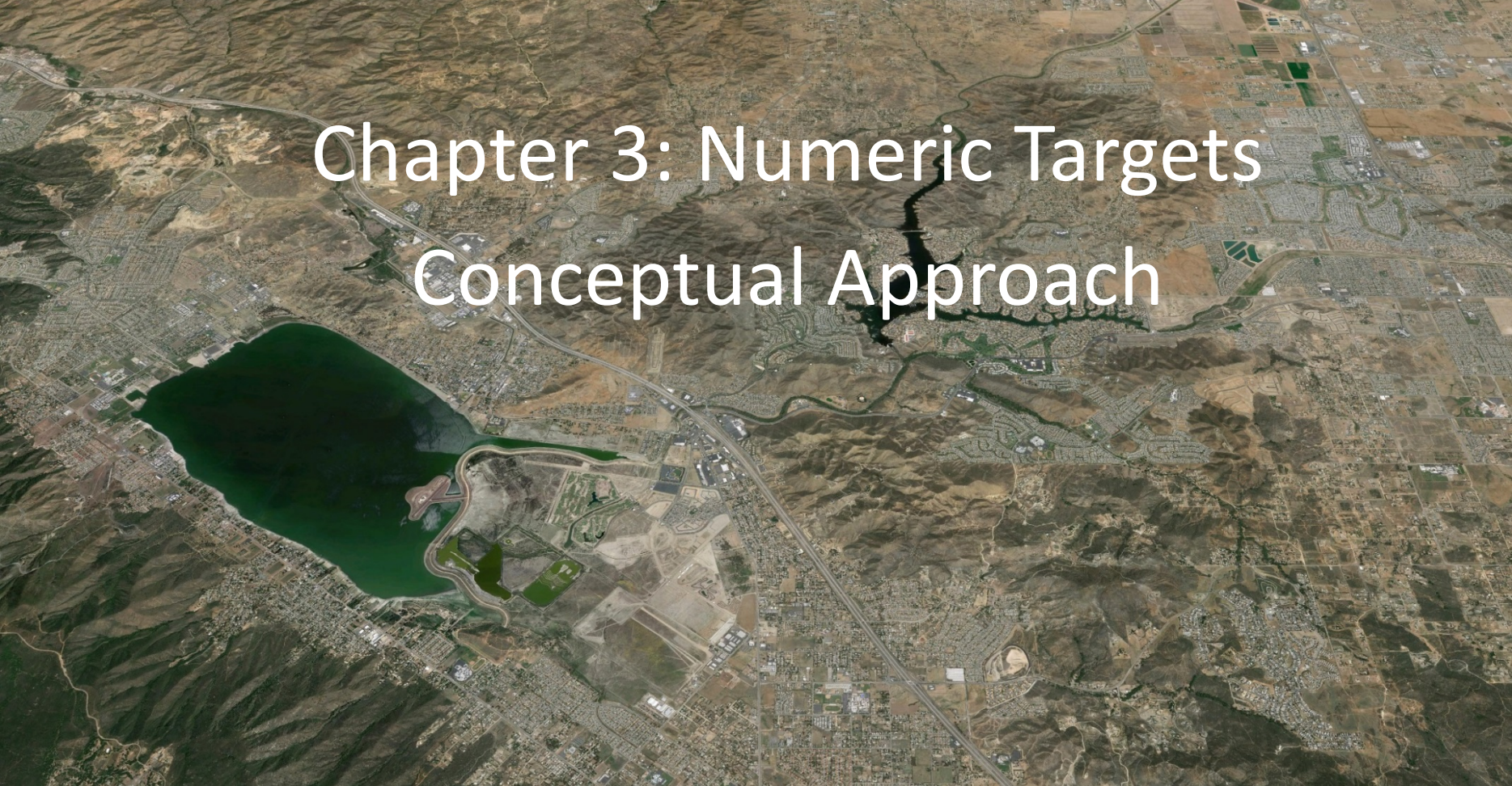


# Revision of the Lake Elsinore & Canyon Lake Nutrient TMDL

CDM Smith Team  
& Risk Sciences



## Chapter 3: Numeric Targets Conceptual Approach

March 22, 2016

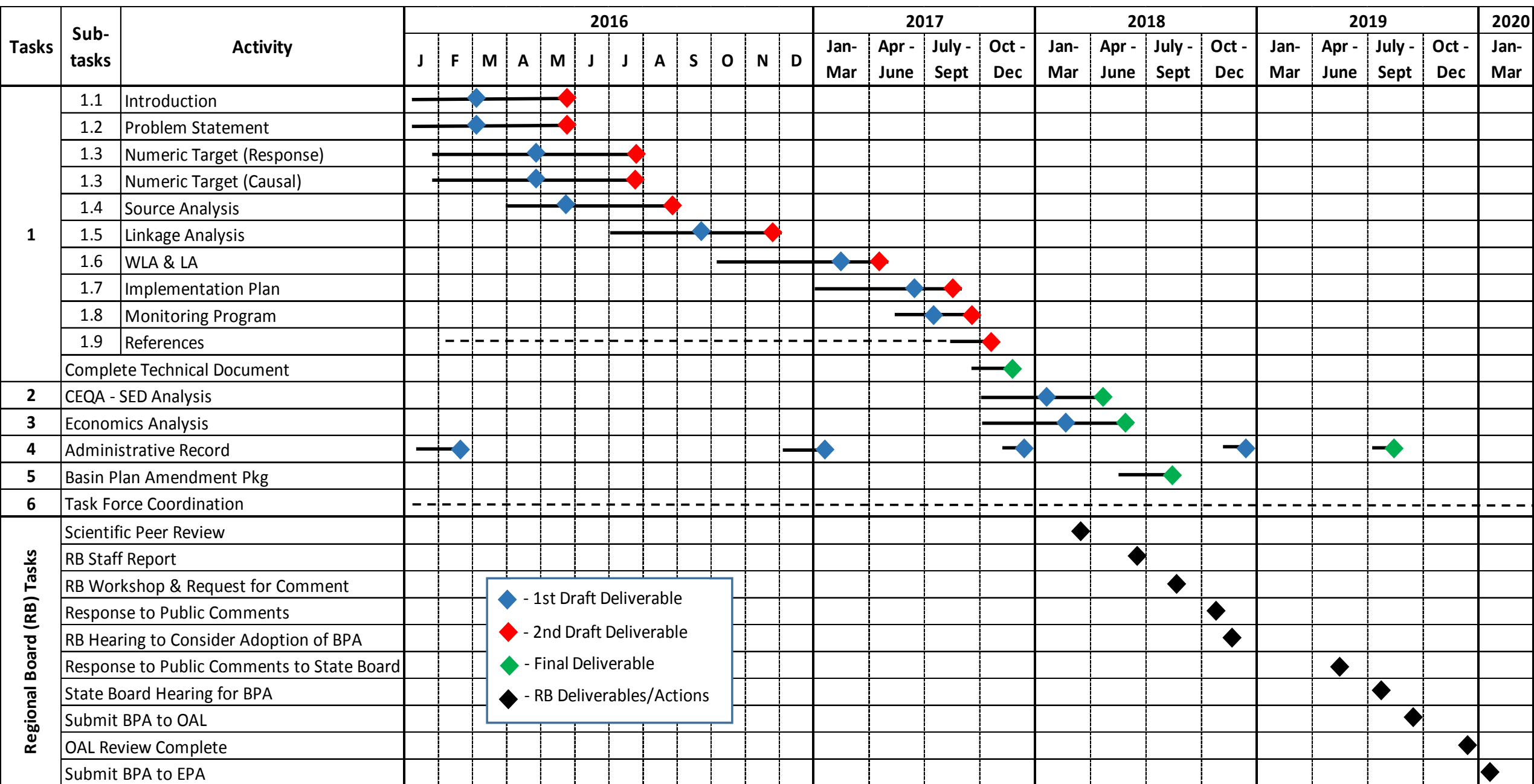
Lake Elsinore/Canyon Lake  
Task Force Meeting

**CDM  
Smith**



# Presentation Outline

- Project Progress/Status
- Existing TMDL Numeric Targets
  - Response Targets
  - Causal Targets
- Conceptual Approach to Establish Revised TMDL Numeric Targets



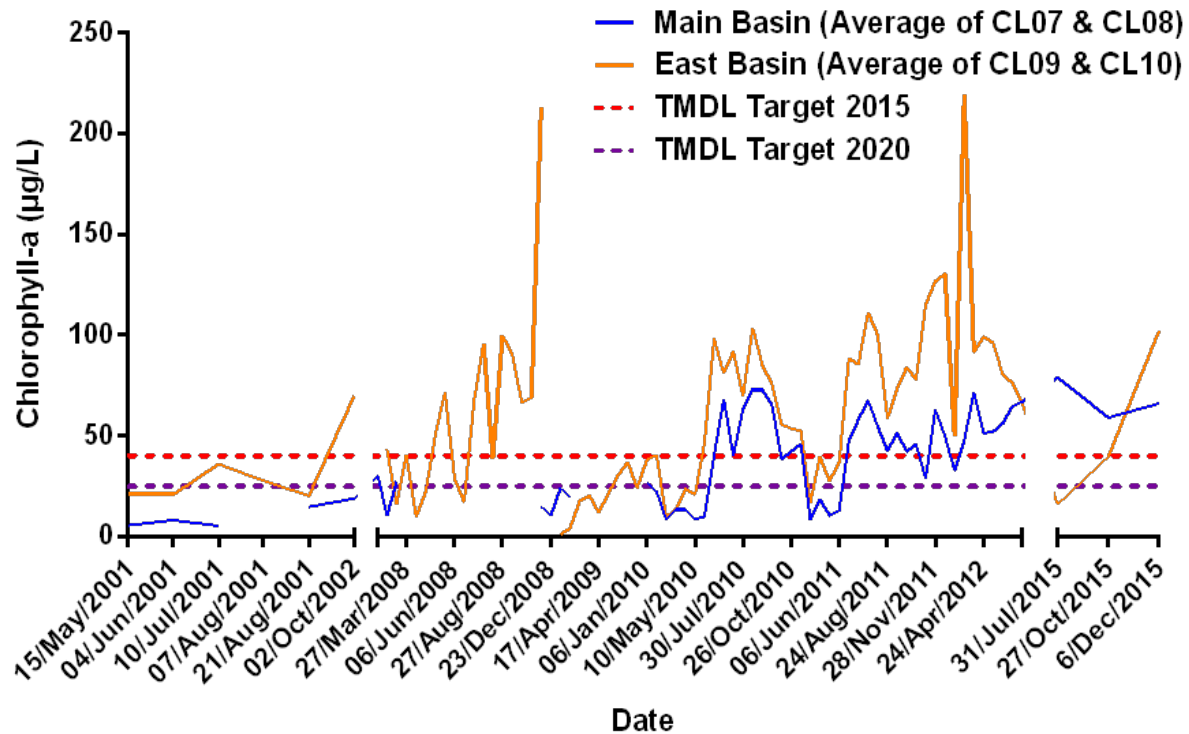
# Numeric Response Targets

- Chlorophyll *a*
- Dissolved Oxygen
- Ammonia Toxicity

# Chlorophyll-*a*

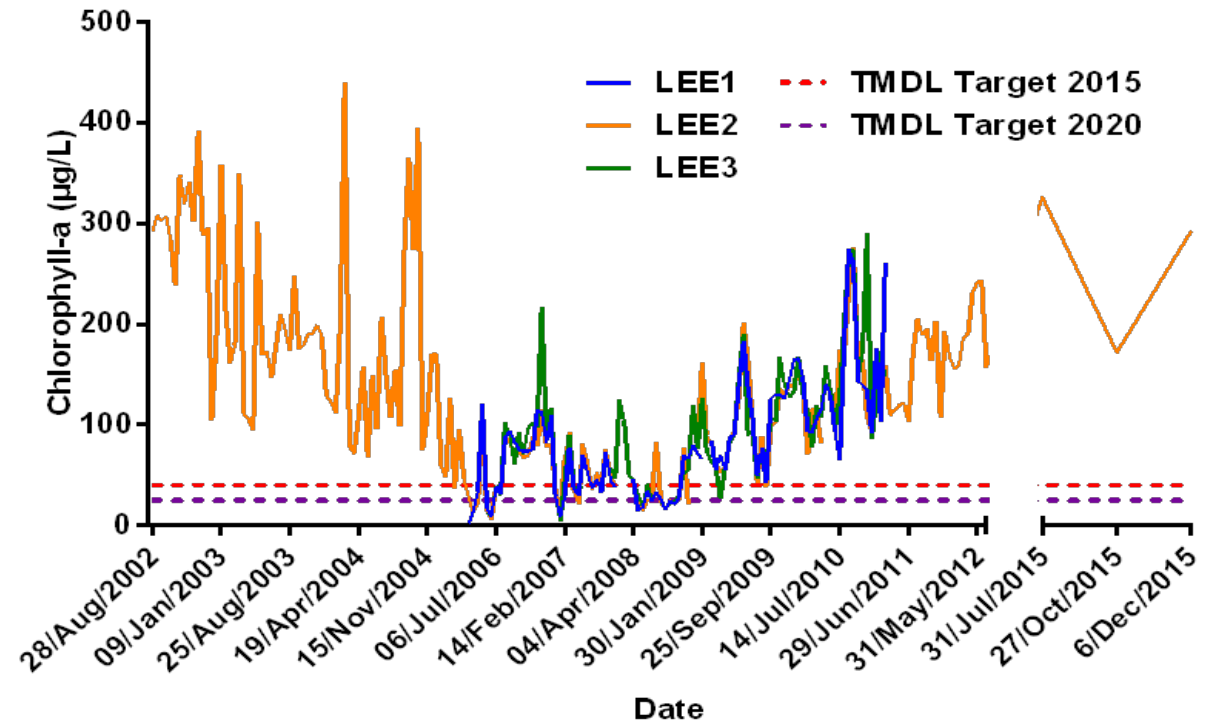
- Averaging Period
  - Annual average for Canyon Lake
  - Summer average for Lake Elsinore
- Undefined Depth
- Interim Target of 40  $\mu\text{g}/\text{L}$  for both lakes
  - Basis: 25<sup>th</sup> percentile of data collected in 2001-2002, assumed to be a reference condition year for Lake Elsinore (no algal blooms or fish kills; 1,240 foot water level)
- Final Target of 25  $\mu\text{g}/\text{L}$  for both lakes
  - Basis: EPA survey of 894 US lakes and reservoirs defined the range for eutrophic conditions to be 10-25  $\mu\text{g}/\text{L}$
  - > 25  $\mu\text{g}/\text{L}$  represents a hypereutrophic condition based on range of lakes across nation

