	81%	69%
28%	86%	76%
31%	90%	76%
34%	90%	76%
38%	90%	76%
41%	92%	81%
45%	94%	86%
48%	96%	90%
52%	98%	90%
55%	100%	90%
59%	100%	90%
62%	100%	95%
66%	100%	100%
67-100%	100%	100%



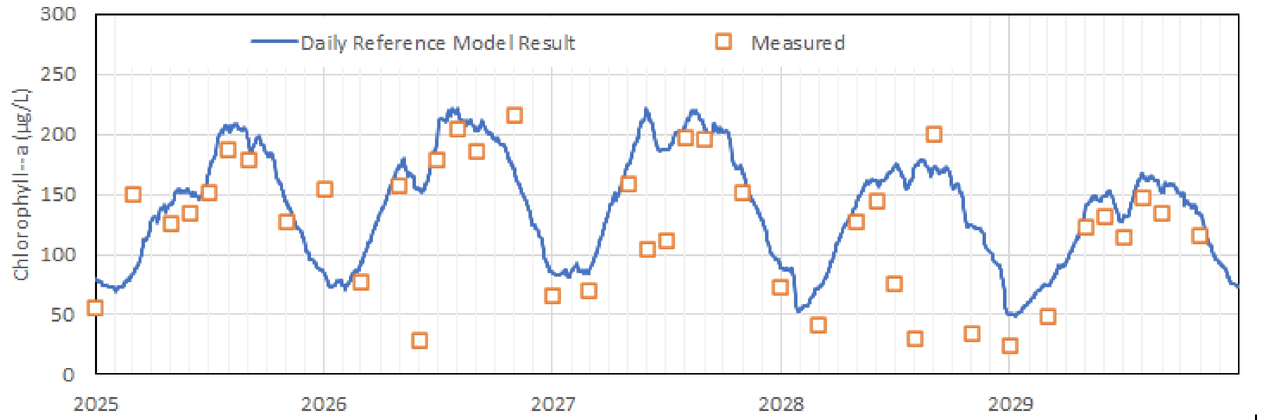
Compliance √

Compliance Assessment

- Algae as chlorophyll- a
- X-axis is concentration of chlorophyll-a in top 1 meter of lake
- Y-axis is frequency
- Lower chlorophyll-a concentration at same frequency is better

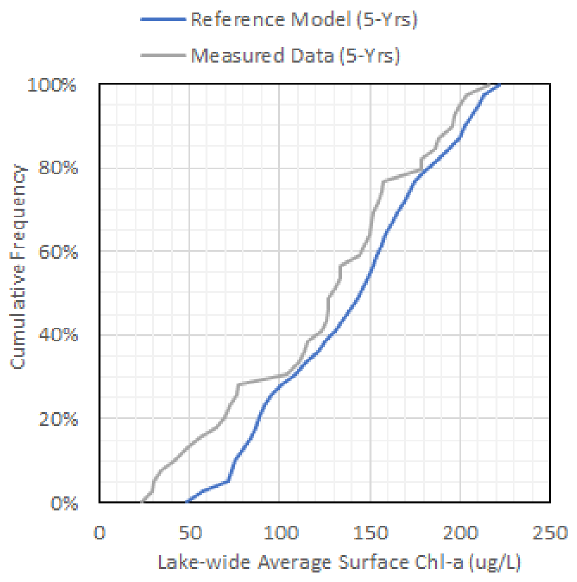
Step 1. Run lake water quality model for preceding five year period, output daily lakewide average surface chlorophyll-a concentration

Step 2. Compile chlorophyll-a from monitoring program dataset



Step 3. Plot measured and modeled chlorophyll-a (ug/L) as CDF

%ile	Observed Data	Reference Model	%ile	Observed Data	Reference Model
0%	24	49	51%	131	146
3%	29	57	54%	134	149
5%	30	71	56%	134	152
8%	34	74	59%	144	154
10%	42	76	62%	147	157
13%	49	80	64%	150	159
15%	55	84	67%	151	162
18%	65	86	69%	152	165
21%	70	88	72%	155	169
23%	72	91	74%	157	172
26%	76	95	77%	158	175
28%	77	101	79%	179	181
31%	104	109	82%	179	188
33%	111	115	85%	186	194
36%	114	121	87%	188	200
38%	116	125	90%	196	203
41%	123	131	92%	197	206
44%	126	135	95%	200	210
46%	127	139	97%	204	213
49%	127	143	100%	216	222

