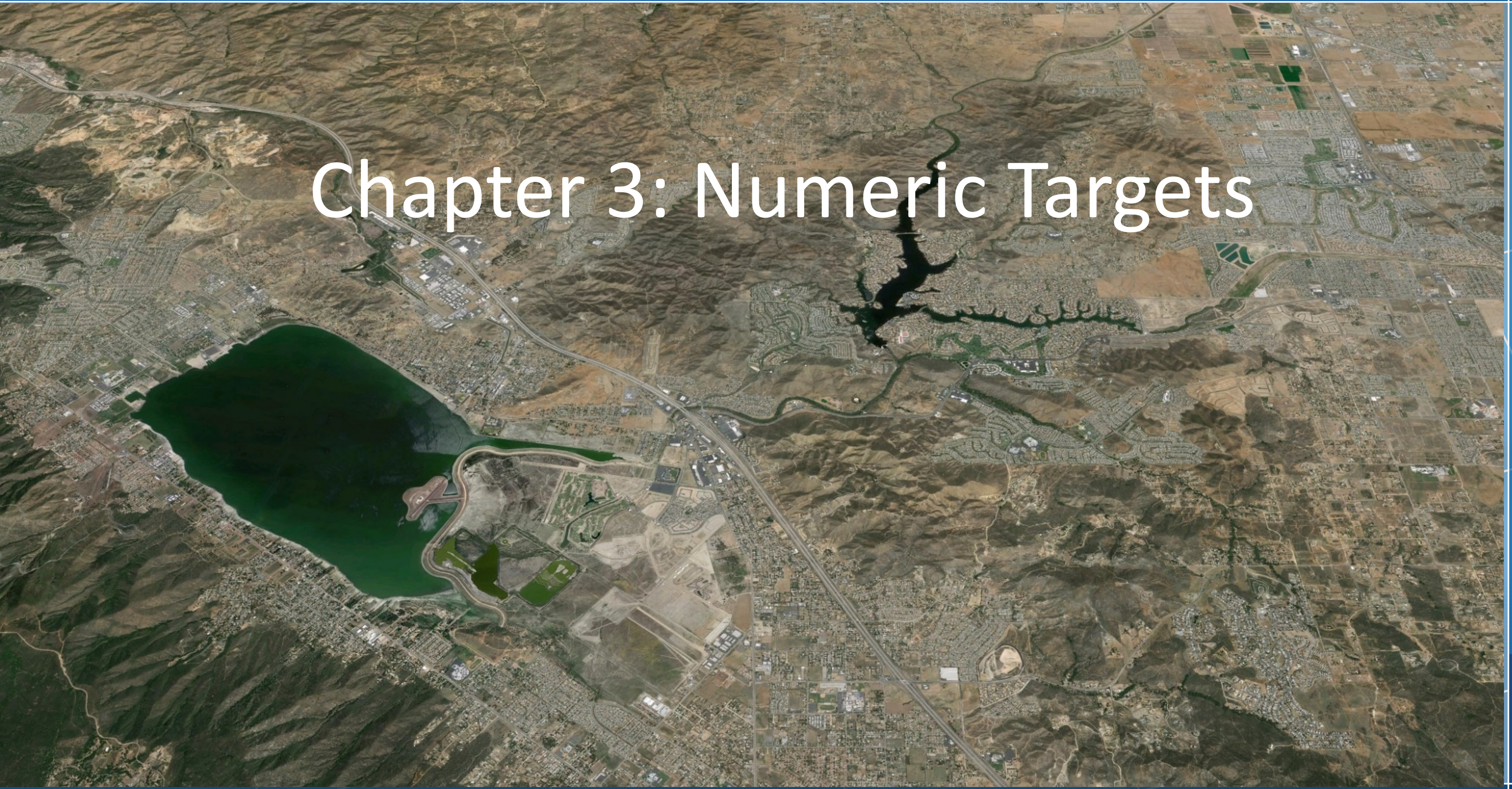
# Revision of the Lake Elsinore & Canyon Lake Nutrient TMDL

CDM Smith Team
& Risk Sciences



## Chapter 3: Numeric Targets

May 3, 2016

Lake Elsinore/Canyon Lake Task Force Meeting

CDM Smith

RISK SCIENCES

# Presentation Outline

- Project Progress/Status
- Baseline versus Managed Lake Condition
- Estimation of Potential Lake Elsinore Numeric Targets
- Multiple Lines of Evidence
- Conservatism
- Canyon Lake Model Development
- Benchmarking against EPA National Lakes Assessment

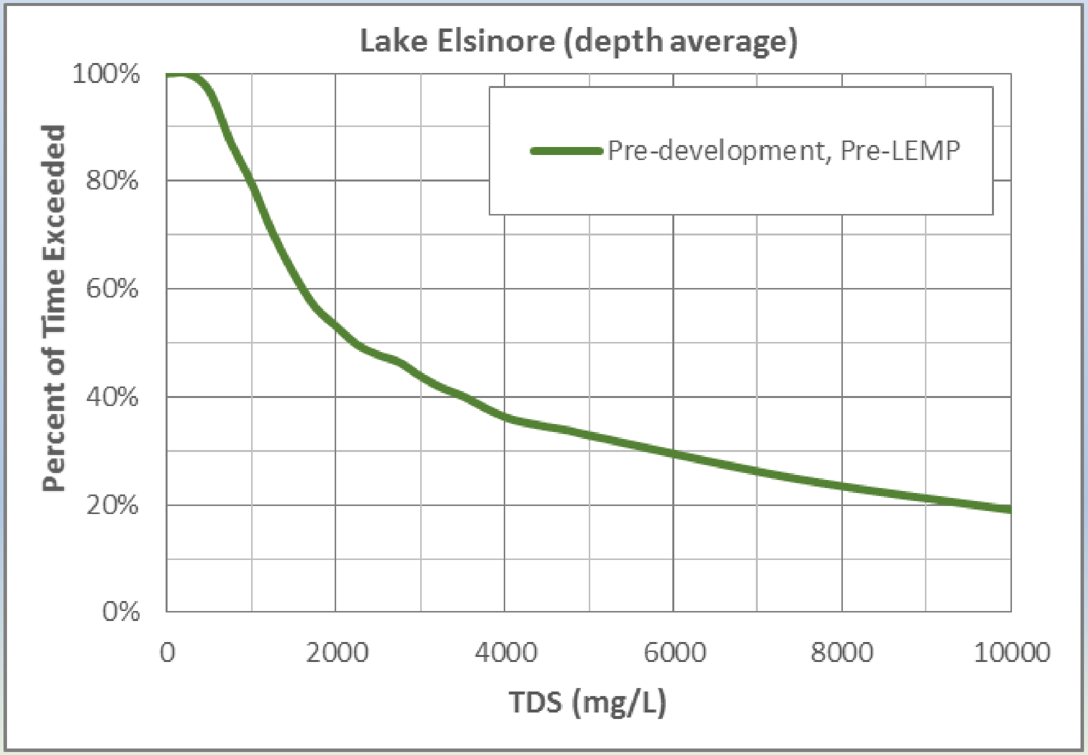
# NUMERIC TARGET DEVELOPMENT

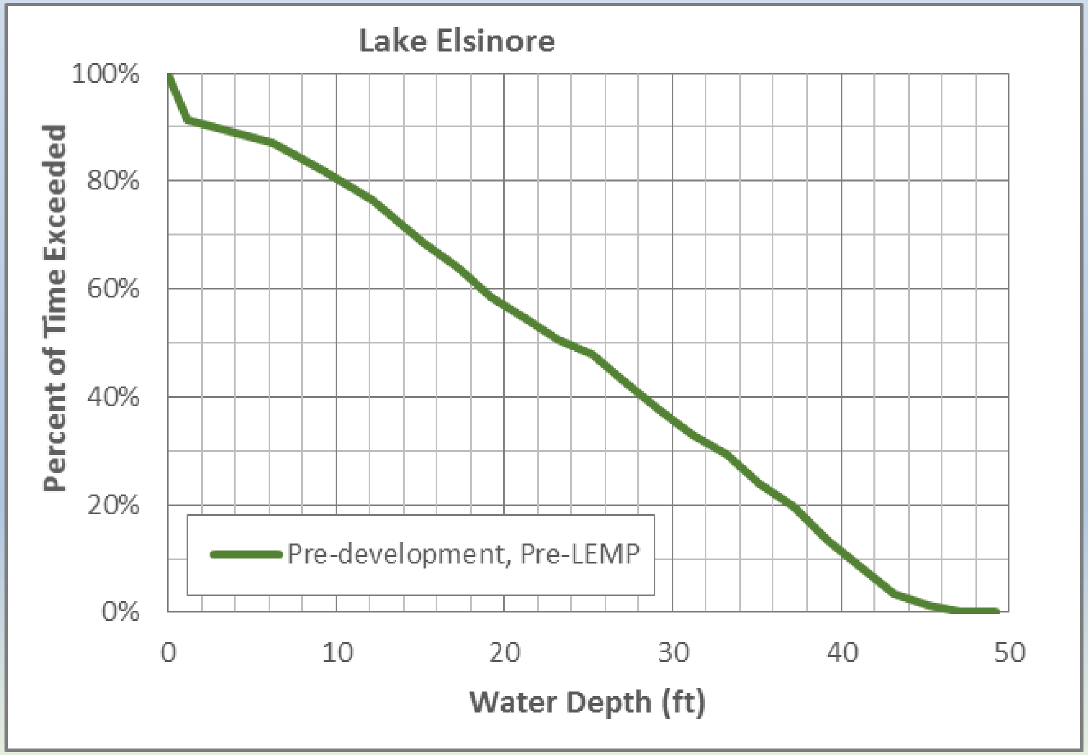
# Numeric Target Development

- Set numeric targets that represent a state that is better than that which occurs naturally
- Consideration of the entire dynamic range of the lake under both pre-development and managed conditions
- Lake models serve as the basis to characterize long term dynamic water quality
- Identify uncertainties and data limitations as well as opportunities for supporting lines of evidence

# Baseline Condition

- Prior to LEMP and without lake level stabilization with recycled water
- Naturally occurring dry or hypersaline conditions during drought impair WARM freshwater use