# Chlorophyll *a* Observations



No data available from October 2002-August 2007; June 2012-July 2015  
 2015 TMDL target of 40 µg/L is annual average to be attained by 2015  
 2020 TMDL target of 25 µg/L is annual average to be attained by 2020

**Canyon Lake – 2001-2015**



No data available from June 2012-July 2015  
 2015 TMDL target of 40 µg/L is summer average to be attained by 2015  
 2020 TMDL target of 25 µg/L is summer average to be attained by 2020

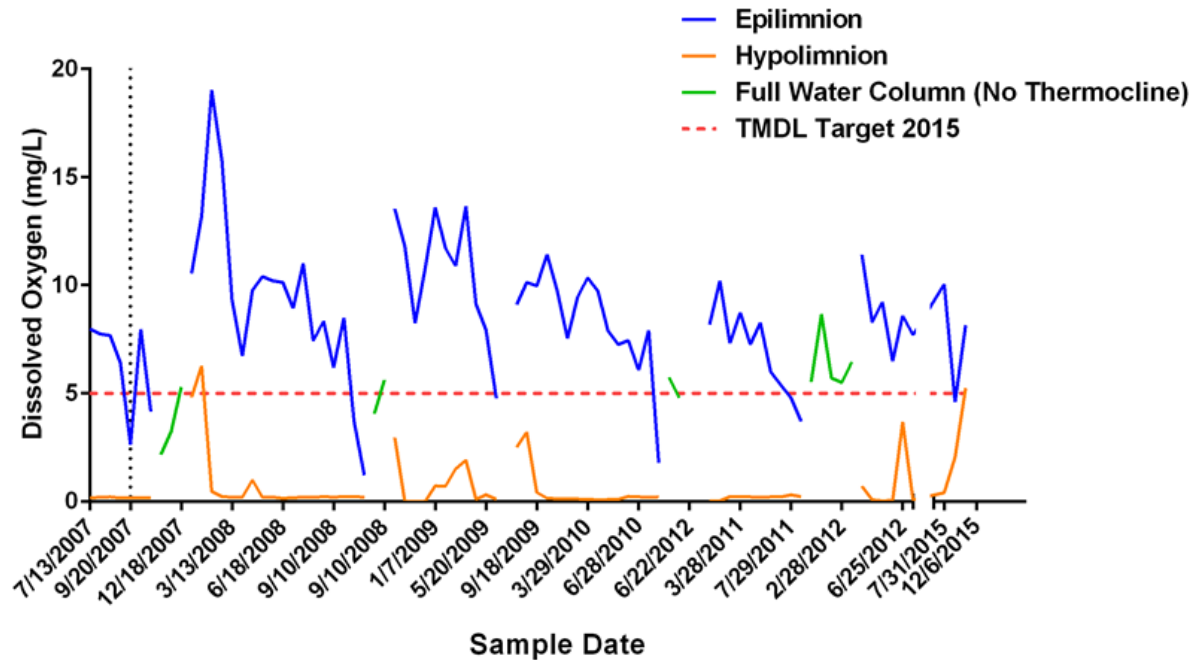
**Lake Elsinore – 2002-2015**

# Dissolved Oxygen

- Instantaneous Target: Criteria to be met at all times
- Basis: Translation of narrative dissolved oxygen water quality objective
  - The dissolved oxygen content of surface waters shall not be depressed below 5 mg/L for waters designated **WARM***
- Lake Elsinore
  - Interim: Depth integrated average > 5 mg/L
  - Final: > 5 mg/L, 1 meter from lake bottom
  - Final: > 2 mg/L from 1 meter to lake bottom
- Canyon Lake
  - Interim: all depths above thermocline > 5 mg/L
  - Interim: > 2 mg/L within bottom 1 meter (subject to new information)
  - Final: hypolimnion > 5 mg/L (subject to new information):

# Dissolved Oxygen Observations – Canyon Lake

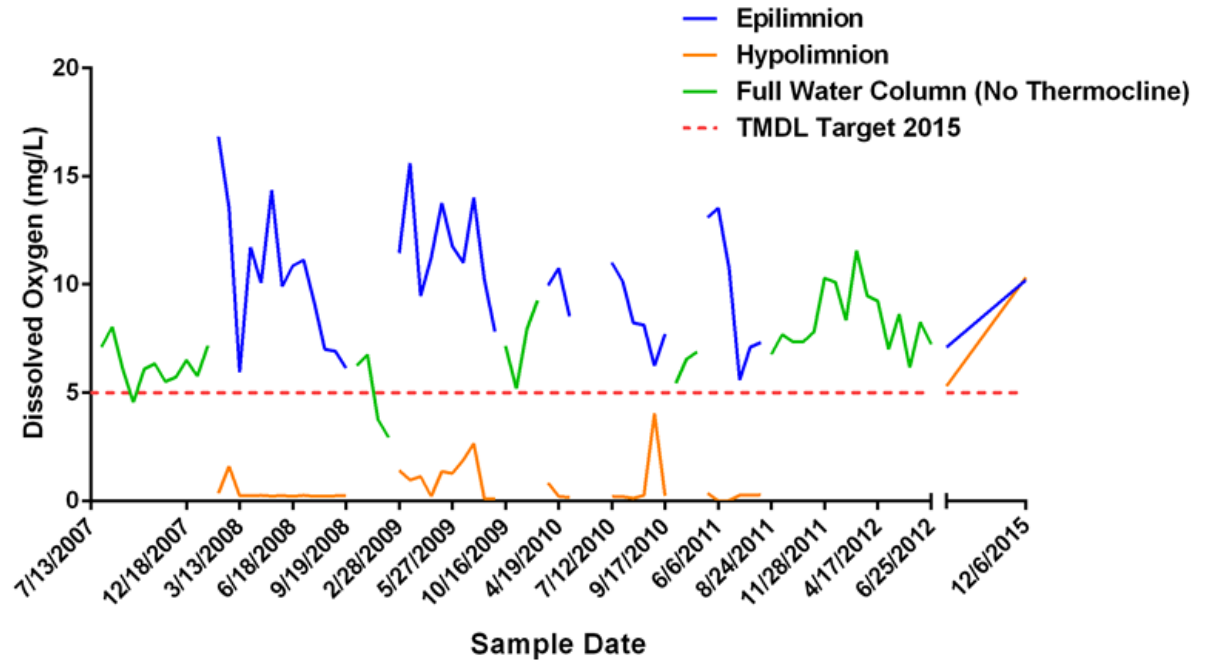
Average Dissolved Oxygen Concentrations  
Canyon Lake - Main Basin



No data available from May 2005 - July 2007; June 2012 - July 2015

Canyon Lake (Main Basin) - 2007-2016

Average Dissolved Oxygen Concentrations  
Canyon Lake - East Basin

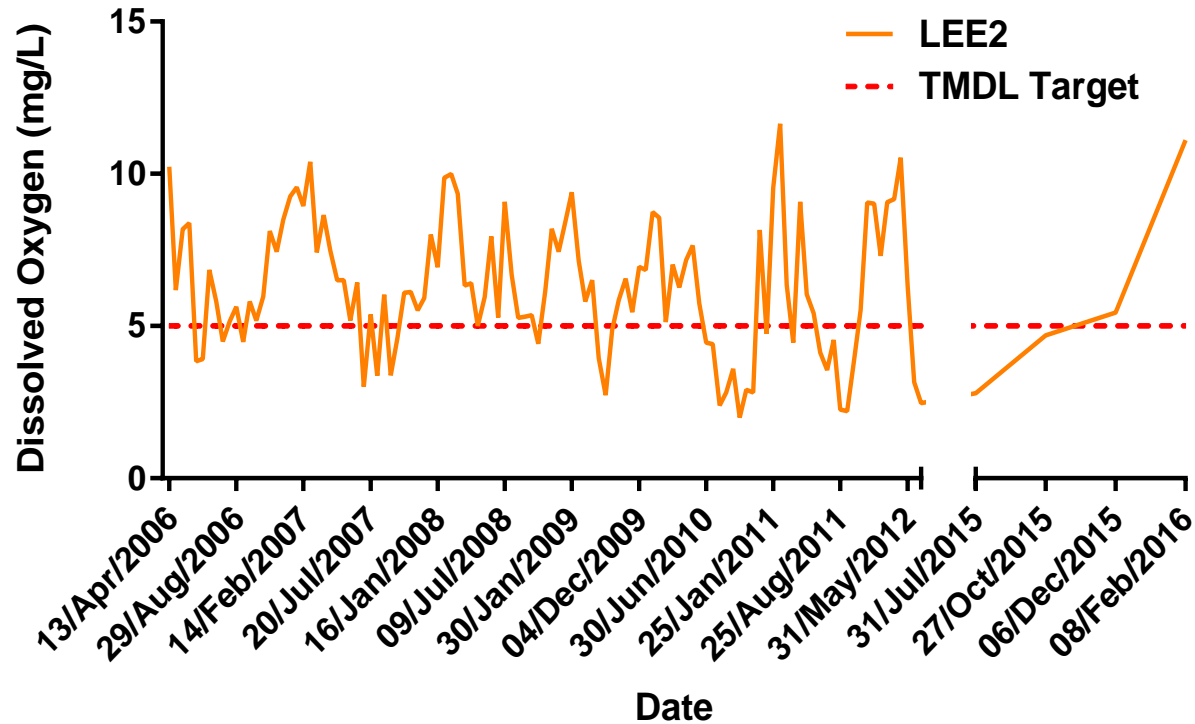


No data available from May 2005 - July 2007; June 2012 - July 2015

Canyon Lake (East Basin) - 2007-2016



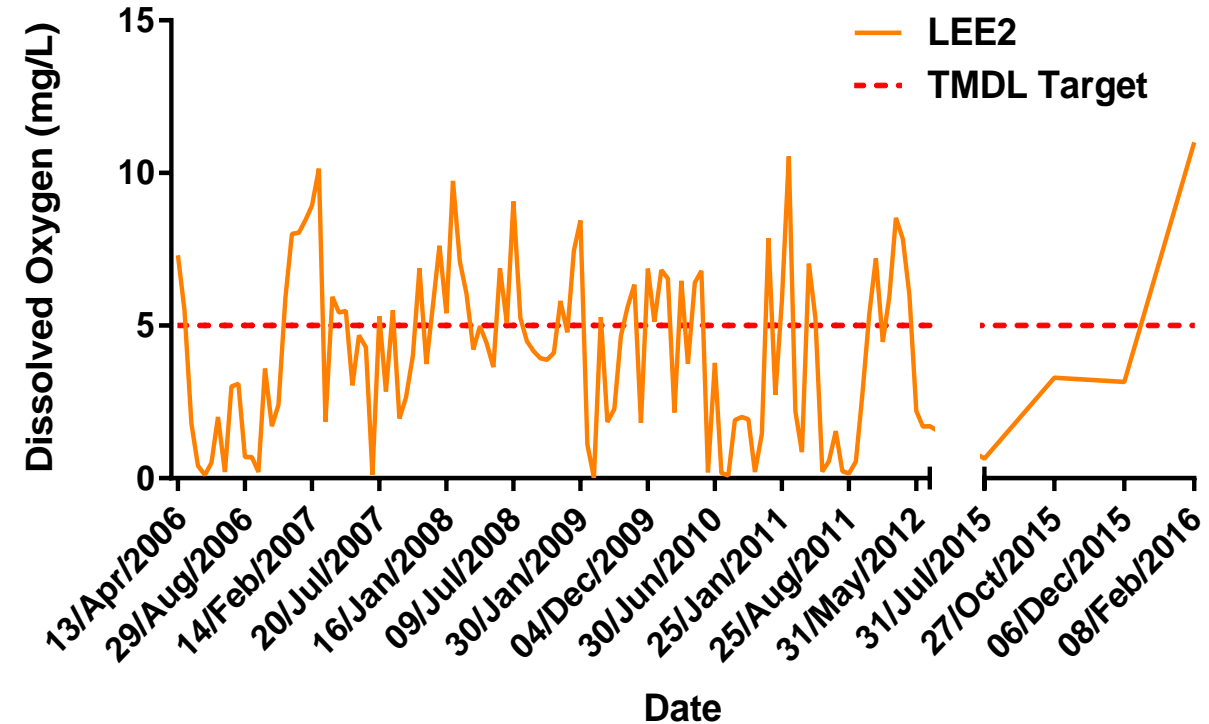
# Dissolved Oxygen Observations – Lake Elsinore