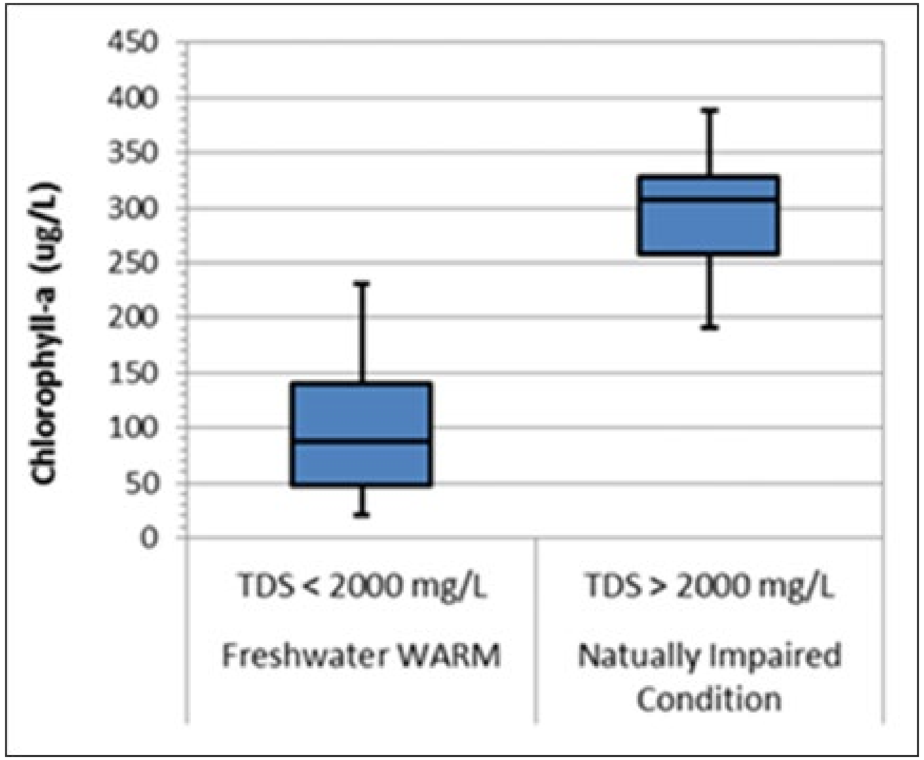


Compliance √

Other Project Updates

Regulatory Changes

- Lake Elsinore 303(d) listing for TDS
- Lake Elsinore 303(d) listing for cyanotoxins
  - Based on caution trigger 6 ug/L microcystin
- Nutrient criteria based on cyanotoxin risk to swimmers
  - EPA stressor-response models
  - California refinement through biostimulatory workgroup



Coordination for Non-Dairy CAFO Source

- Source assessment for 2018 draft TMDL Technical Report involved a single CAFO land use with assumptions linked to dairy permit
- Regional Board working on a separate permit for non-dairy CAFOs (anticipated for 2024) – separate load allocation in 2023 update
- Estimation of nutrient load in updated source assessment for non-dairy CAFO based on literature values
- About five facilities impacted – small load relative to watershed
  - Covered poultry operations
  - Horse ranches

Schedule

- Comments on Source Assessment and Allocations received
- Drafts of Numeric Targets, Linkage Analysis, and Implementation to be submitted for Task Force review week of May 1
- Other sections with less significant changes to follow
- Regional Board planning staff in process of scheduling workshop and adoption for the 2023-24 fiscal year

Backup slides – DI Plots Lake Elsinore