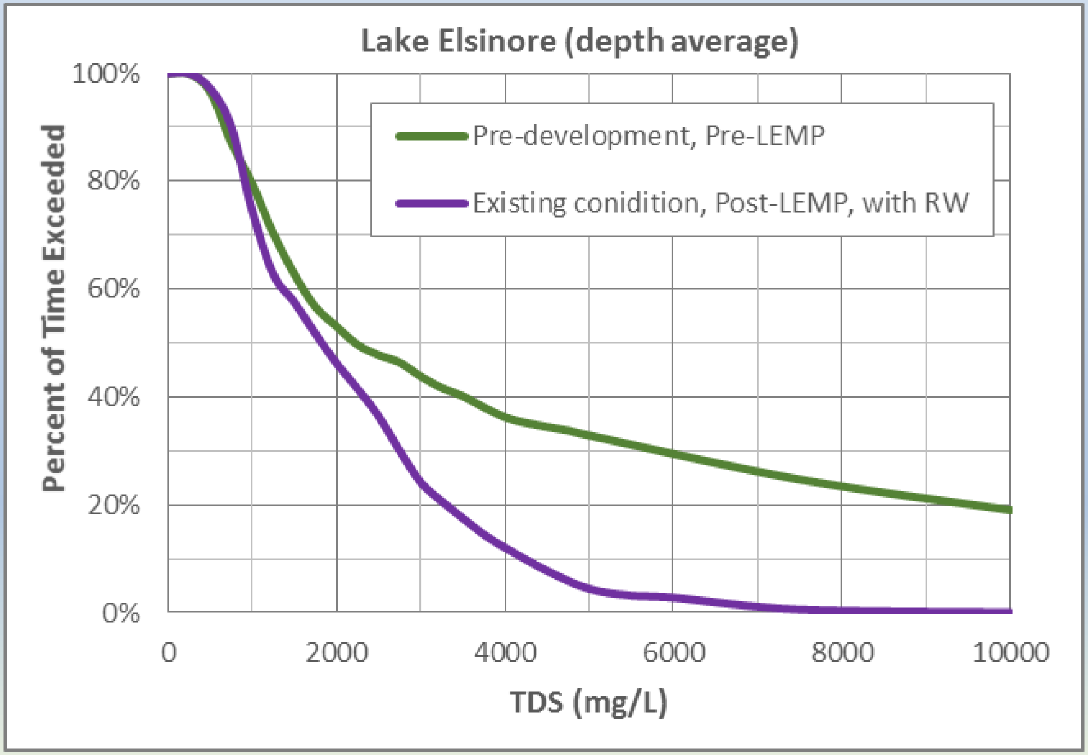



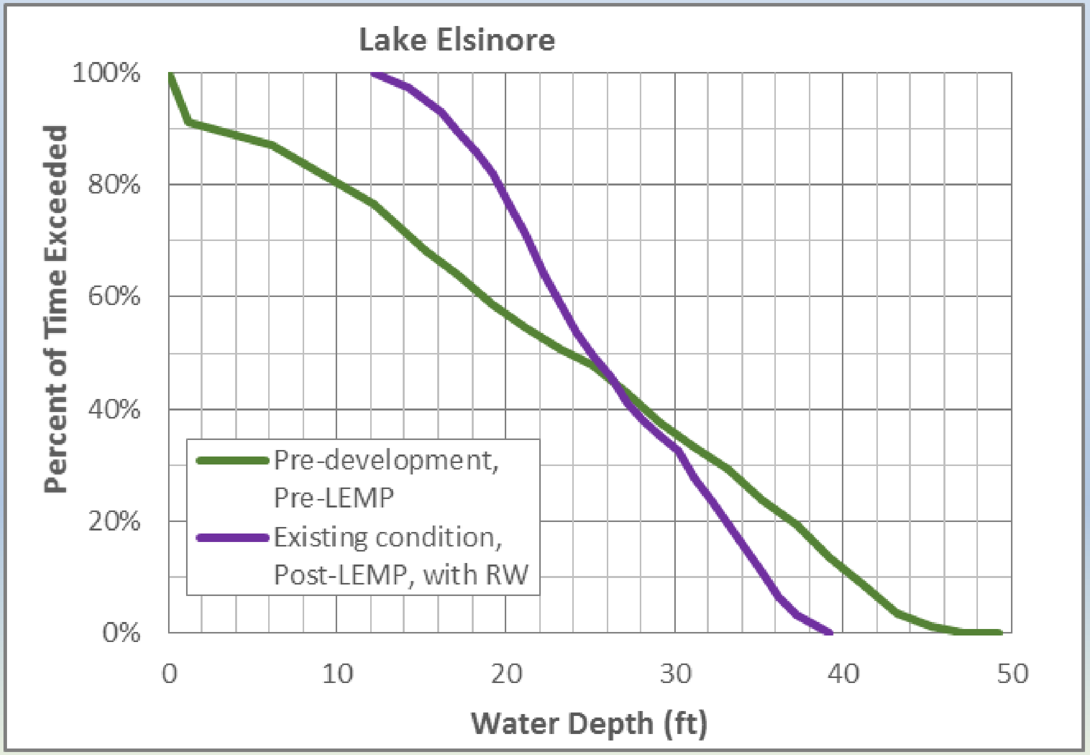
# Managed Lake Condition

- Management of Lake Elsinore (projects completed prior to TMDL adoption)
  - Lake Elsinore Management Project
  - Lake level stabilization by reclaimed water addition
- Lake management for water level and TDS to attain REC and freshwater WARM uses more frequently than in a pre-development lake condition

# Managed Lake Condition

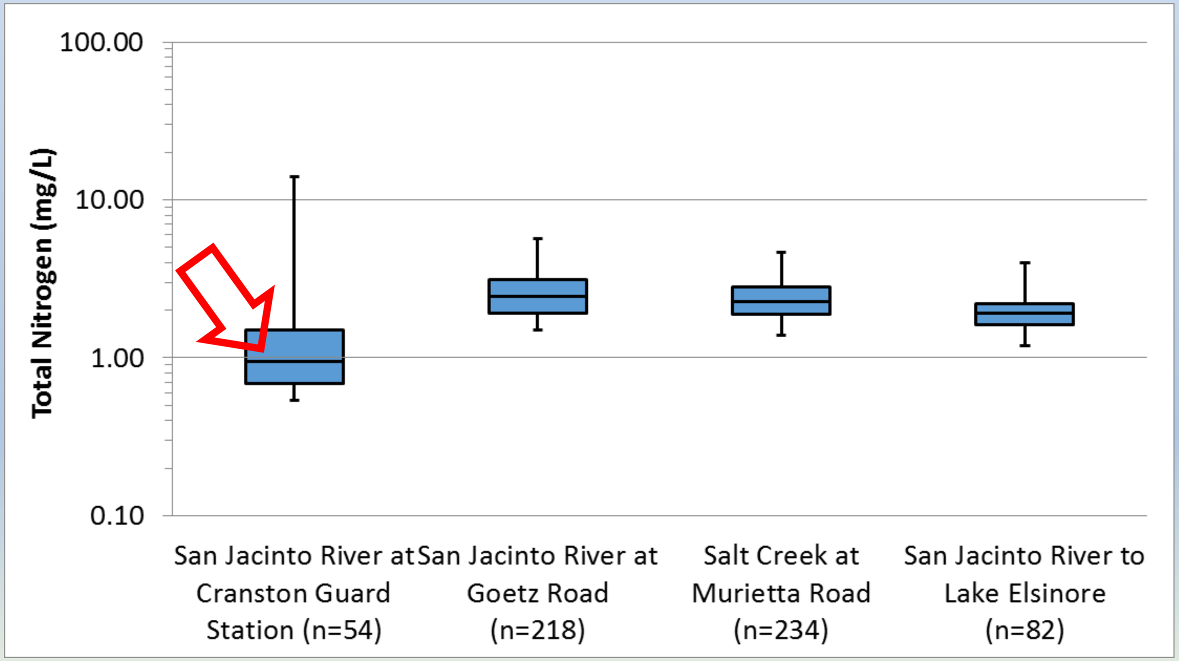
- Completion of LEMP and lake level stabilization with recycled water
  - Policy choices that were made PRIOR to adoption of the TMDL
  - Maintaining a wet lake prevents natural occurring hypersaline conditions
  - Prevents natural reset

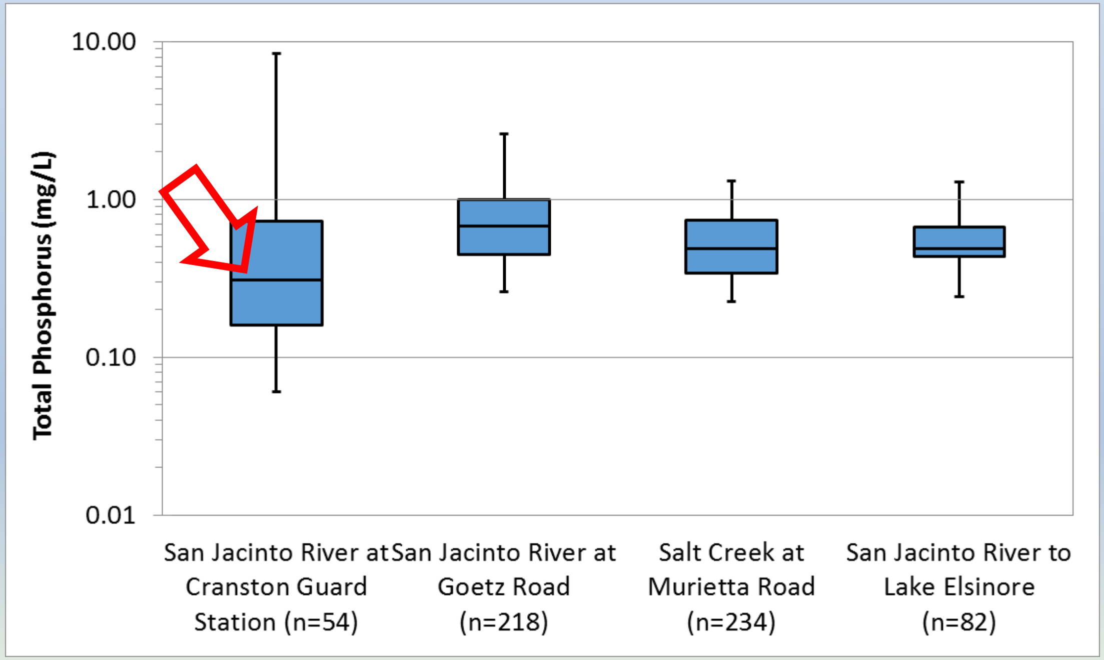


# Numeric Target Development

- External nutrient loading
  - Runoff inflows based on gauged flow data
  - Estimated undeveloped land nutrient washoff from monitoring data