No data available from June 2012-July 2015

TMDL target of 5 mg/L is depth average to be attained by 2015

**Depth Integrated - 2006-2016**



No data available from June 2012-July 2015

TMDL target of 5 mg/L is 1m off lake bottom to be attained by 2015

**1 meter from Bottom - 2006-2016**

# Ammonia Toxicity

- US EPA 1999 ammonia toxicity criteria basis for calculated concentration of un-ionized ammonia  $\text{NH}_3$
- Acute (30-day) and chronic (1-hour) thresholds for ammonia nitrogen exceeded no more than once in 3 years, on average

pH-dependent values of ammonia acute toxicity criteria (total ammonia nitrogen, in mg N/L)		Temperature and pH-dependent values for ammonia chronic criteria (total ammonia nitrogen, in mg N/L)								
pH	CMC	Temperature (C)								
		14	16	18	20	22	24	26	28	30
8.0	8.41	2.430	2.210	1.940	1.710	1.500	1.320	1.160	1.020	0.897
8.5	3.20	1.090	0.990	0.870	0.765	0.672	0.591	0.520	0.457	0.401
8.6	2.65	0.920	0.836	0.735	0.646	0.568	0.449	0.439	0.386	0.339
8.7	2.20	0.778	0.707	0.622	0.547	0.480	0.422	0.371	0.326	0.287
8.8	1.84	0.661	0.601	0.528	0.464	0.408	0.359	0.315	0.277	0.244
8.9	1.56	0.565	0.513	0.451	0.397	0.349	0.306	0.269	0.237	0.208
9.0	1.32	0.486	0.442	0.389	0.342	0.300	0.264	0.232	0.204	0.179
9.5	0.70									
10.0	0.50									

- New US EPA toxicity criteria developed in 2013

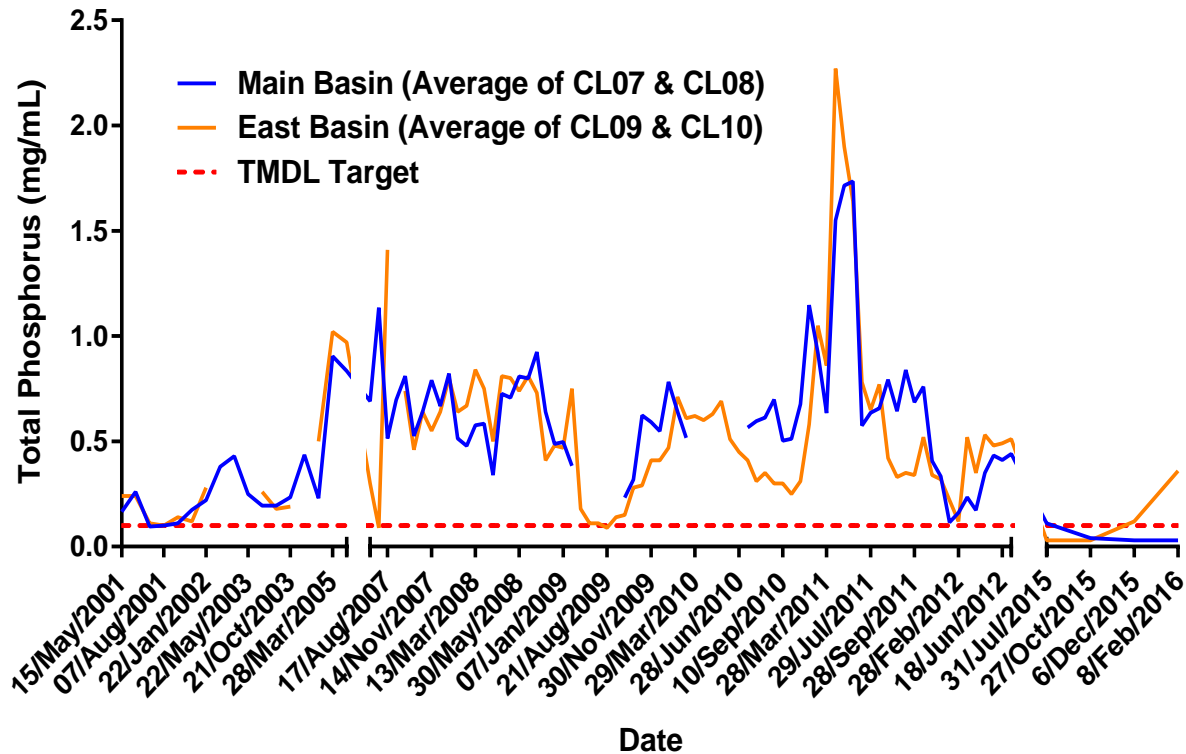
# Numeric Causal Targets

- Total Phosphorus
- Total Nitrogen

# Total Phosphorus

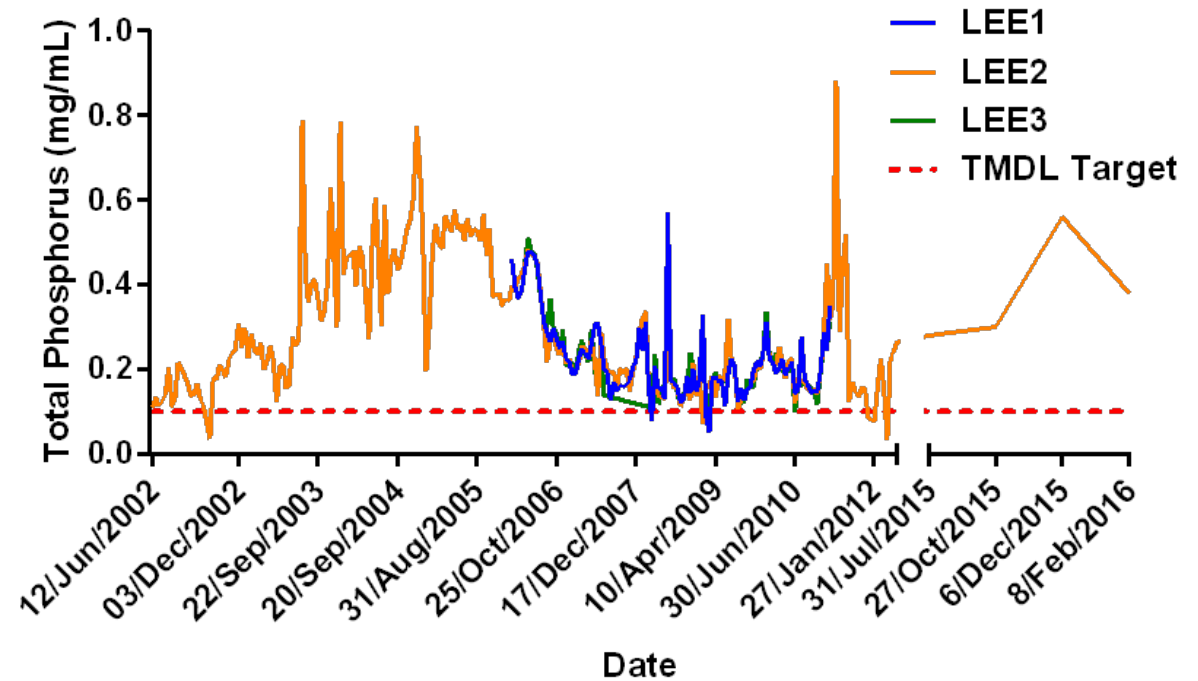
- Numeric Target: 0.1 mg/L for both Lake Elsinore and Canyon Lake
  - Annual averaging period
  - Depth integrated average concentration
- Basis for Target:
  - 25<sup>th</sup> percentile of 2001-2002 data for Lake Elsinore, assumed to be a reference condition year for Lake Elsinore (no algal blooms or fish kills; 1240' water level)
  - Lake Elsinore calculated target cross-applied to Canyon Lake
- Other Targets Considered:
  - Initially proposed 0.1 mg/L as interim (2015) target, but changed it to 0.1 mg/L as the final (2020) target in Supplemental Staff Report (December 20, 2004)
  - Initially, a lower target of 0.05 mg/L total phosphorus was proposed, but target was found to be unachievable even in a completely forested watershed

# Total Phosphorus Observations



No data available from May 2005-July 2007; June 2012-July 2015  
 TMDL target of 0.1 mg/L is annual average to be attained by 2020

**Canyon Lake – 2001-2016**



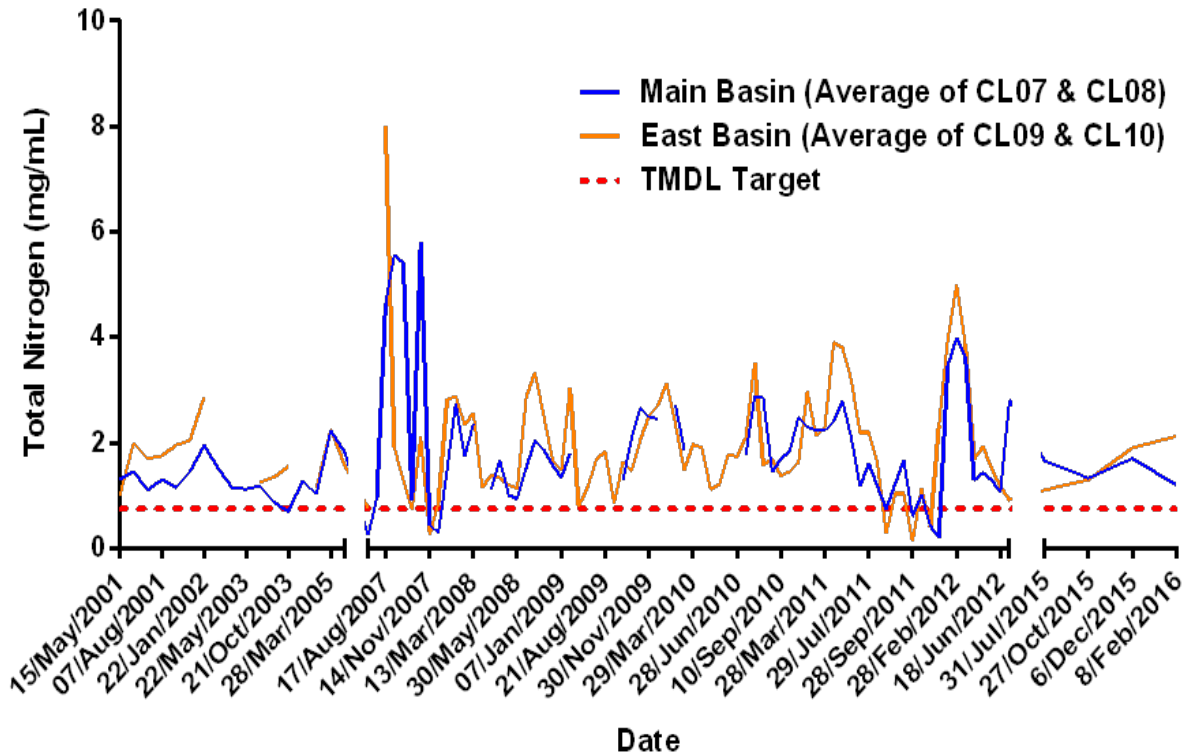
No data available from June 2012-July 2015  
 TMDL target of 0.1 mg/L is annual average to be attained by 2020

**Lake Elsinore – 2002-2016**

# Total Nitrogen

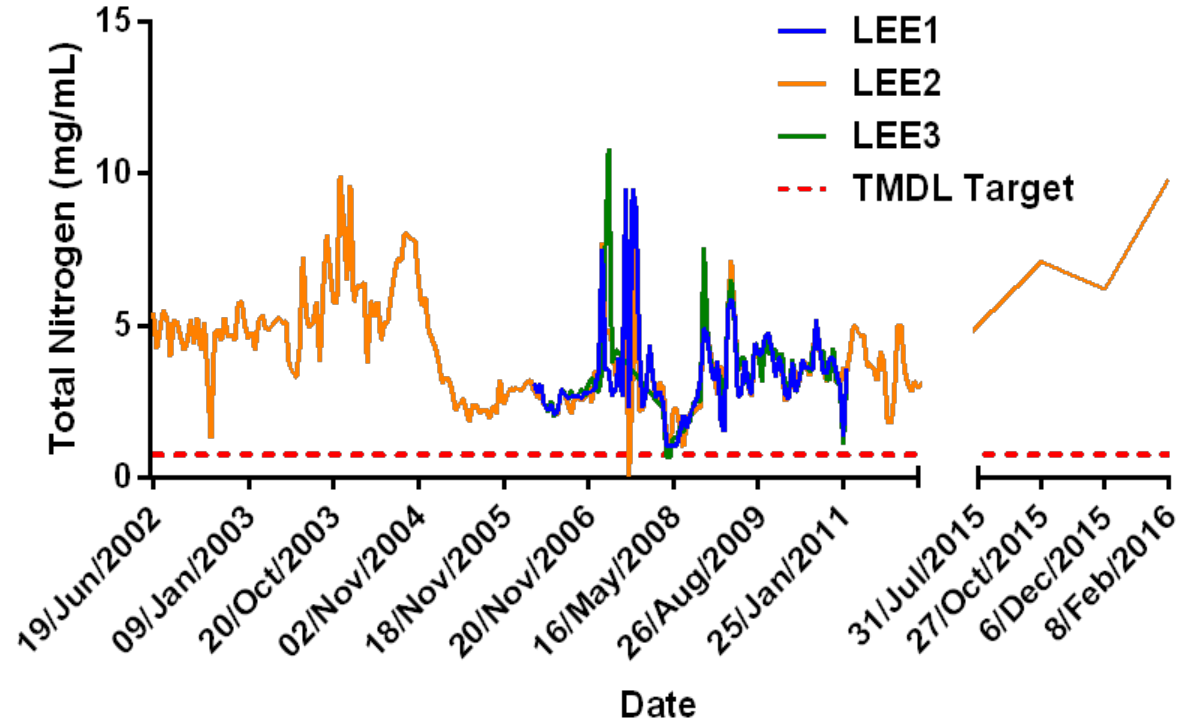
- Numeric Target: 1.0 mg/L for both Lake Elsinore and Canyon Lake
  - Annual averaging period
  - Depth integrated average concentration
- Basis: Target TN/TP ratio of 10:1 to maintain nutrient balance for beneficial algal growth (10 times phosphorus target)

# Total Nitrogen Observations



No data available from May 2005-July 2007; June 2012-July 2015  
 TMDL target of 0.75 mg/L is annual average to be attained by 2020

**Canyon Lake – 2001-2016**

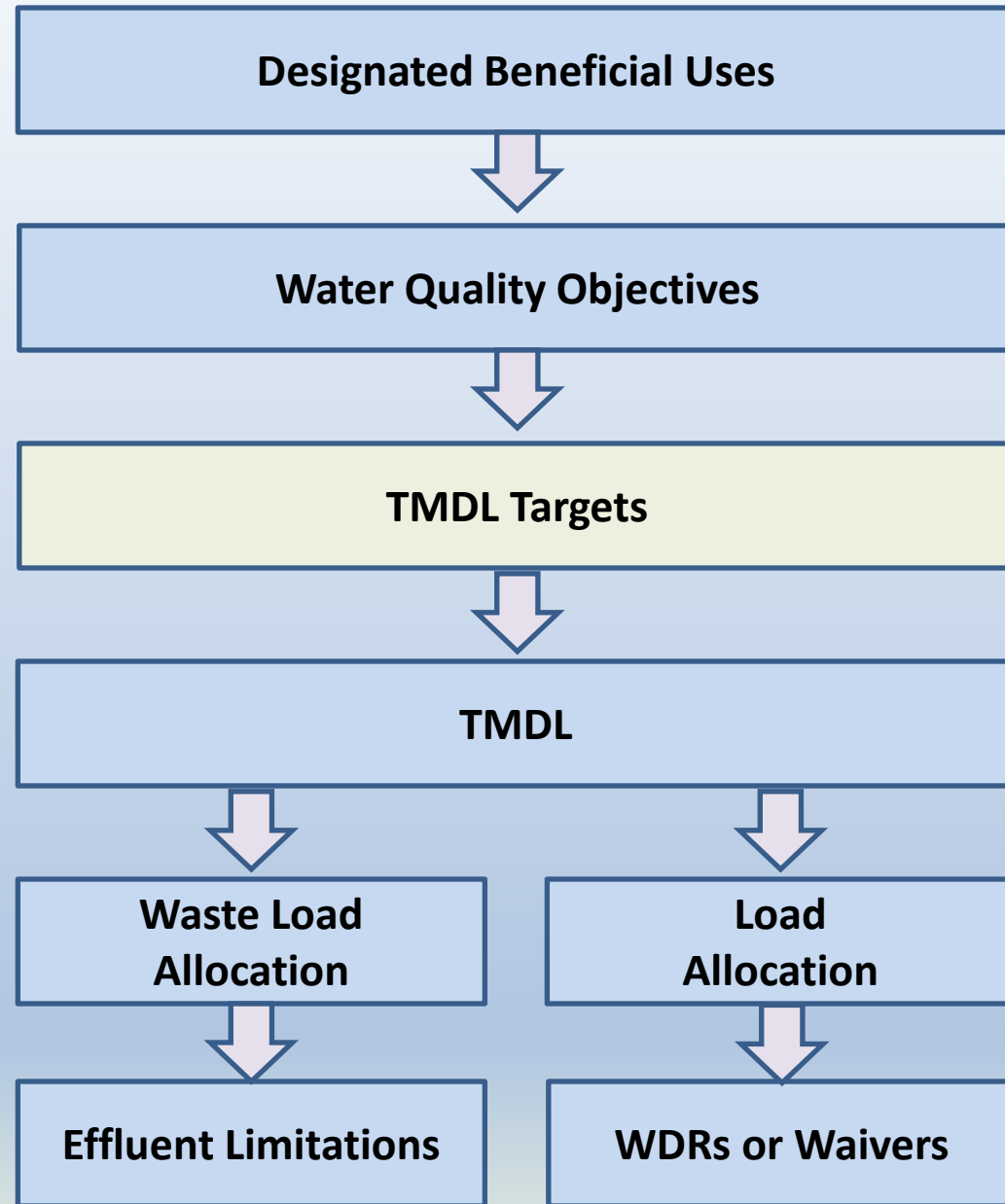


No data available from June 2012-July 2015  
 TMDL target of 0.75 mg/L is annual average to be attained by 2020

**Lake Elsinore – 2002-2016**

# Revising the TMDL Water Quality Targets





# Designated Beneficial Uses

## Canyon Lake

Warm

REC-1 & REC-2

MUN

## Lake Elsinore

Warm

REC-1 & REC-2

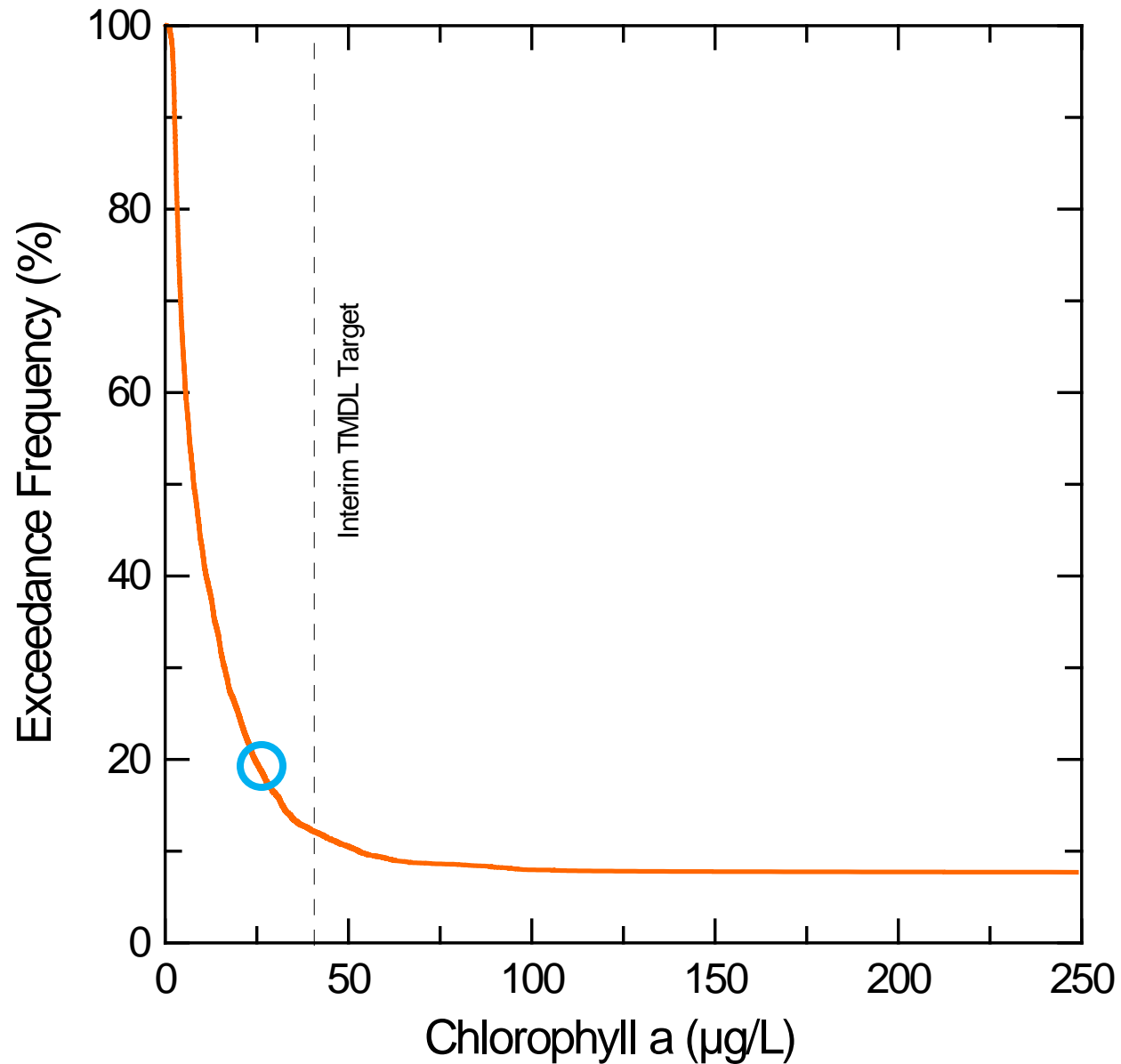
# Water Quality Objectives

Water Quality Objectives	WARM	REC-1 & 2	MUN
Nitrogen	Lake Elsinore = 1.5 mg/L as TIN		Canyon Lake = 8.0 mg/L as TIN
Ammonia	Numeric formula (pH & temperature)	N/A	N/A
DO	≤ 5 mg/L	N/A	N/A
Algae	“Discharges shall not contribute to excessive algae growth”		
Salinity	Lake Elsinore = 2,000 mg/L and Canyon Lake = 700 mg/L		
Phosphorus	None		
Chlorophyll-a	None		
Narrative	Discharge of waste shall not degrade aquatic populations	Discharge of waste shall not cause nuisance	No discharge of waste harmful to human health or creating nuisance (taste/odor)

# Problems w/ Current TMDL Targets

- Underestimated natural background loads
- Assumed static lake levels
- Literature-based targets for TP, TN & Chl-*a*
- Underestimated in-lake nutrient cycling
- Did not evaluate target attainability
- Targets expressed as Not-to-Exceed values
- Did not account for asymmetric loading rates
- Did not specify averaging procedures

# Natural Exceedances in Lake Elsinore



# Natural Exceedances in Canyon Lake

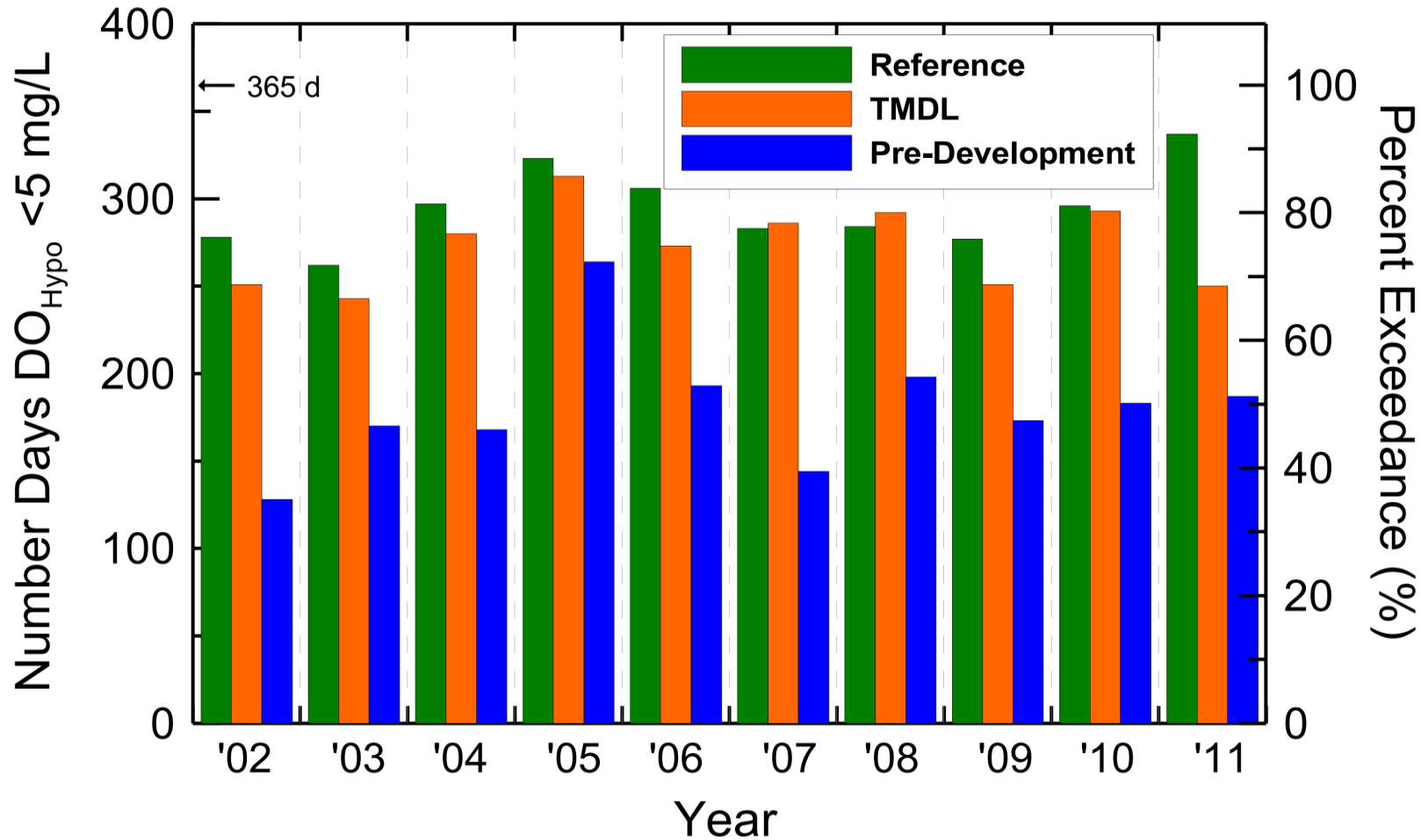


Fig. 8. Number of days each year when hypolimnetic DO concentrations were below the TMDL target of 5 mg/L under the reference (existing) condition, TMDL-prescribed reductions in external loading, and the pre-development scenario.