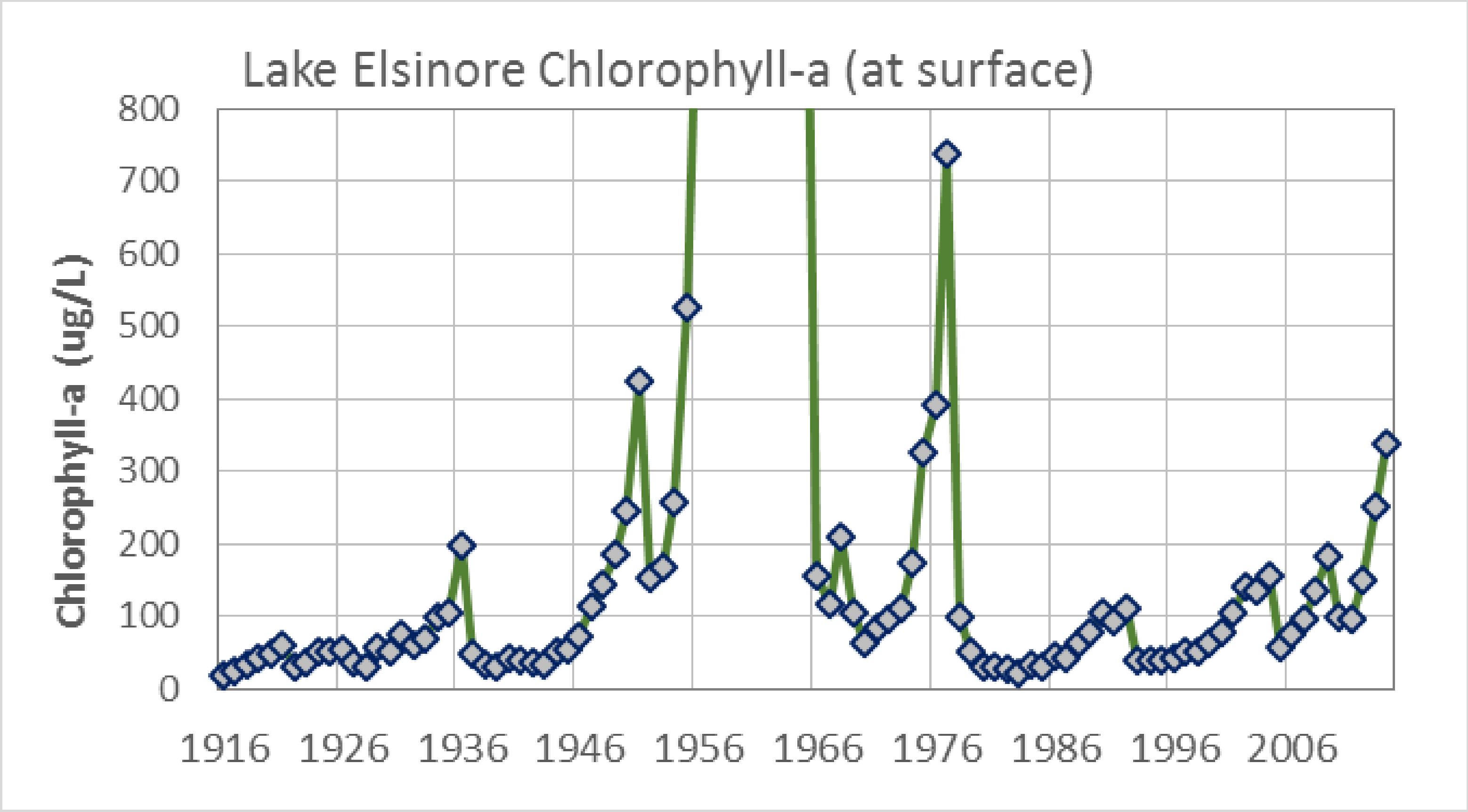


# LAKE ELSINORE RESPONSE TARGETS CHLOROPHYLL-A

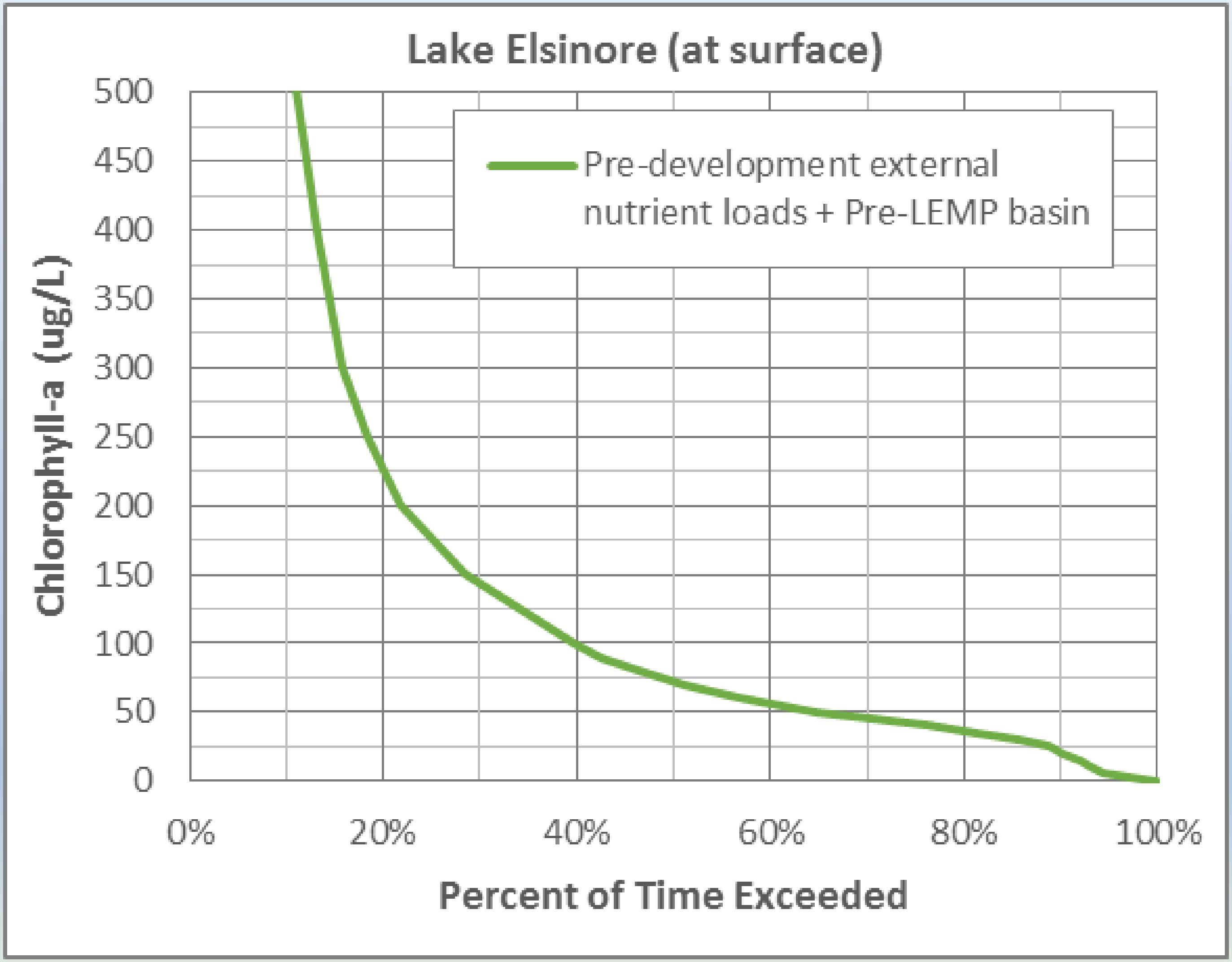
# Lake Elsinore Chlorophyll-a

- Lake water quality model serves as basis
- Pre-development, pre-LEMP, 99 year simulation



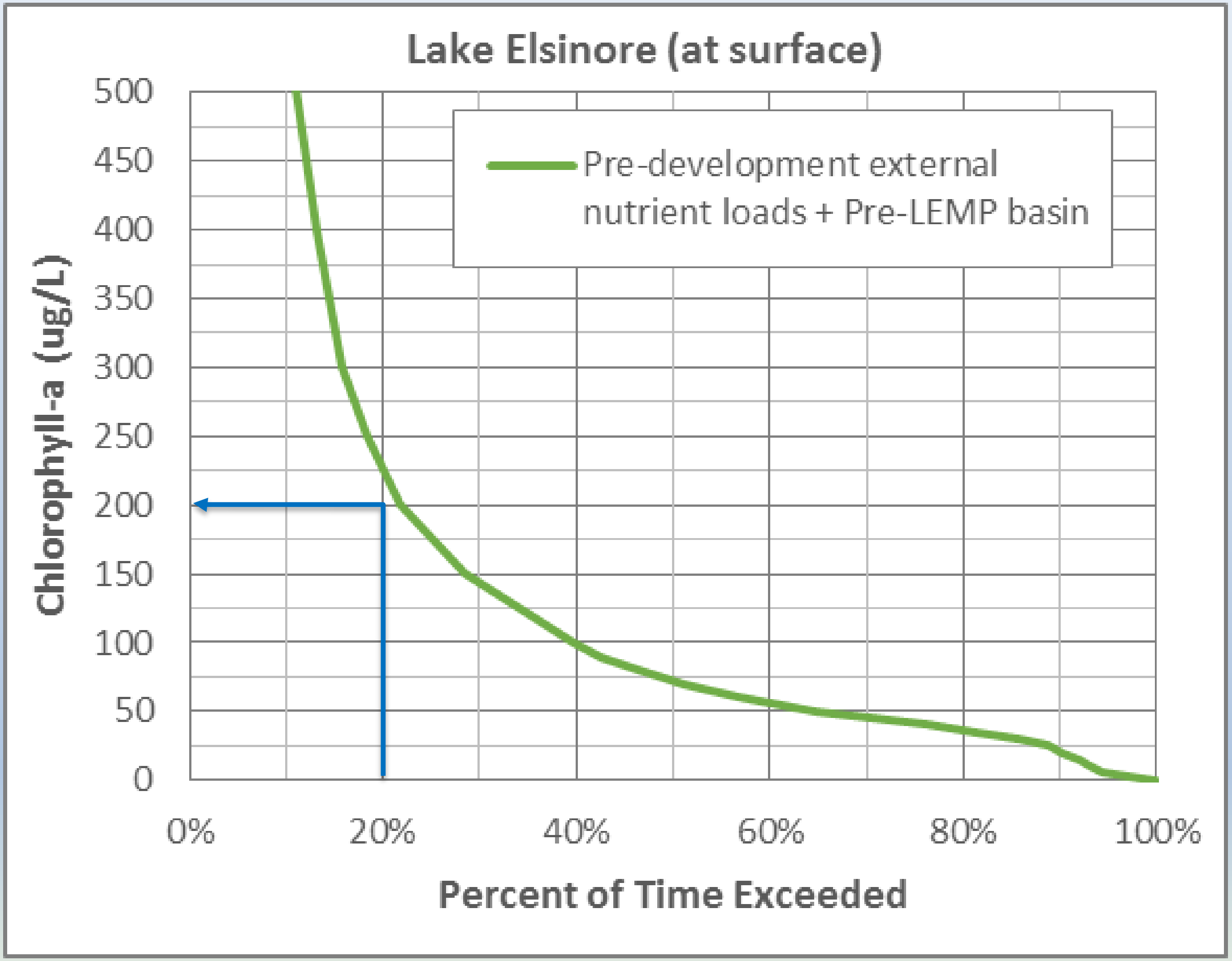
# Lake Elsinore Chlorophyll-a (Model Results)

- Median, geomean of 75 µg/L
- Dry or extreme drought in 10 percent of years
- Chlorophyll-a > 200 µg/L in 20 percent of years
- Only 1 in 10 years would meet the final numeric target in 2004 TMDL



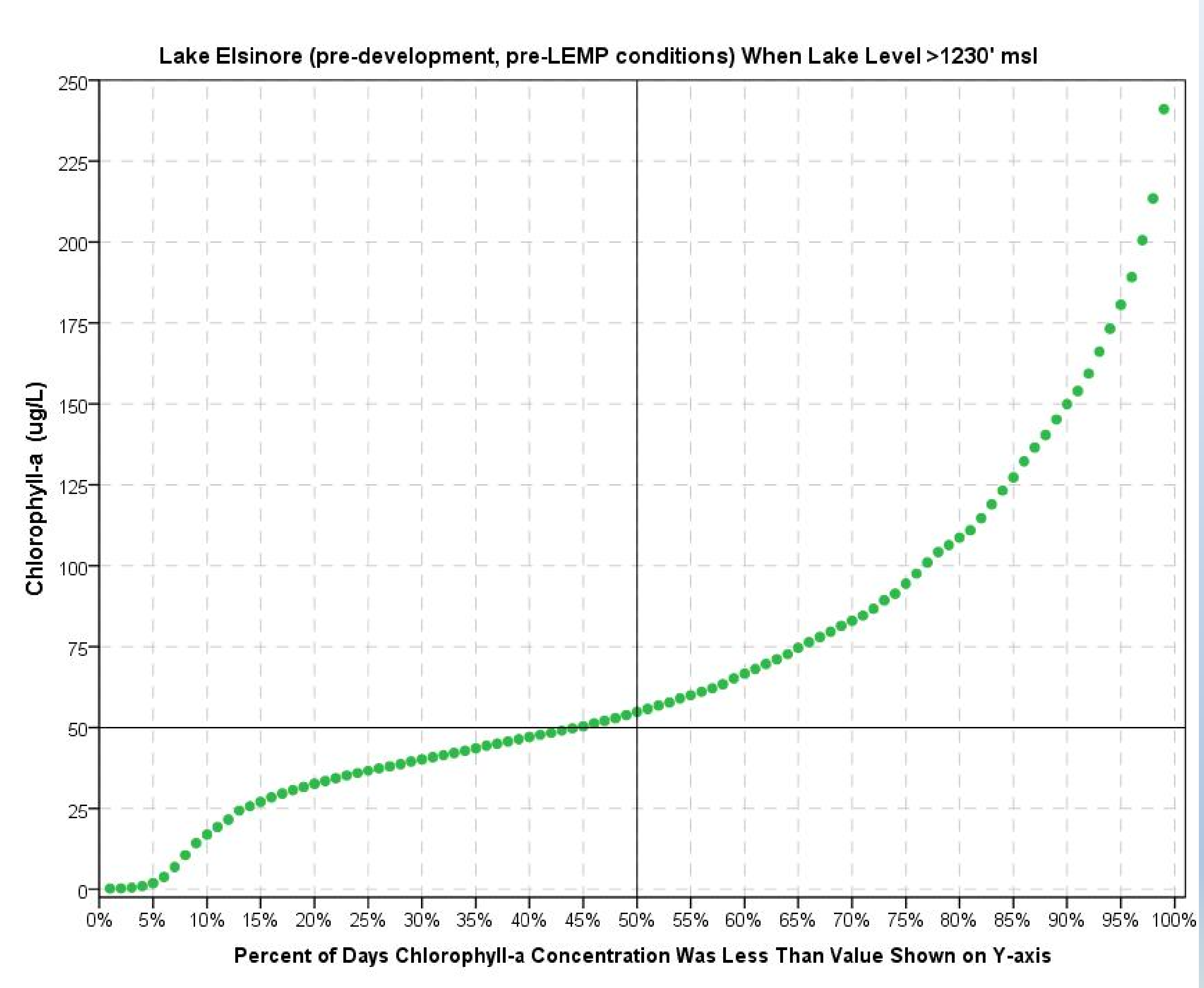
# Lake Elsinore Chlorophyll-a (Potential Numeric Targets)