# Broken Linkage Analysis

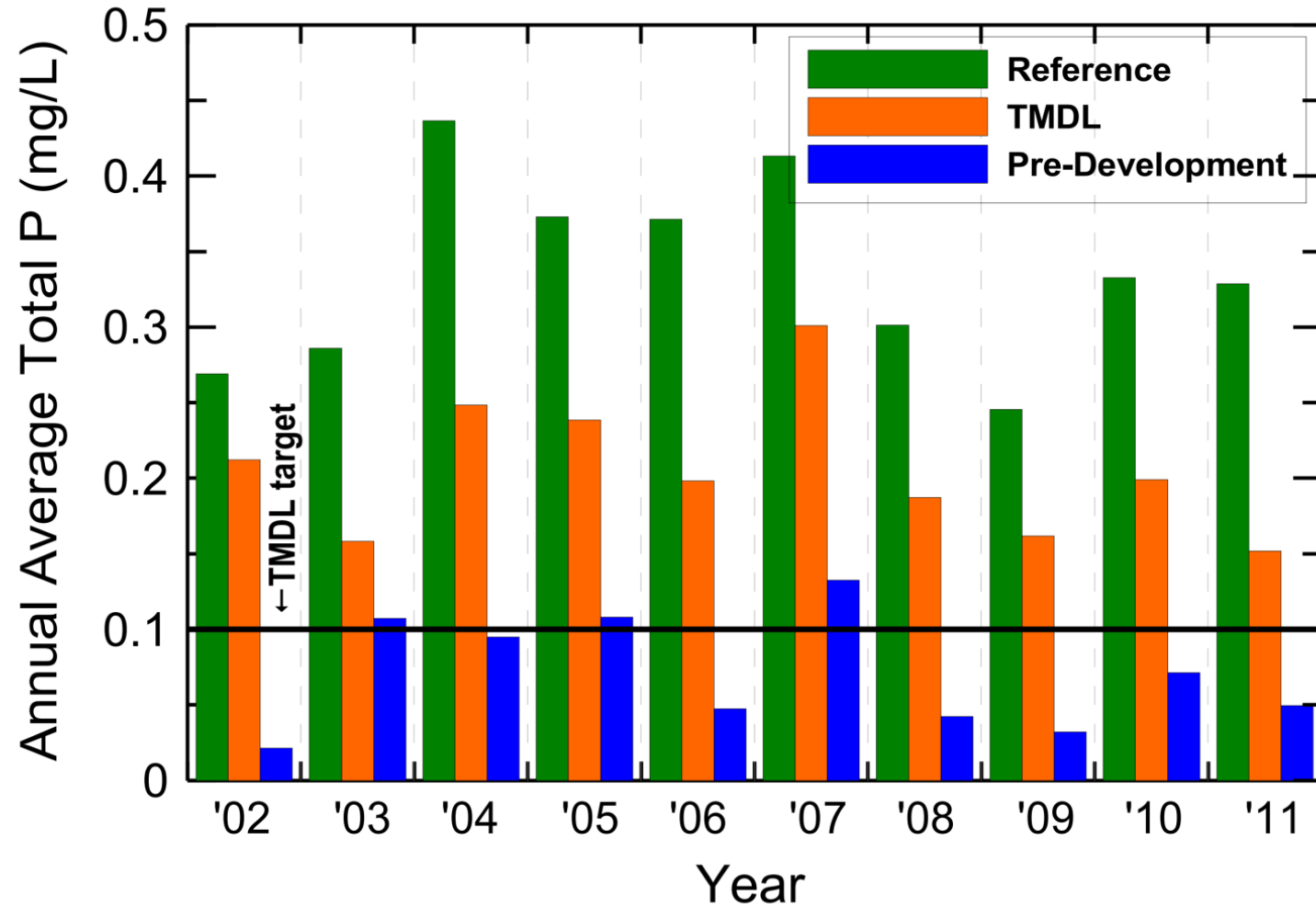


Fig. 4. Annual average total P concentrations under the reference (existing) condition, TMDL-prescribed reductions in external loading, and the pre-development scenario.

# Dynamic Level of Lake Elsinore

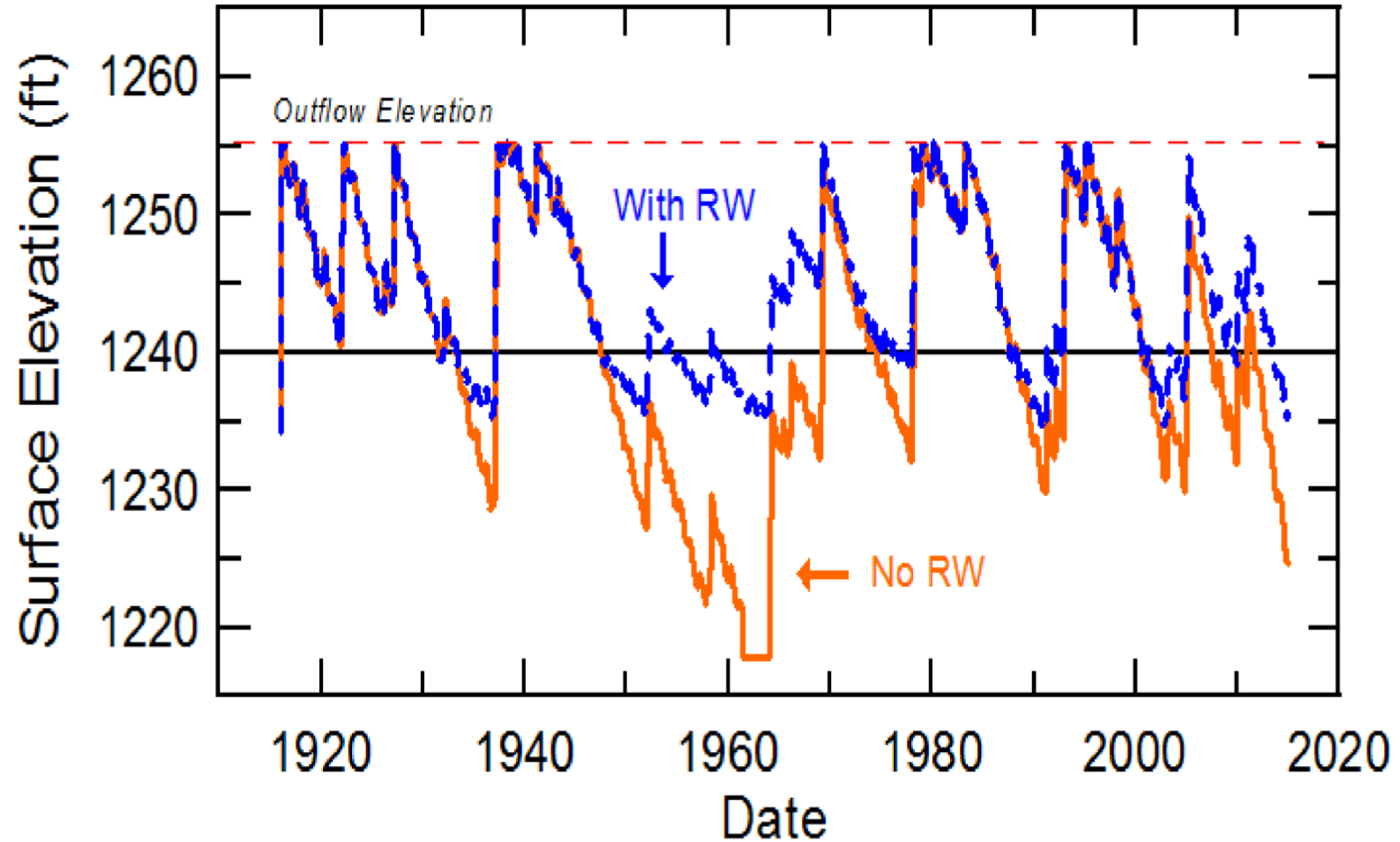
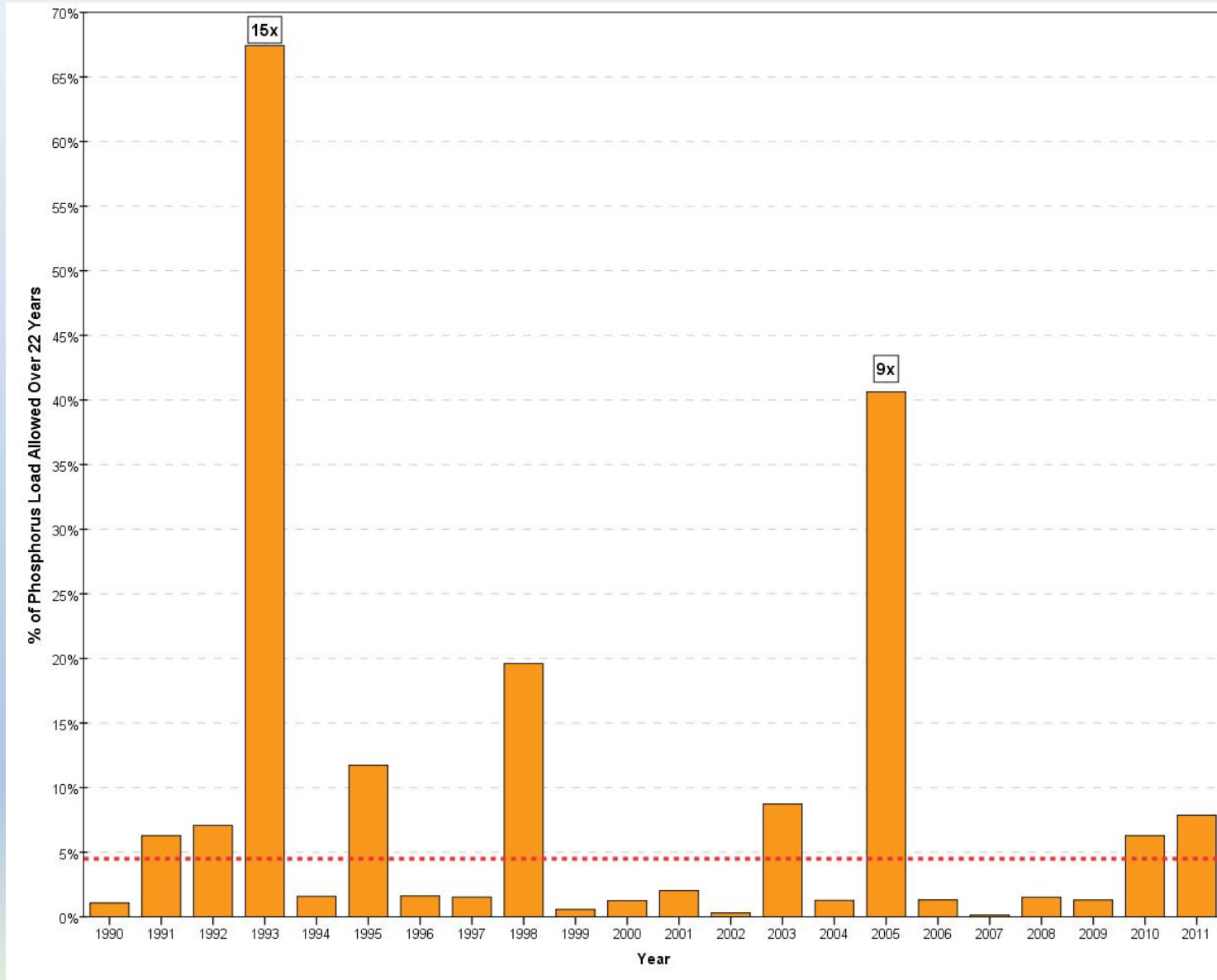