- Annual average depth integrated chlorophyll-a not to exceed 200 µg/L in more than 20 percent of years



# Lake Elsinore Chlorophyll-a (Potential Numeric Targets)

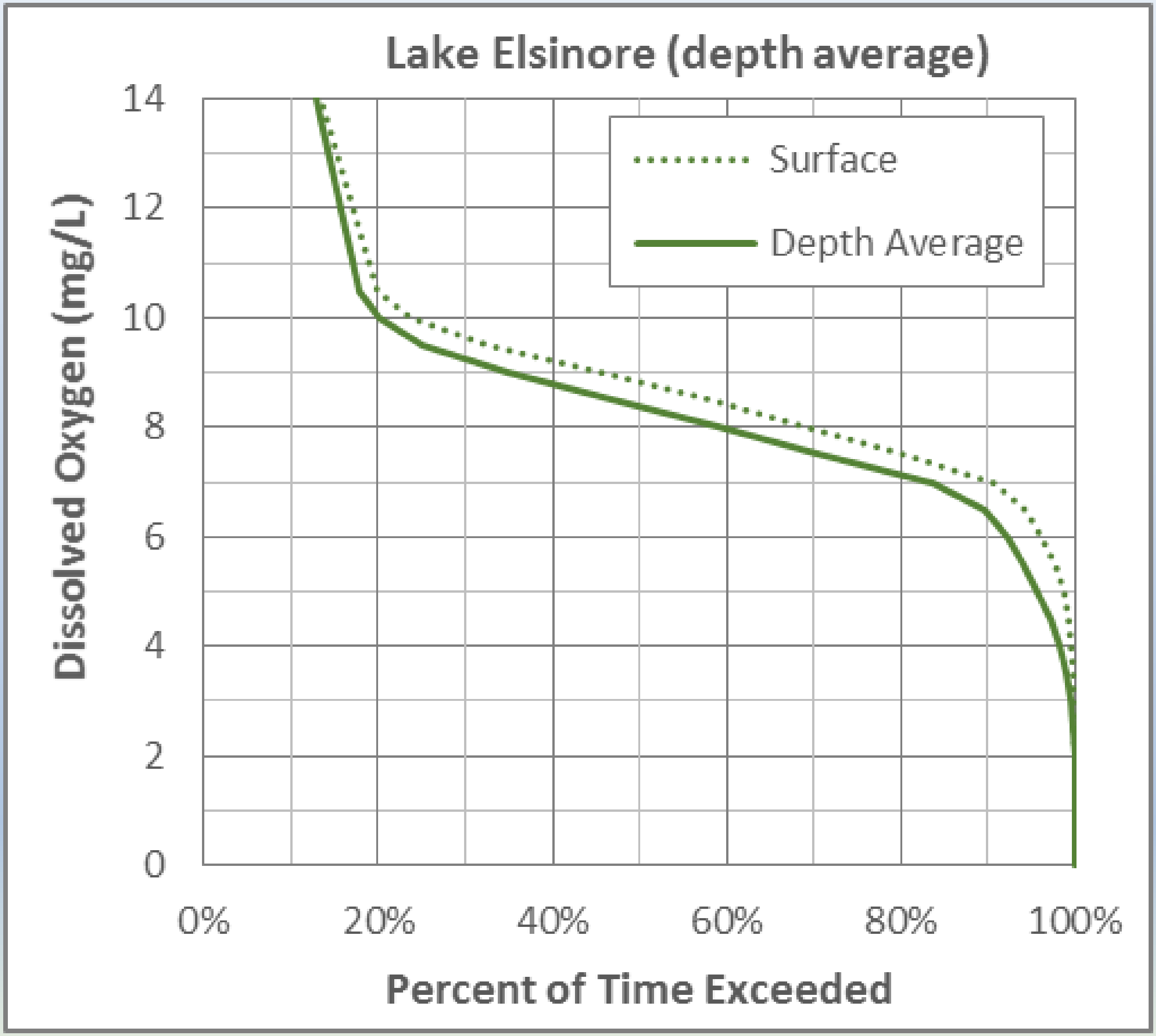
- 10 Year geomean not to exceed chlorophyll-a of 50 µg/L in top meter
- Excludes model results when lake level was below 1230’ msl



# LAKE ELSINORE RESPONSE TARGETS
# DISSOLVED OXYGEN

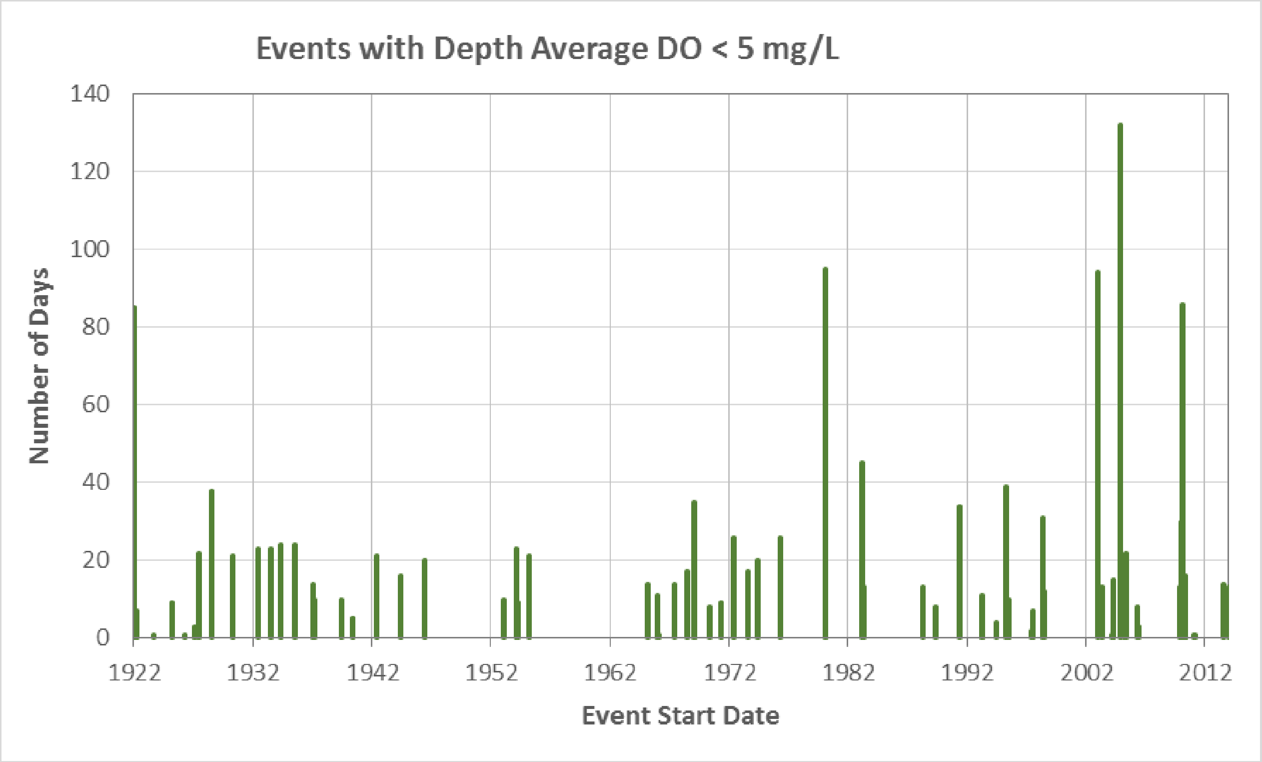
# Lake Elsinore Dissolved Oxygen (Model Results)

- Lake water quality model serves as basis
- Pre-development, pre-LEMP, 99 year simulation
- More than 95 percent of days with > 5 mg/L depth average DO



# Lake Elsinore DO (Protection of WARM use)

- Numeric water quality objective is 5 mg/L for WARM use
- Fish require oxygen all of the time, but not for all of lake volume
- If depth average less than 5 mg/L, refugia may not overlap important habitat areas
- 75 events within 49 years with depth average < 5 mg/L)
- 512 days within 32 events with no refugia



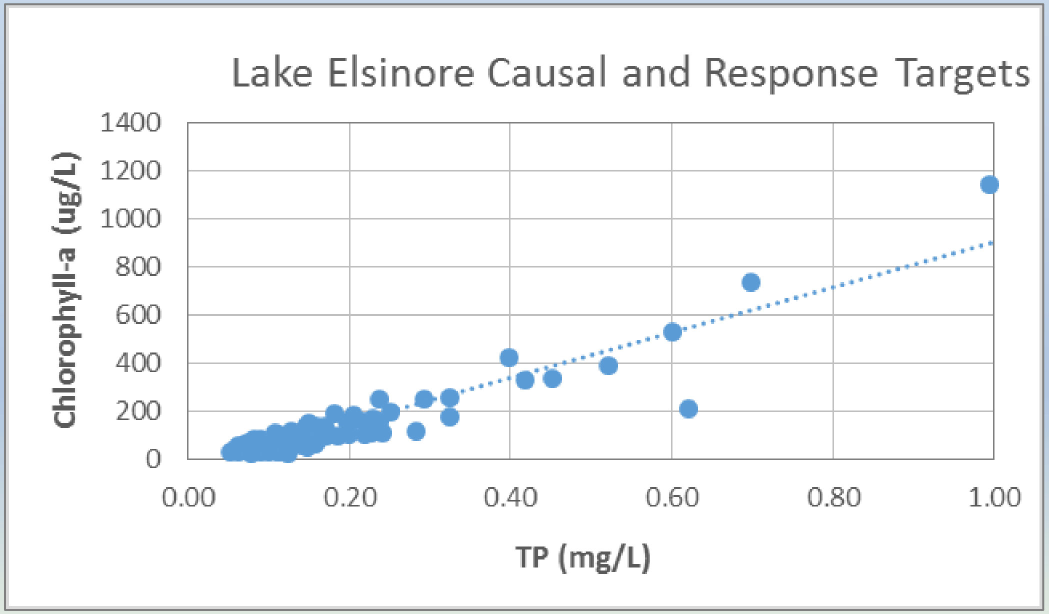
# Lake Elsinore DO (Potential Numeric Target)

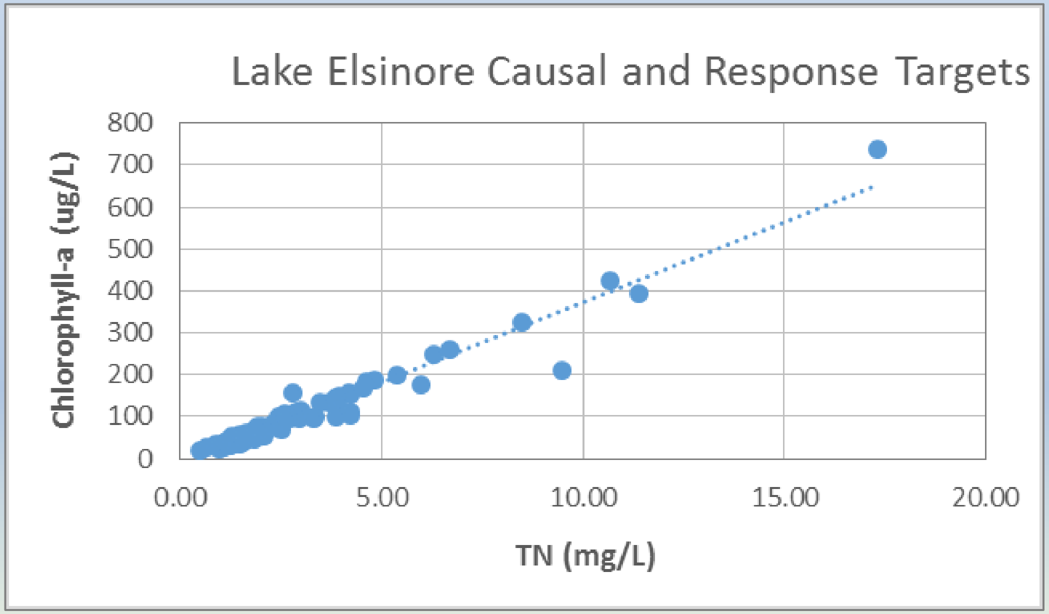
- Make 2004 interim target requiring depth average > 5 mg/L for all days
- Remove numeric target of 5 mg/L at 1 meter from the lake bottom

# LAKE ELSINORE CAUSAL TARGETS

# Lake Elsinore Nutrients(Model Results)

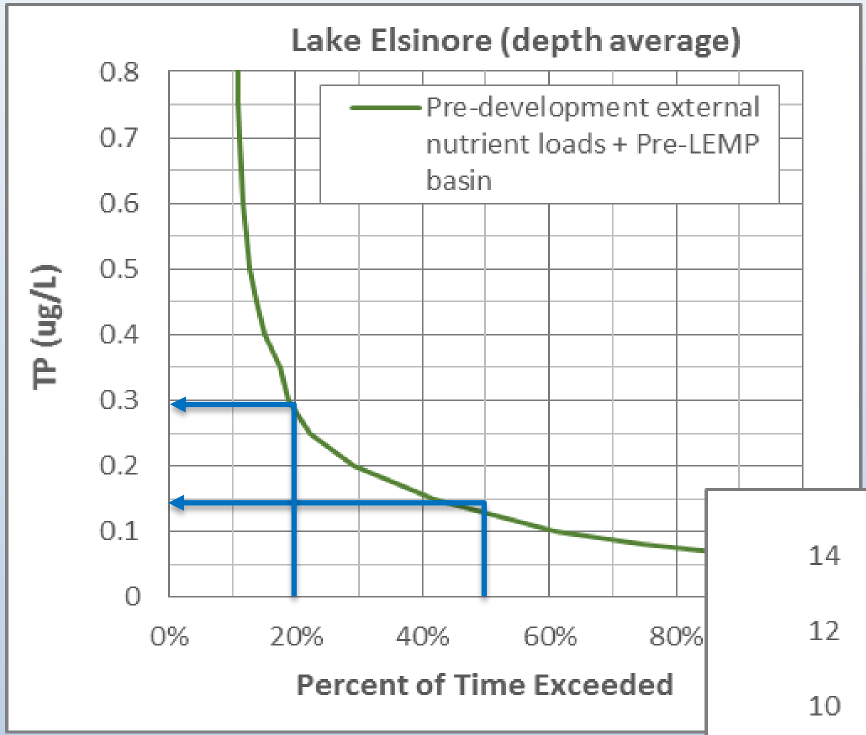
- Lake water quality model serves as basis
- Pre-development, pre-LEMP, 99 year simulation
- DYRESM-CAEDYM model estimated a strong correlation between annual depth average nutrients and surface chlorophyll-a

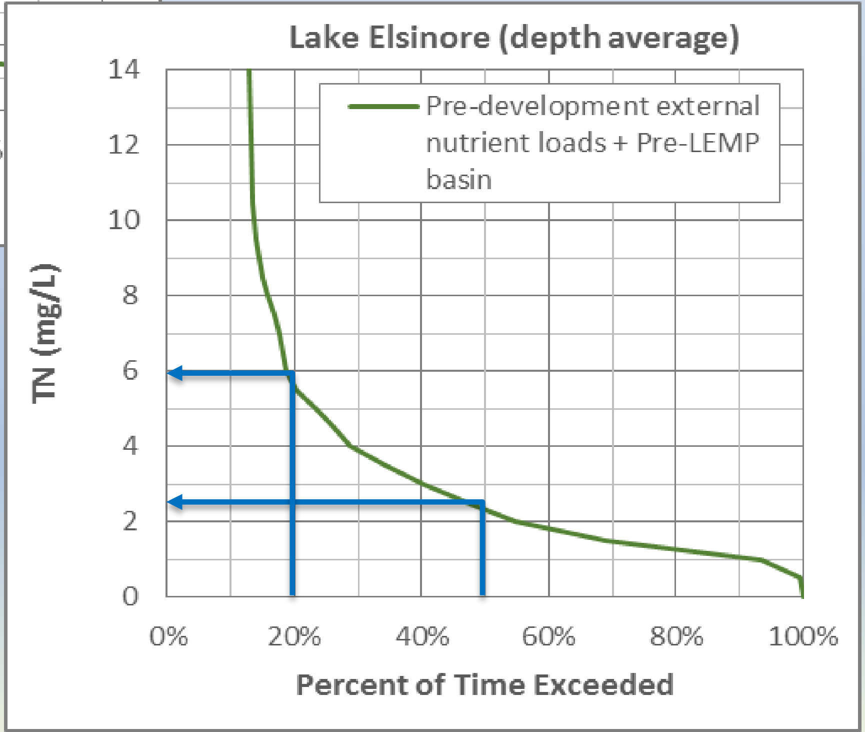


# Lake Elsinore Nutrients (Potential Numeric Targets)

- 10-yr geomean not to exceed 0.15 mg/L TP and 2.5 mg/L TN as depth average
- Annual average depth integrated not to exceed 0.29 mg/L TP and 6.0 mg/L TN in more than 20 percent of years



# MULTIPLE LINES OF EVIDENCE

# Multiple Lines of Evidence

- Natural histories showing highly variable lake volume and water quality
- Well calibrated dynamic lake water quality model

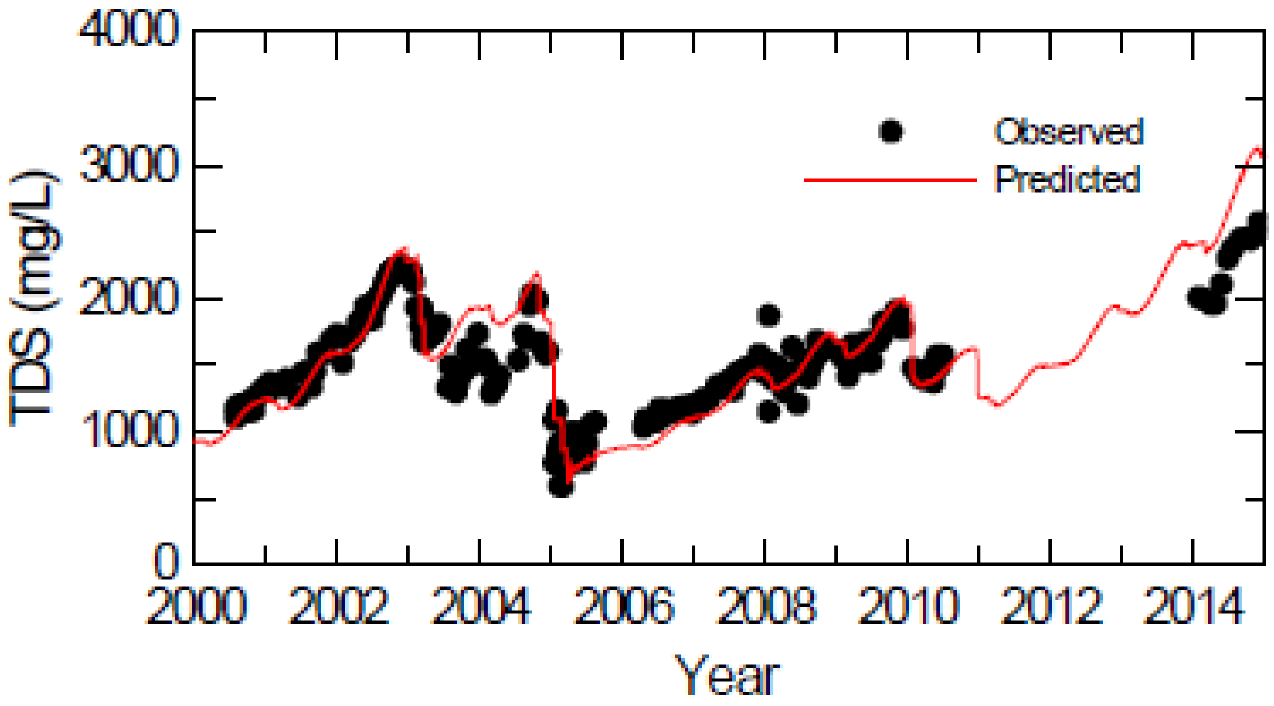



*Fig. 6. Predicted and observed TDS concentrations for the calibration period 2000-2014.*

# Multiple Lines of Evidence

- Potential to build upon previous paleolimnology studies
- Potential to collect supplemental data on undeveloped land nutrient washoff
- Benchmarking against reference lakes in xeric west ecoregion

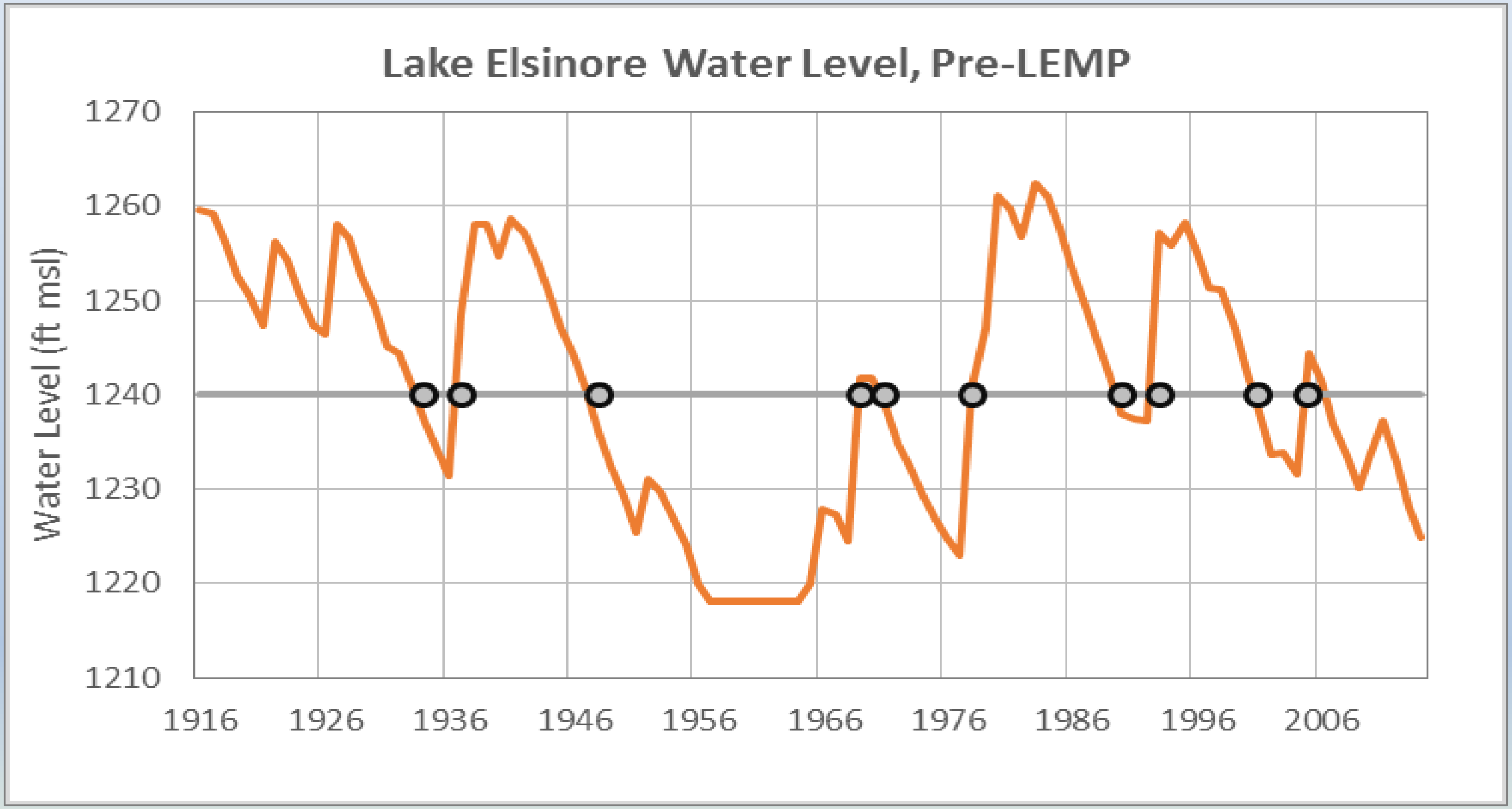
# CONSERVATISM

# Proposed Targets are Conservative

- Geomean targets are set lower than the modeled values
  - Computed with exclusion of modeled years with less than 1230’ elevation
- Modeling used median values for nutrient washoff from undeveloped lands