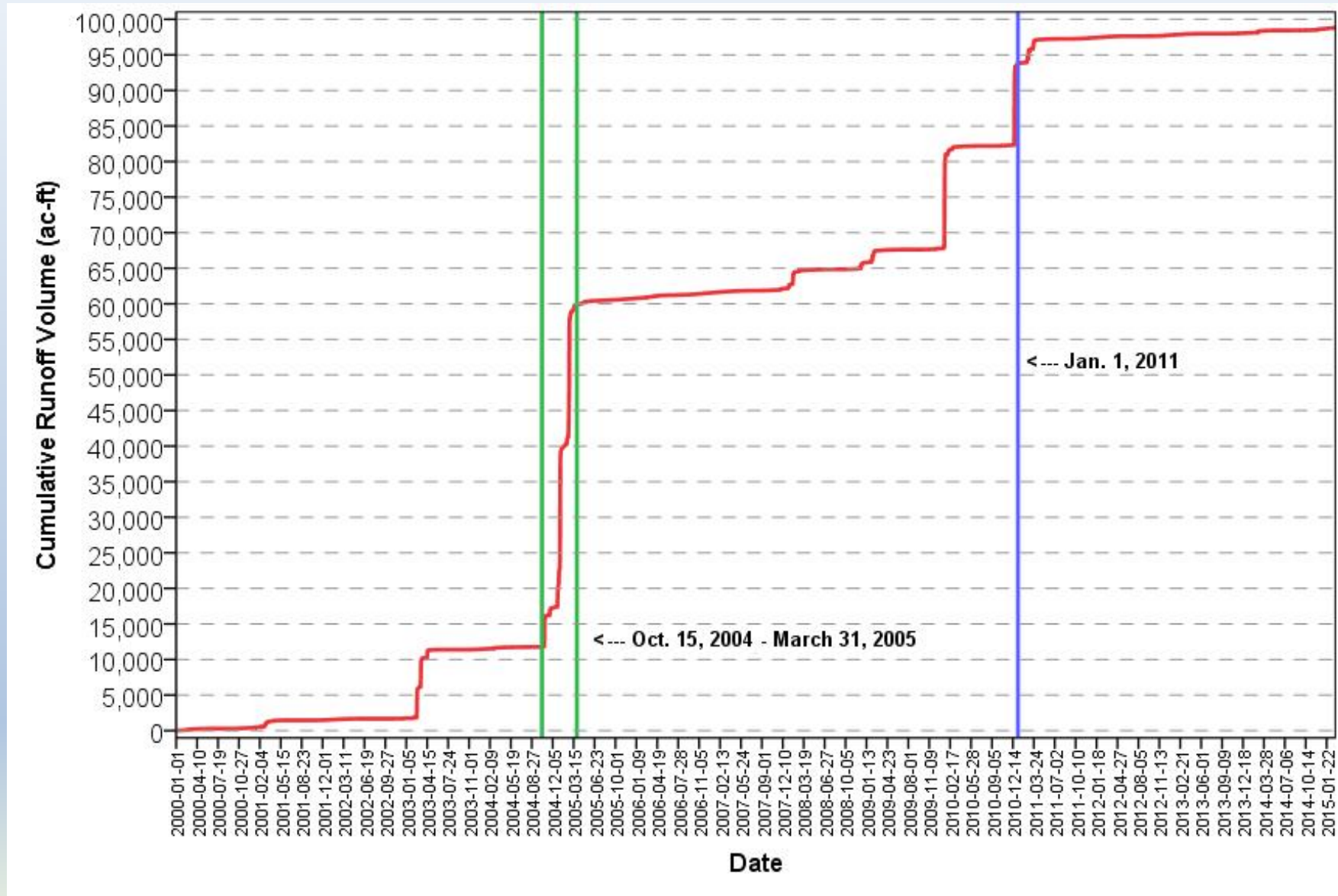
Fig. 1. Lake surface elevation with LEMP basin and natural flows (solid orange line) and supplemented inflows with recycled water (dashed blue line).



# Asymmetric Loading to Canyon Lake



# Asymmetric Loading to Lake Elsinore

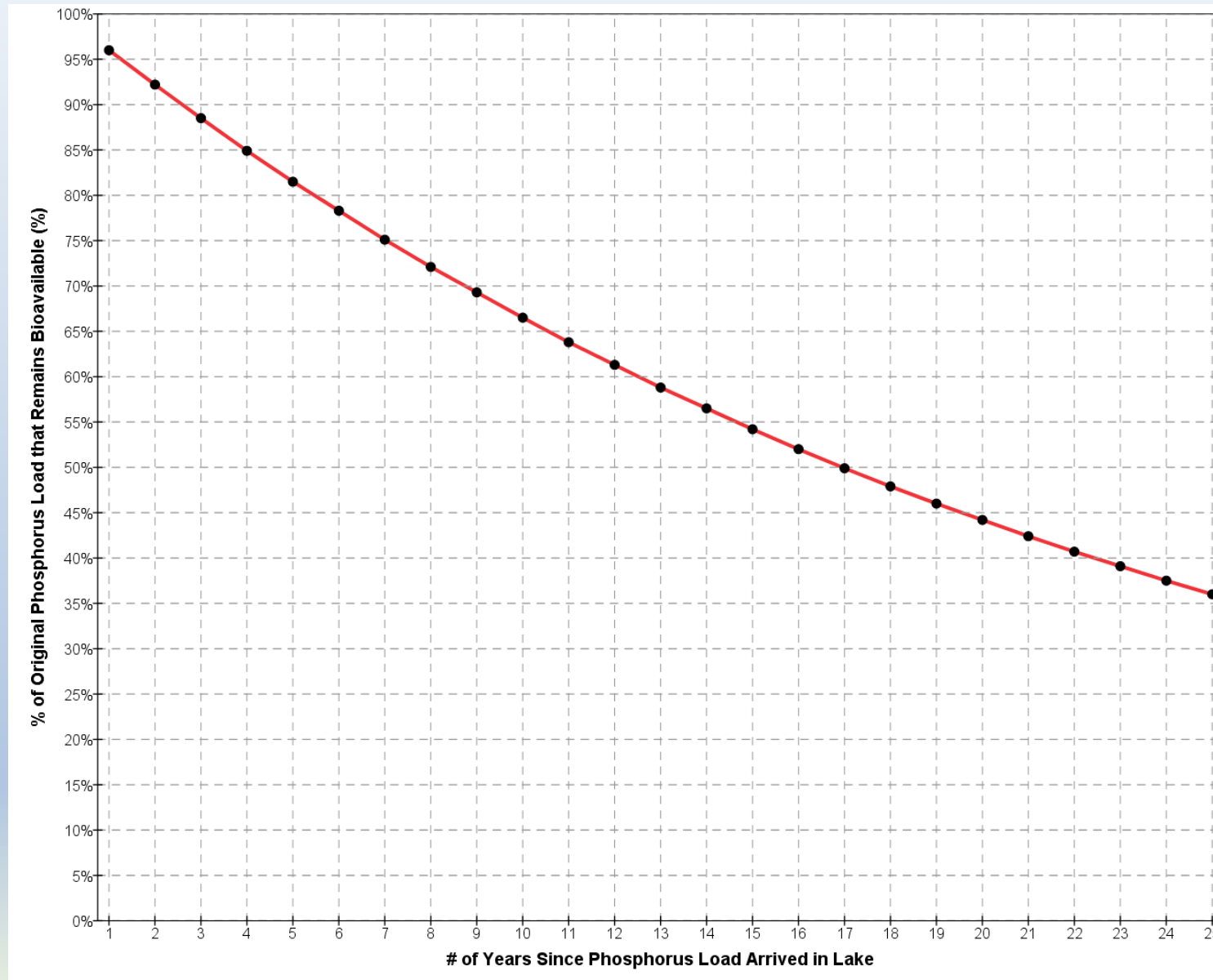


# In-Lake Nutrient Cycling

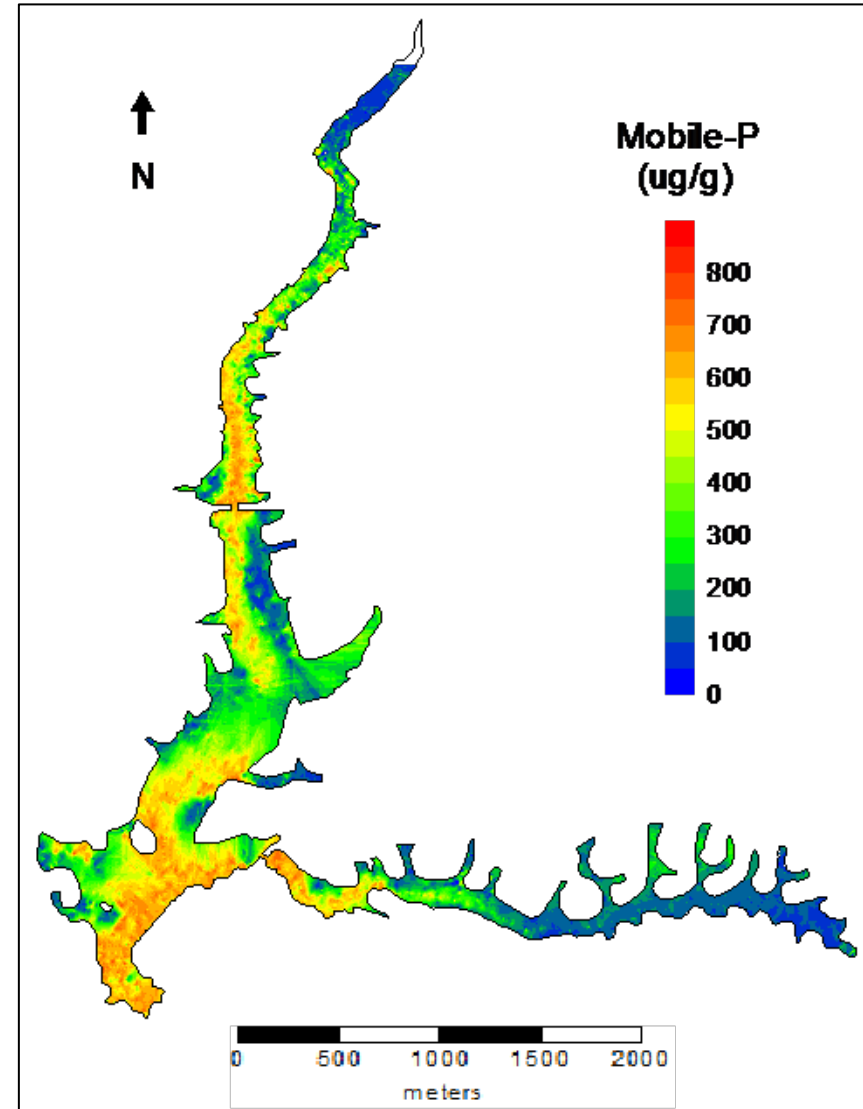
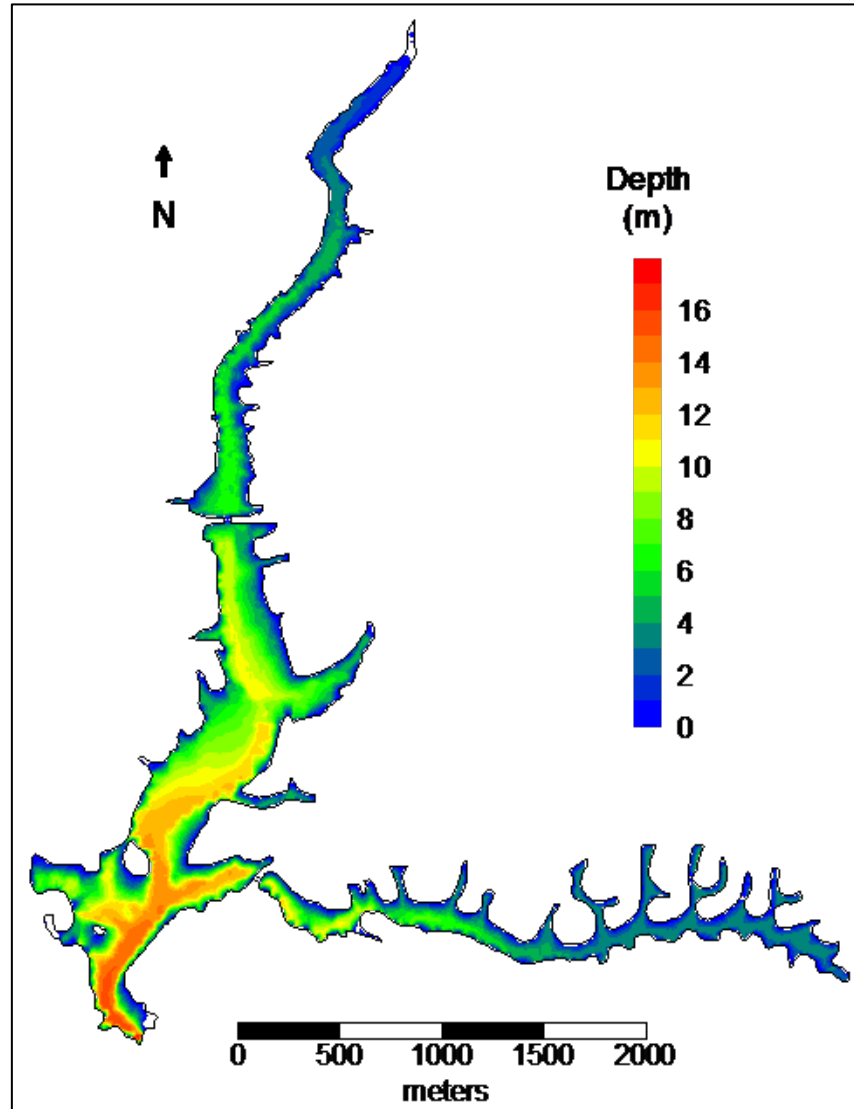
Table X. Mineralization rate and half-life for total organic C, total N and organic P in East Bay, Canyon Lake and Lake Elsinore.