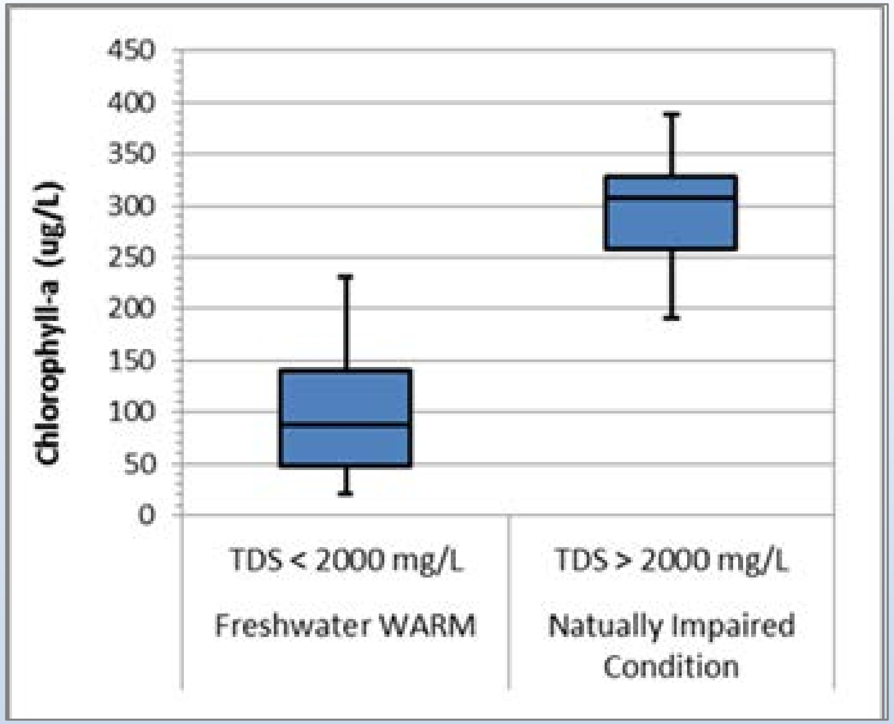
# Proposed Targets are Conservative

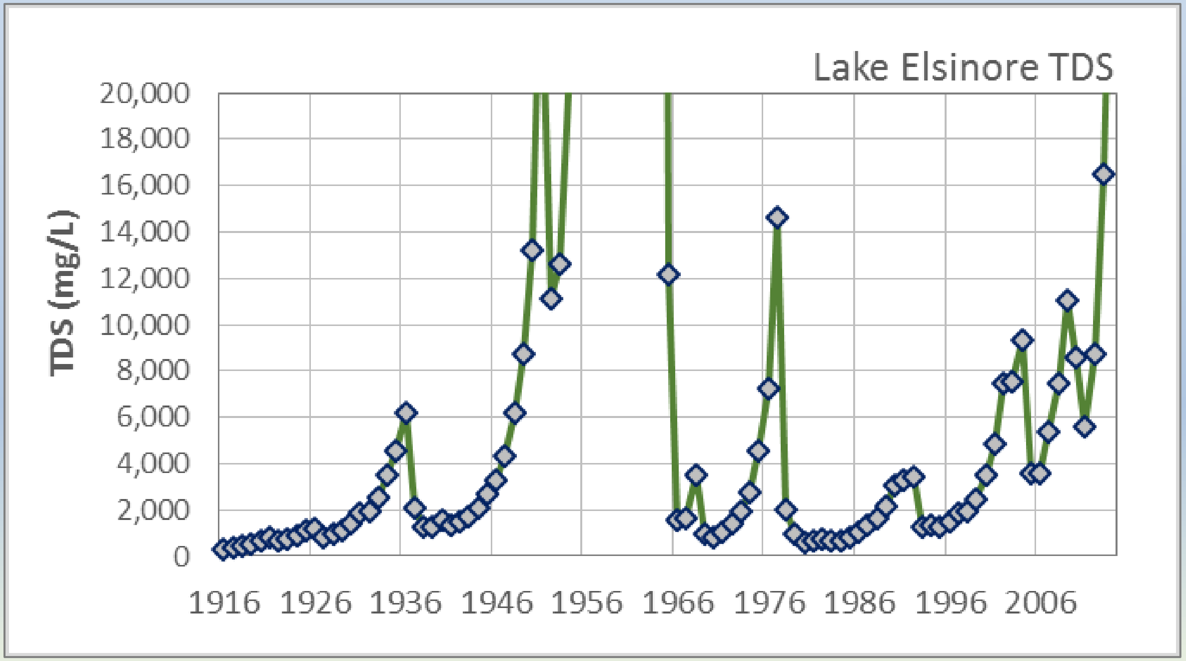
- For Lake Elsinore, 10 year averaging period does not account for full range of hydrologic conditions



# Proposed Targets are Conservative

- Review of 15 year water quality record shows importance of TDS in hyper-eutrophication
- Baseline (pre-development, Pre-LEMP) condition model estimated more frequent exceedances of 2000 mg/L than managed lake scenario



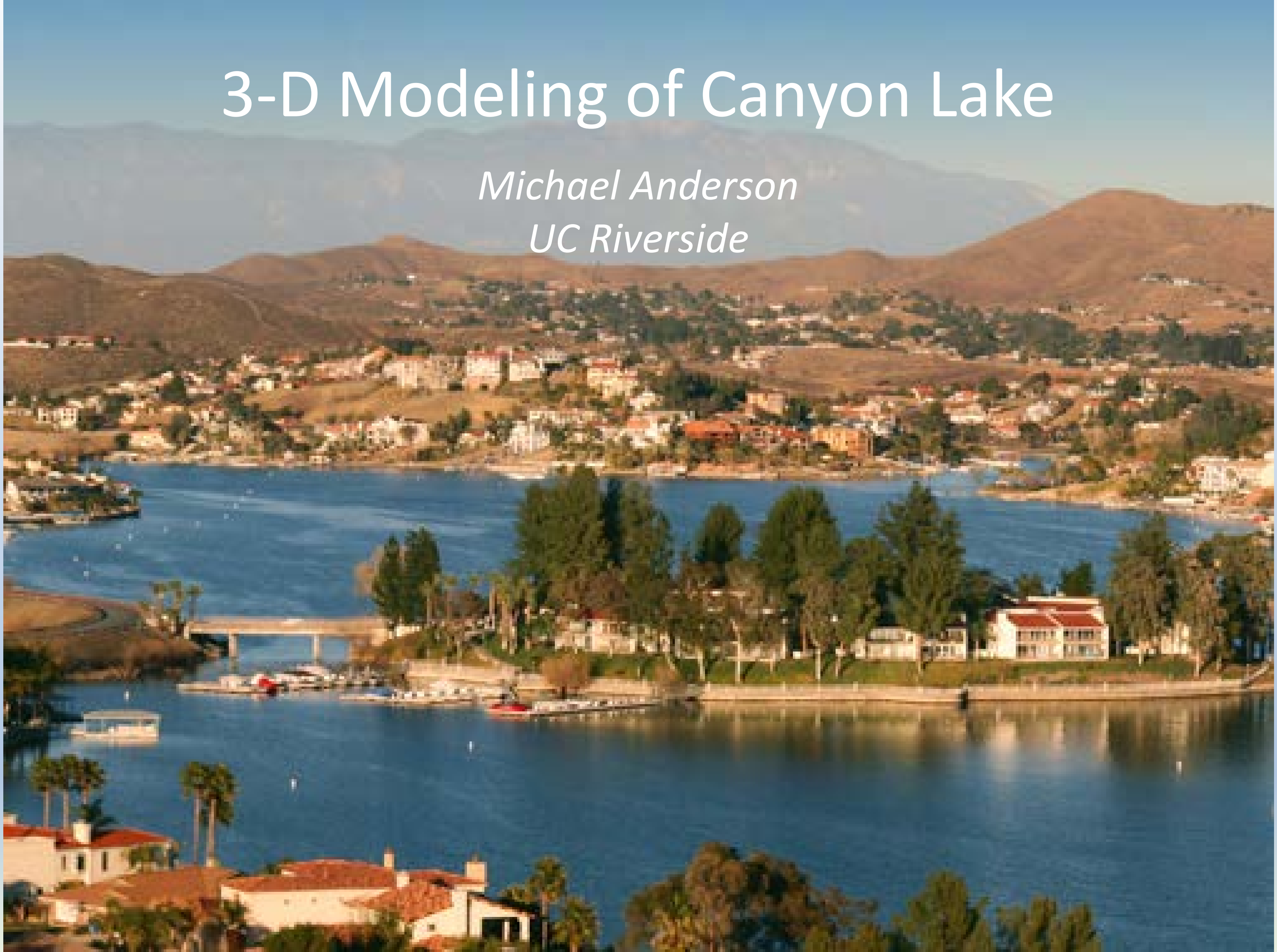
# Proposed Targets are Conservative

- Model estimated 75 events with depth average DO < 5 mg/L
- When depth average DO > 5 mg/L, fish may find refugia (i.e. habitat) for the entire water column almost all of the time

| Fraction of Water Column > 5 mg/L | Less than 25% | 26% – 50% | 51% - 75% | 76% - 99% | Full |
|---|---|---|---|---|---|
| Modeled Days when Depth Average Target Met | 0 | 43 | 267 | 213 | 30094 |

# 3-D Modeling of Canyon Lake

*Michael Anderson*
*UC Riverside*

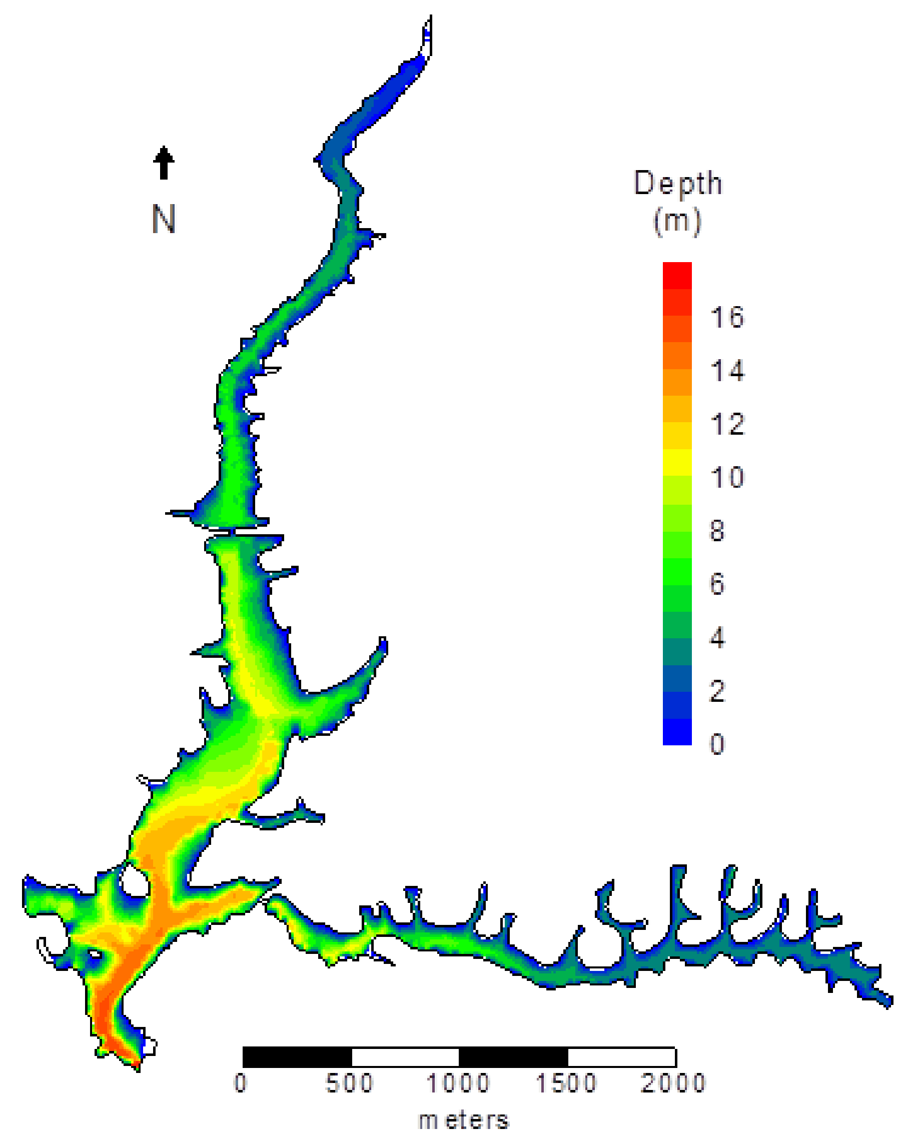


# Existing 1-D Hydrodynamic Model

- Previous modeling using DYRESM-CAEDYM
- Comprehensive water quality and ecology model (CAEDYM)
- DYRESM uses the 1-D approximation in which the primary gradients are assumed to be in the vertical direction
- It is clear that very significant gradients exist *across* the lake
  - East Bay, Main Lake, North Ski Area
- With detailed bathymetry from the hydroacoustic survey conducted in December 2014, an accurate 3-D representation of the lake basin is available

# Development of 3-D Hydrodynamic Model

- 3-D modeling will provide detailed new insights into hydrodynamics and water quality across the lake
- Modeling will be also be able to quantify suspended solids transport and deposition, improving our understanding of sedimentation processes in the lake



# Development of 3-D Hydrodynamic Model

- ELCOM model using a 10 m x 10 m lateral grid, with 1 m vertical layers
- Model runs from 2000-2012
- Daily inflows in San Jacinto River and Salt Creek taken from USGS gages #11070365 and #1107465
- Meteorological data taken from the CIMIS station at UCR
- Outflow determined using a dynamic boundary condition from lake elevation and spillway rating curve

# Development of 3-D Hydrodynamic Model

- Some example results below highlight the information available from the model and highlights the complex hydrodynamics of the lake
- The image below shows the water velocity across lake in response to inflows from SJR and Salt Creek
- The attached movies dynamically demonstrate temperature and water velocities

velocity_movie.mov

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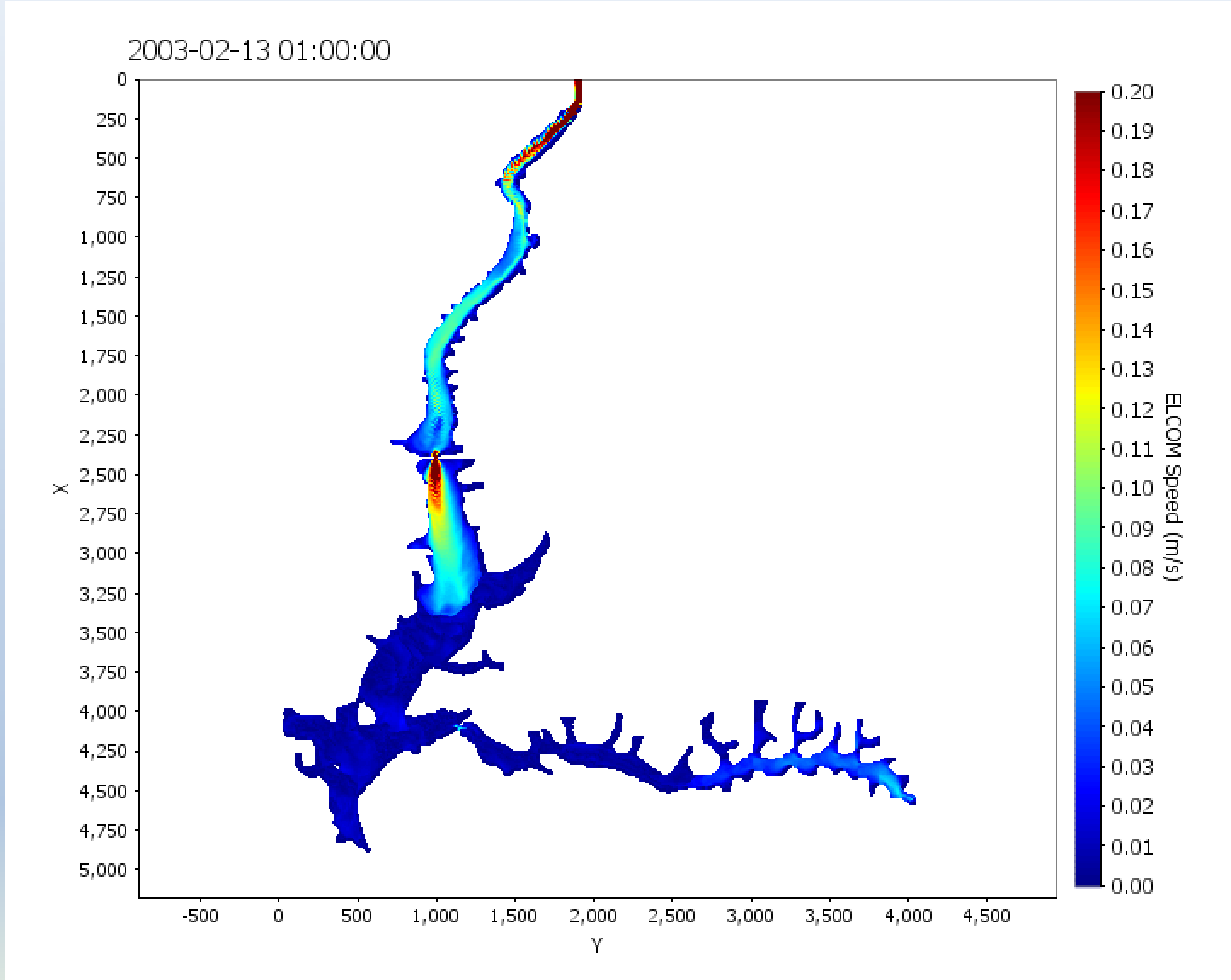
# Development of 3-D Hydrodynamic Model

- Example results highlight complex hydrodynamics of the lake
- Water velocity across lake in response to inflows from SJR and Salt Creek
- The attached movies dynamically demonstrate temperature and water velocities



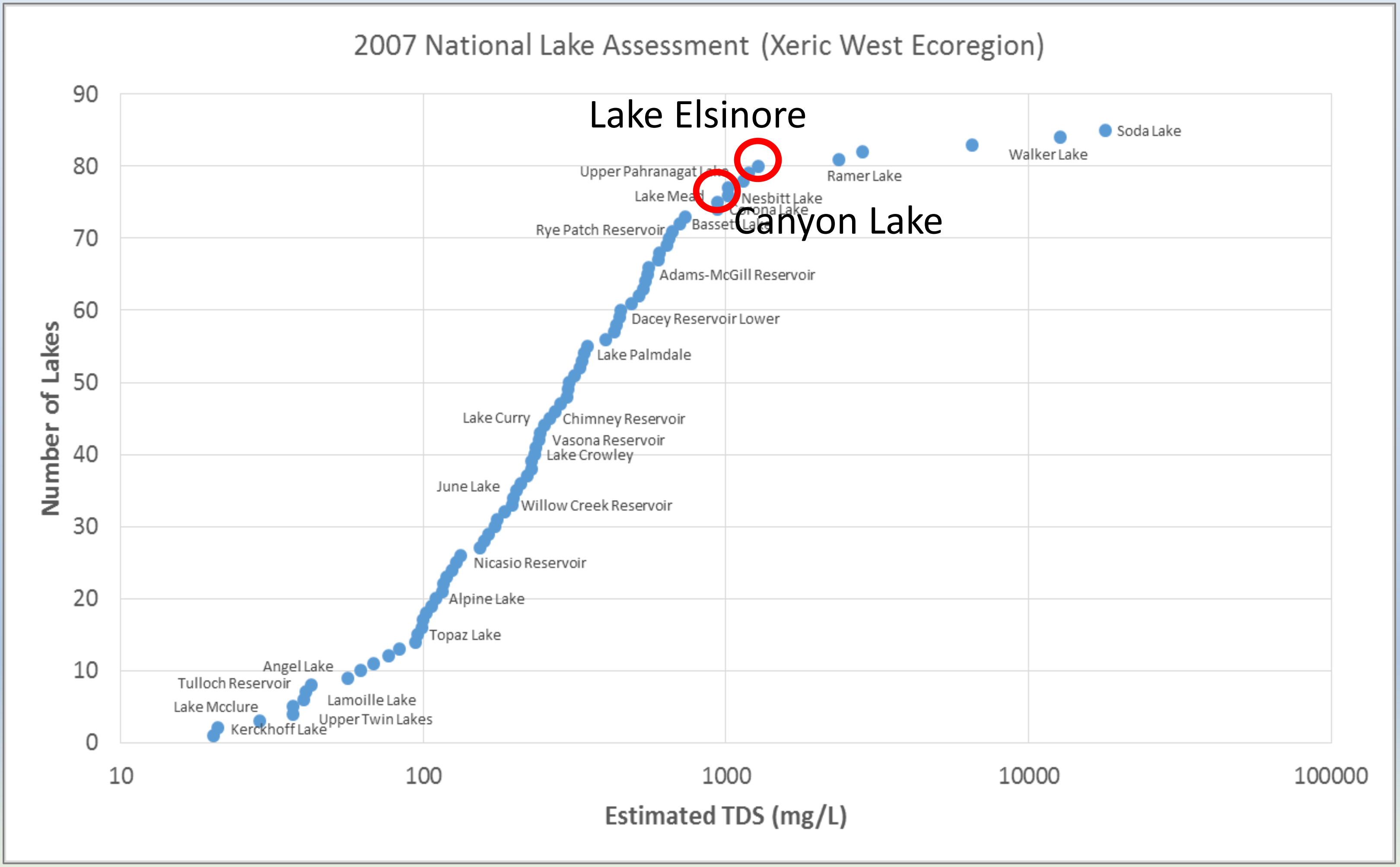
# Development of 3-D Hydrodynamic Model

- Verification of ELCOM model results (lake level, temperatures, stratification) is being finished
- Following this, CAEDYM (using input files from previous DYRESM-CAEDYM simulations) will be implemented
- Model will provide high resolution hydrodynamic and water quality results across Canyon Lake, including Main, East and North Bays for both pre-development and current conditions
- Model can also be used to assess different restoration strategies, targeting specific regions of the lake and local water quality challenges there