	$k_r$ (yr <sup>-1</sup> )		$t_{1/2}$	
	1-phase	2-phase	1-phase	2-phase
<b><i>Canyon Lake</i></b>				
Organic C	0.050 ± 0.010	0.113 ± 0.081	13.9 ± 2.9	8.2 ± 5.9
Total N	0.042 ± 0.002	0.065 ± 0.018	16.5 ± 0.8	11.1 ± 3.1
Organic P	0.105 ± 0.015	0.125 ± 0.071	6.7 ± 1.0	6.6 ± 3.7
<b><i>Lake Elsinore</i></b>				
Organic C	0.029 ± na	0.047 ± na	23.9 ± na	14.7 ± na
Total N	0.023 ± na	0.043 ± na	30.1 ± na	16.0 ± na
Organic P	0.011 ± na	0.023 ± na	60.4 ± na	29.7 ± na

# Slow Decay Rate for Phosphorus



# Canyon Lake Bathymetry & Sediments



# Unique Factors: Lake Elsinore

- Terminal lake w/ very little flushing flow
- Periodically DRY under natural conditions
- Naturally-elevated TDS concentrations
- Artificially maintained ecosystem
  - Levee constructed in 1996
  - Recycled water added since 2002
  - Large-scale fishery management program
  - Aeration and mixing system since 2008

# Unique Factors: Canyon Lake

- Ratio of watershed area to lake area
- Reservoir operated with little flow-through
- Min. lake level required by contract
- Little hydraulic interaction between branches
- East Bay extremely shallow

# Unique Factors: Both Lakes

- Low average precipitation
- Extreme asymmetry in runoff
- High evaporation rates
- Abundant sunshine
- No natural reset mechanism



# Target-setting Approach

- Literature Values
- Reference Conditions
  - Nutrient loads from the undeveloped watershed
  - Simulations of the pre-development condition
  - Corroborated by historical records
- Highest Sustainable Use
- Best Available Technology (BAT)
- Net Environmental Benefit (EPA's EDWP)

# Reference Conditions

- Lake Elsinore in 1972 & 1994 (pre-LEMP)
- Pre-development land use assumptions
- Validated natural background loads
- Variable lake levels and water quality
- No recycled water
- No aeration and mixing system
- Limited fishery management program

# TDS in Lake Elsinore

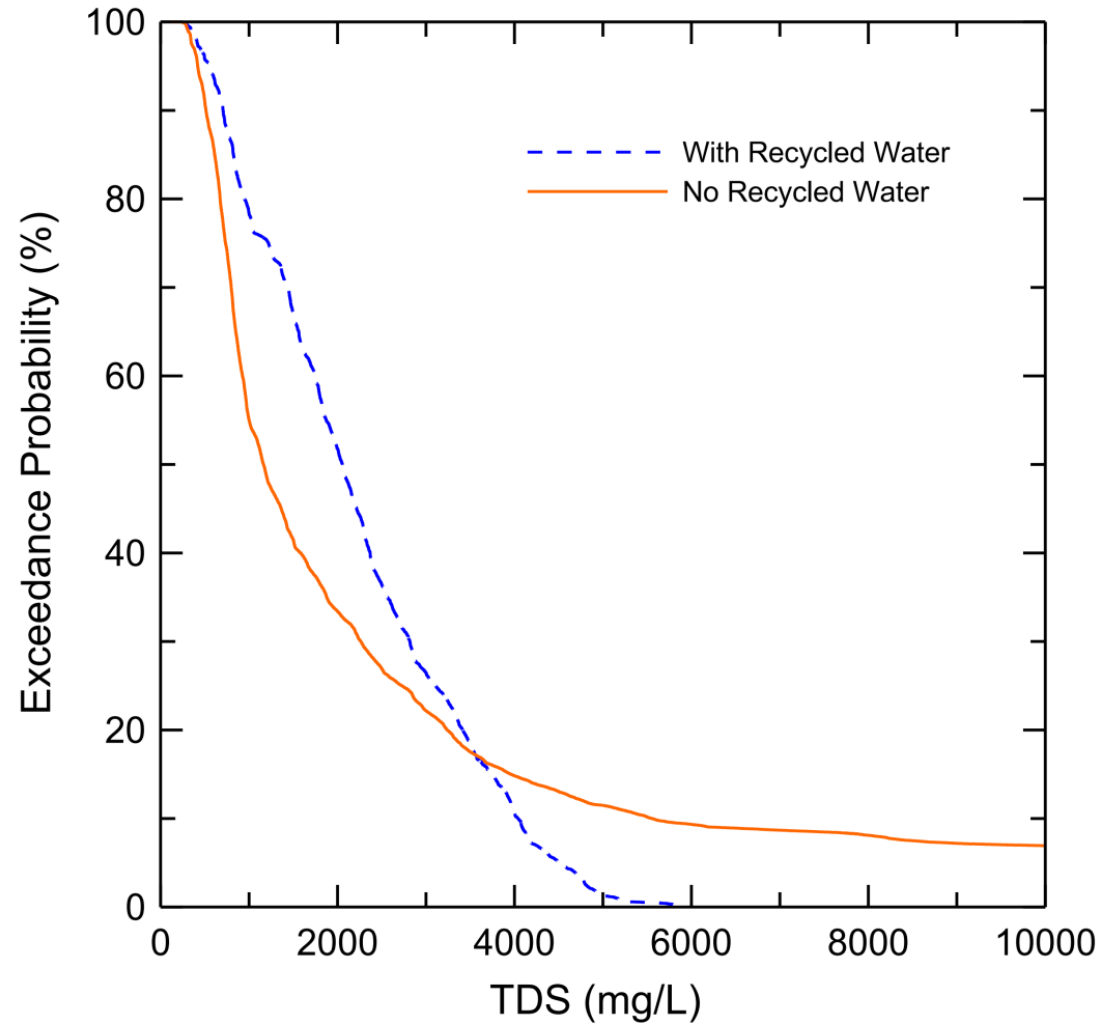
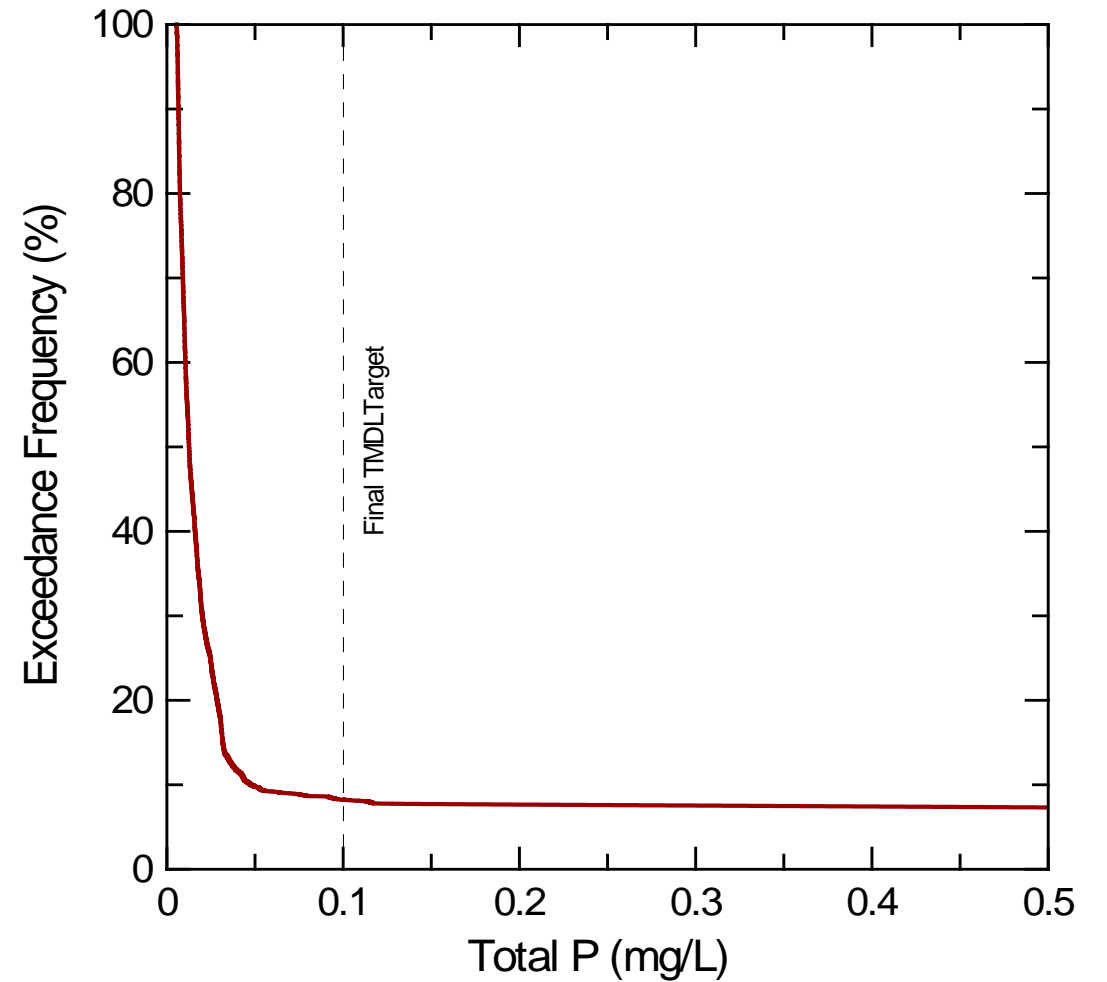
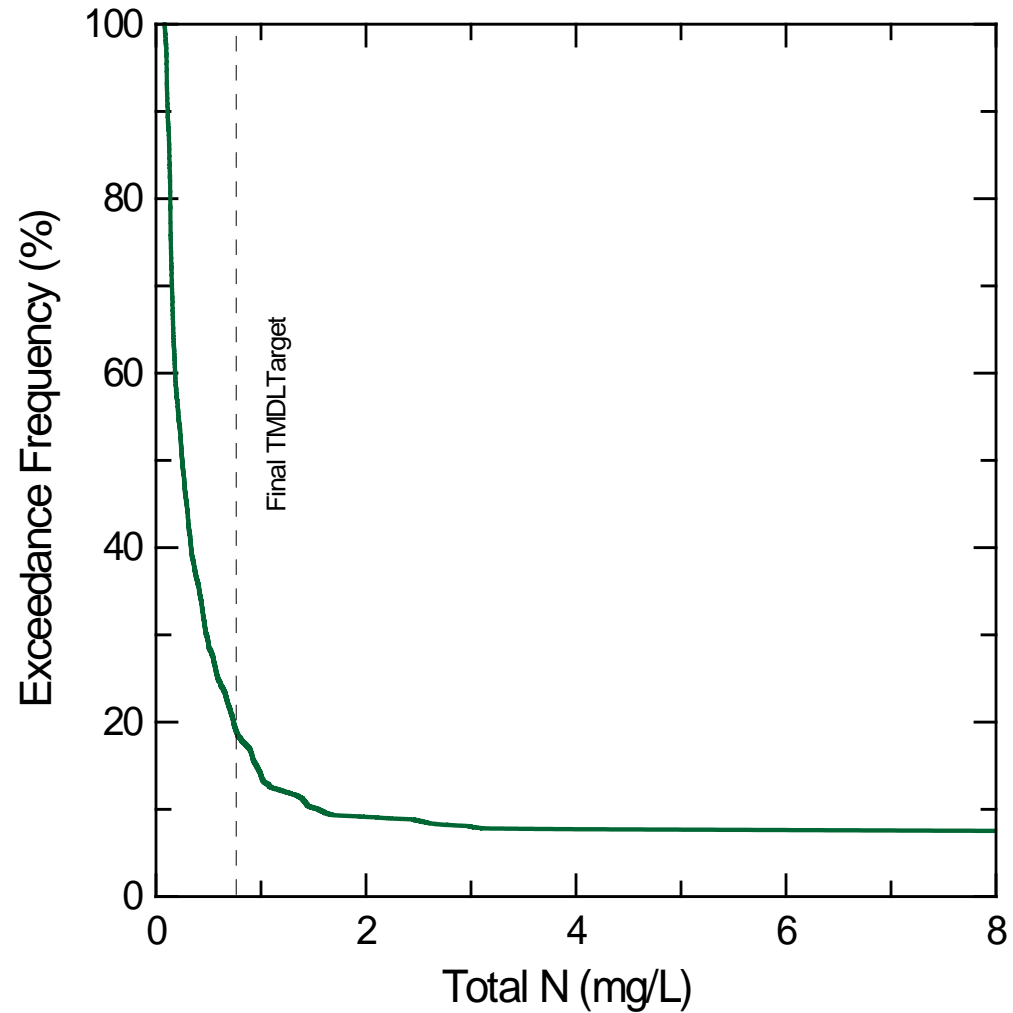
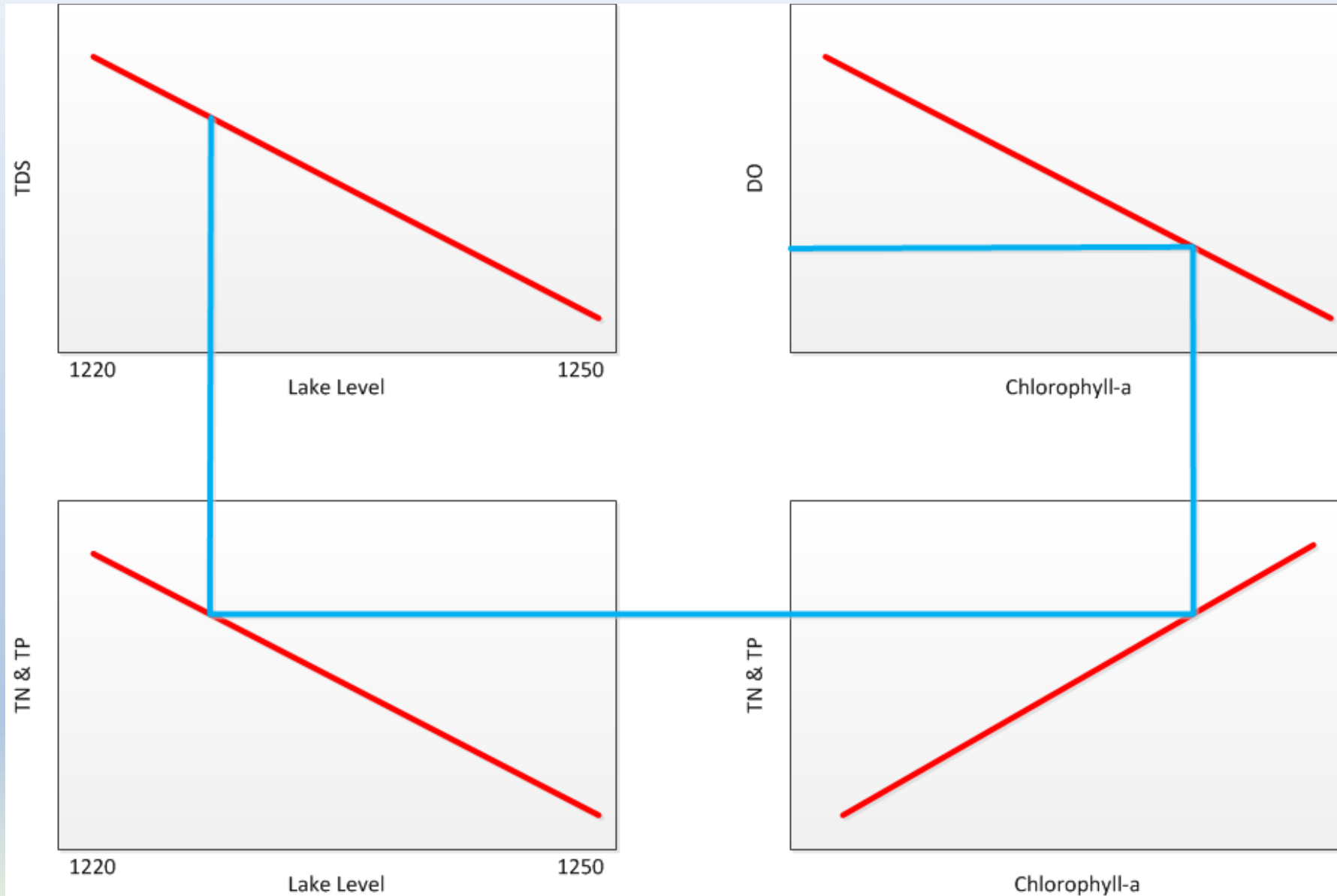


Fig. 6. Cumulative distribution function showing exceedance probability for TDS concentrations for the LEMP basin with natural flows (solid orange line) and inflows supplemented with recycled water (dashed blue line).

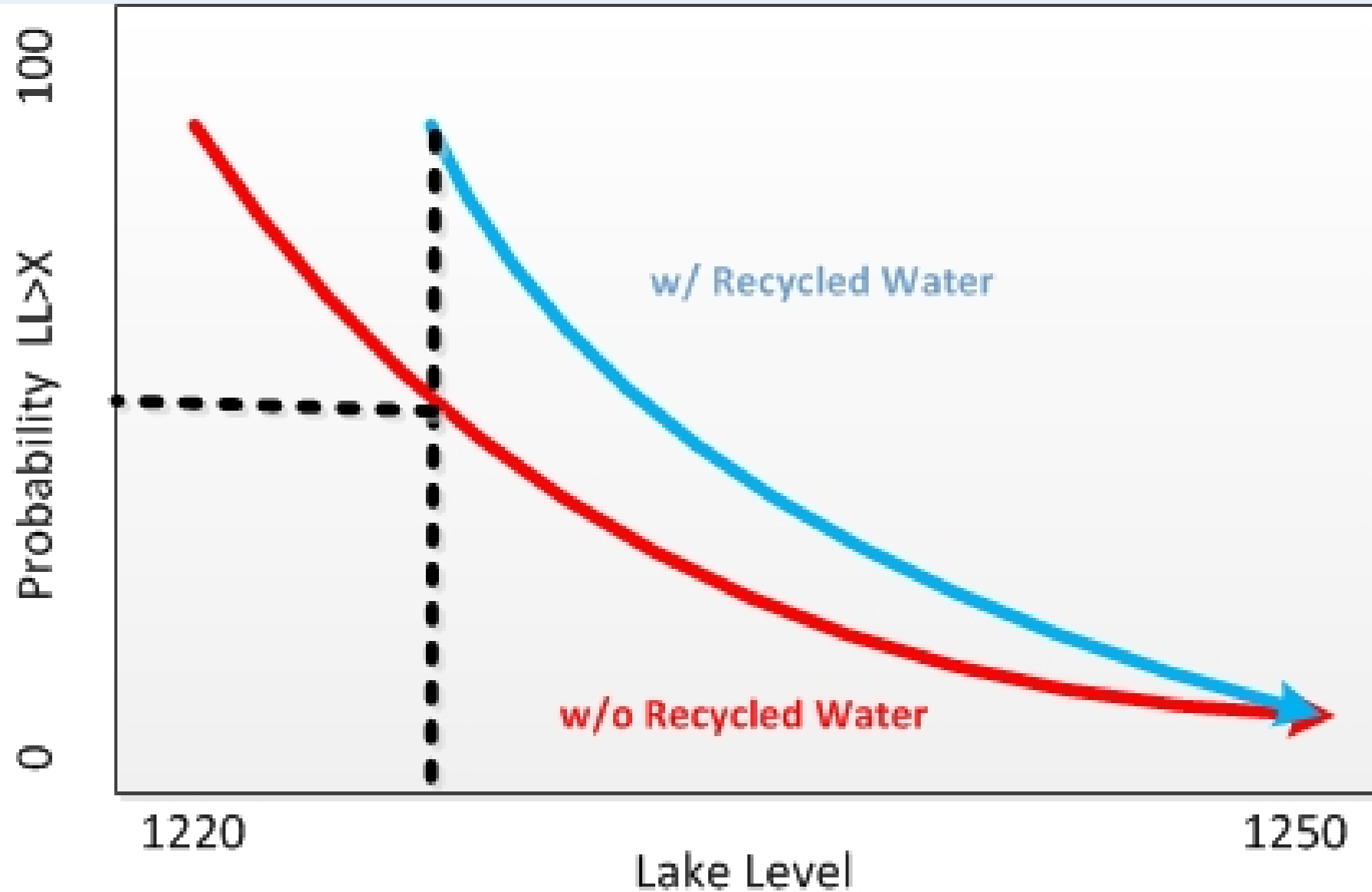
# Nutrients in Lake Elsinore



# Conceptual Target Derivation



# Net Environmental Benefit

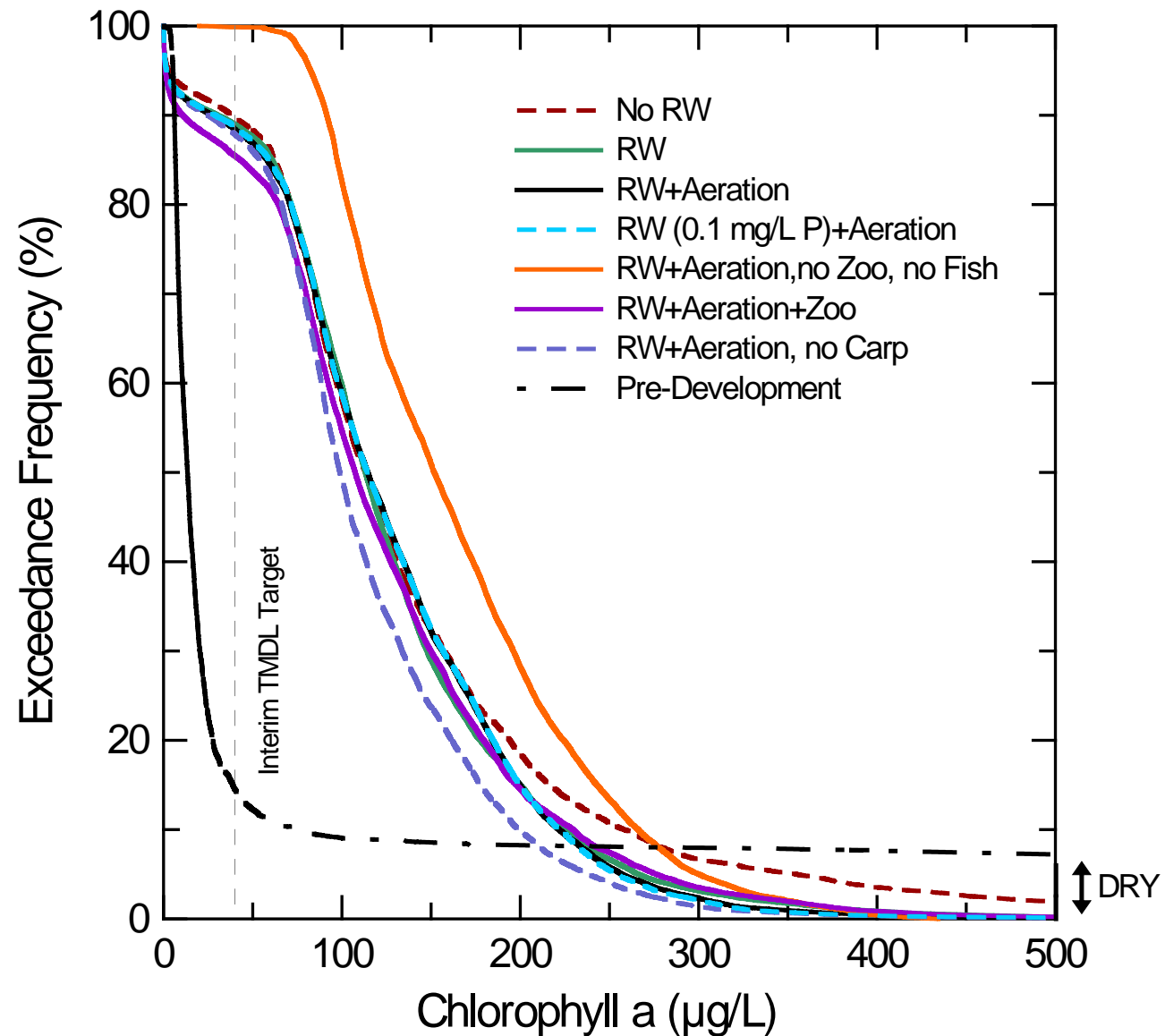


# Net Environmental Benefit

## Mean Predicted Values: 1916-2014

	Mean Concentration (mg/L or µg/L)			
	DO	Total N	Total P	Chl a
Pre-Development	7.77	0.59	0.02	19.0
Current/no RW	8.85	4.27	0.27	140
With RW	8.30	4.20	0.26	125
With RW+Aeration	9.03	4.01	0.24	125
With RW(0.1 PO <sub>4</sub> )+Aer	9.02	4.01	0.23	125

# Progress Toward Attainment





# Target-setting Goals

- Consider natural background loads
- Consider dynamic lake levels
- Consider asymmetric loading
- Consider slow nutrient decay rates
- Consider full probabilistic range of values
- Consider exceedance frequency
- Consider appropriate averaging strategies
- Consider other water quality constraints
- Consider reasonable attainability
- Consider target hierarchies

# Key Concern: EPA Acceptance

- Well-documented reference condition
- Strong support for highest sustainable use
- Clear proof of Net Environmental Benefit
- Credible evidence of BAT & MEP
- Period reassessment required
- May require Interim & Final targets
- Will require long-term compliance schedules
- May require UAA (Intermittent/Limited?)
- May require Site-specific Objectives
- May require variance from water quality standards



*Lake Elsinore*

# Questions & Discussion



# Monitoring Impacts

# Monitoring Program Impacts

- Numeric targets must be measurable to be effective
- Samples for laboratory analysis cannot be collected daily, across the lakes
- Currently available remote monitoring technologies are limited
- Alternative target setting approach needed

# Monitoring Program

- Current Monitoring Plan elements
  - In-situ depth profiling multi-sensor at two Lake Elsinore sites (Temperature, DO, pH, conductivity)
  - Field measured parameters at three site in Lake Elsinore and three sites in Canyon Lake (Temperature, DO, pH, conductivity)
  - Every other month, discreet (hypolimnion, epilimnion) and depth integrated samples collected for laboratory analysis at one site in Lake Elsinore and four sites in Canyon Lake (NO<sub>2</sub>/3, TAN, TKN, TP, SRP, TDS)
  - Monthly satellite imagery analysis for chlorophyll-a
- Monthly data from single points compared with seasonal and annual targets