# BENCHMARKING WITH XERIC WEST LAKES

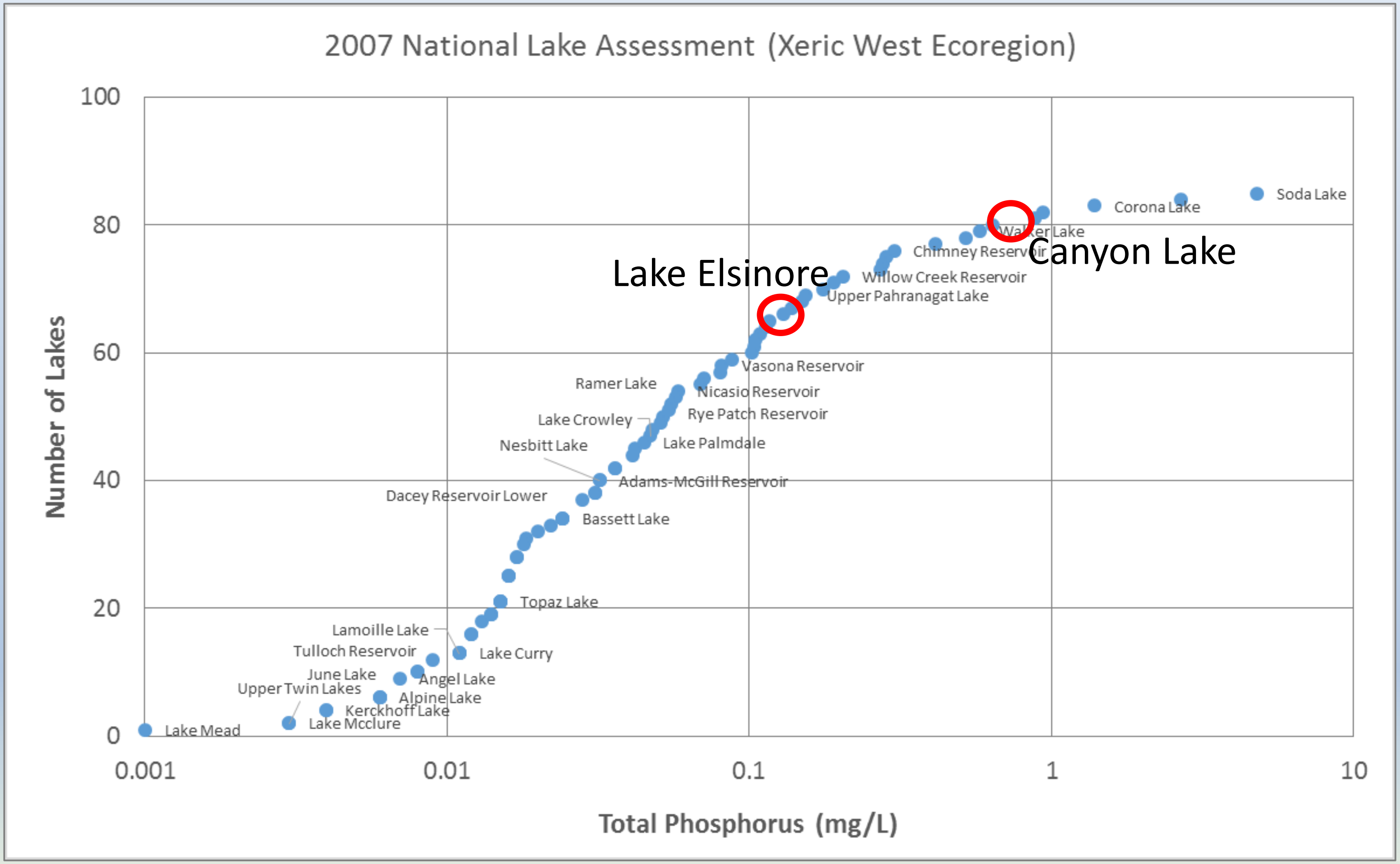
# EPA 2007 – National Lakes Assessment

- Lake Elsinore  and Canyon Lake compared with 'xeric west' ecoregion
- Estimated TDS from field measured conductivity
- One of few lakes with salinity challenges in 2007



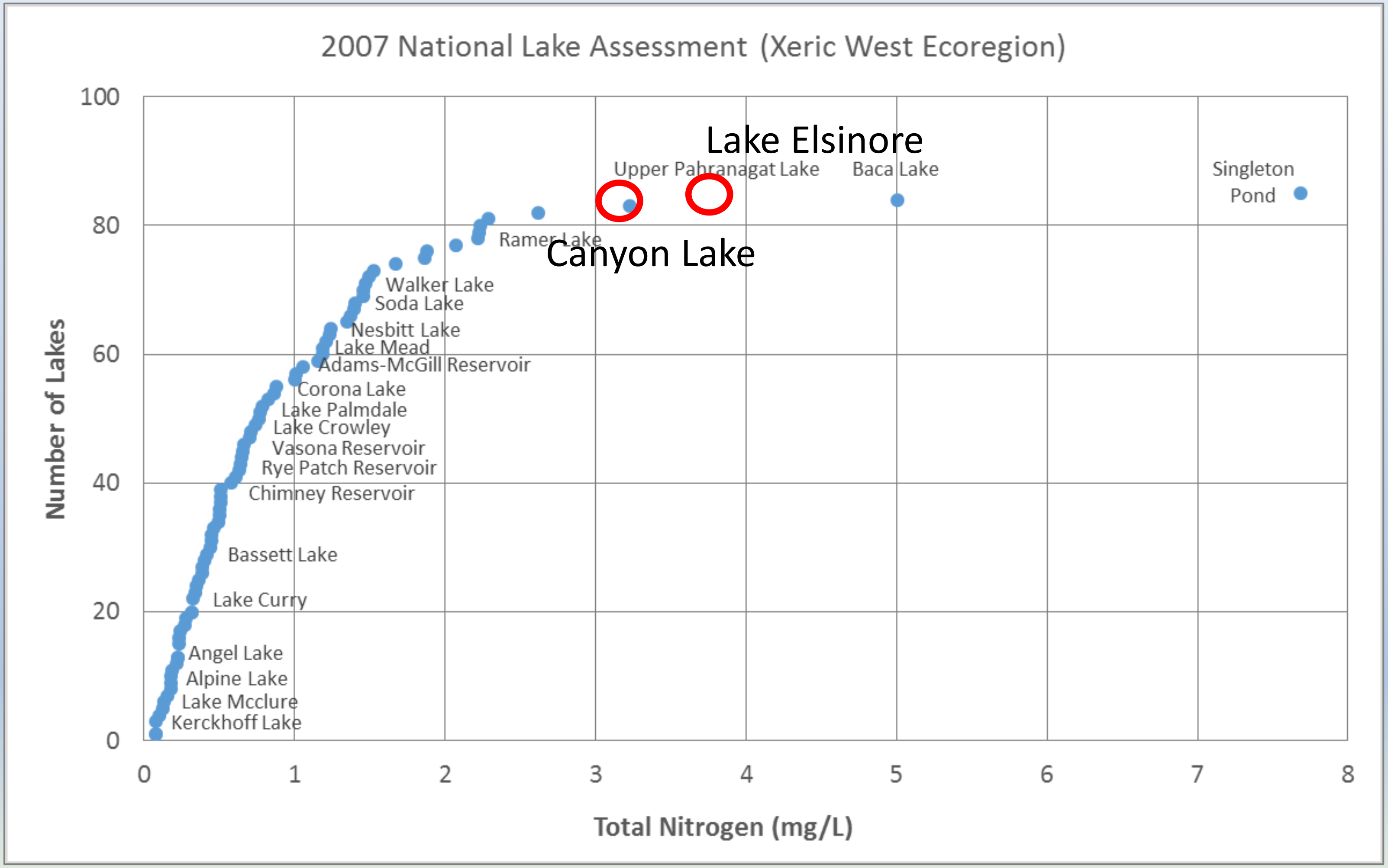
# EPA 2007 – National Lakes Assessment

- Lake Elsinore and Canyon Lake compared with 'xeric west' ecoregion
- TP from summer of 2007
- Very dry year, following very wet year of 2005



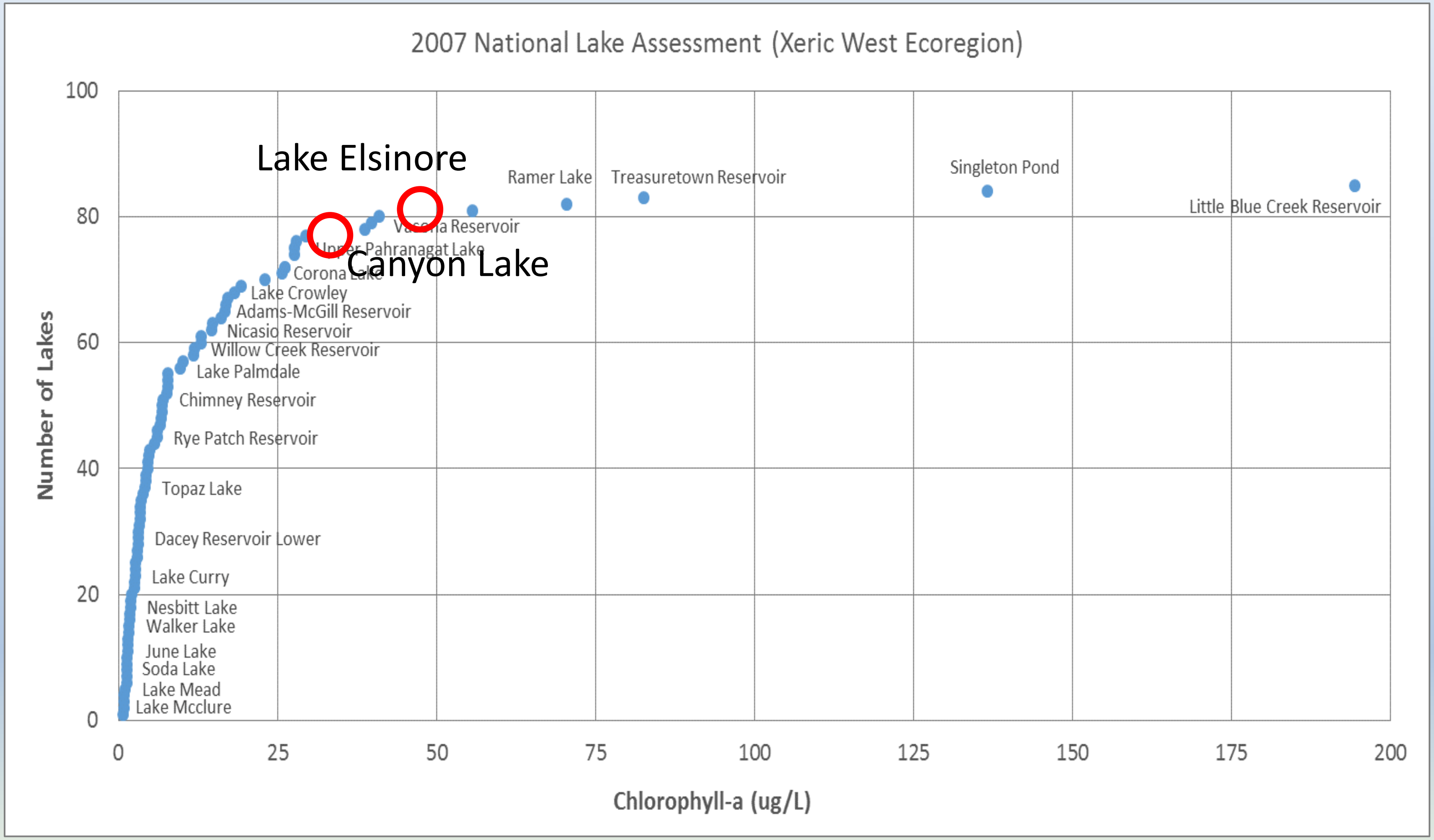
# EPA 2007 – National Lakes Assessment

- Lake Elsinore and Canyon Lake compared with 'xeric west' ecoregion
- TN from summer of 2007
- Very dry year, following very wet year of 2005



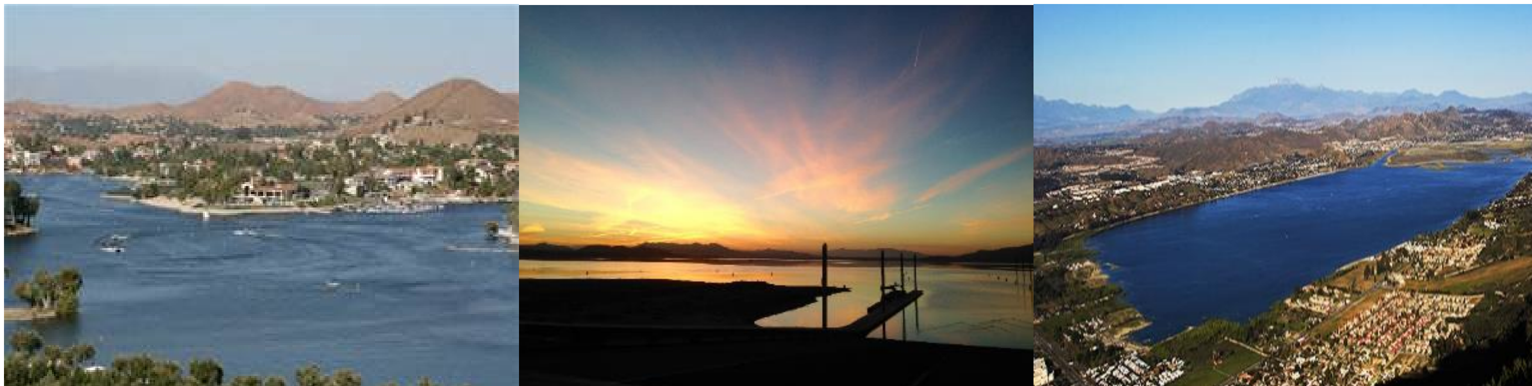
# EPA 2007 – National Lakes Assessment

- Lake Elsinore and Canyon Lake compared with 'xeric west' ecoregion
- Chlorophyll-a from summer of 2007
- Very dry year, following very wet year of 2005

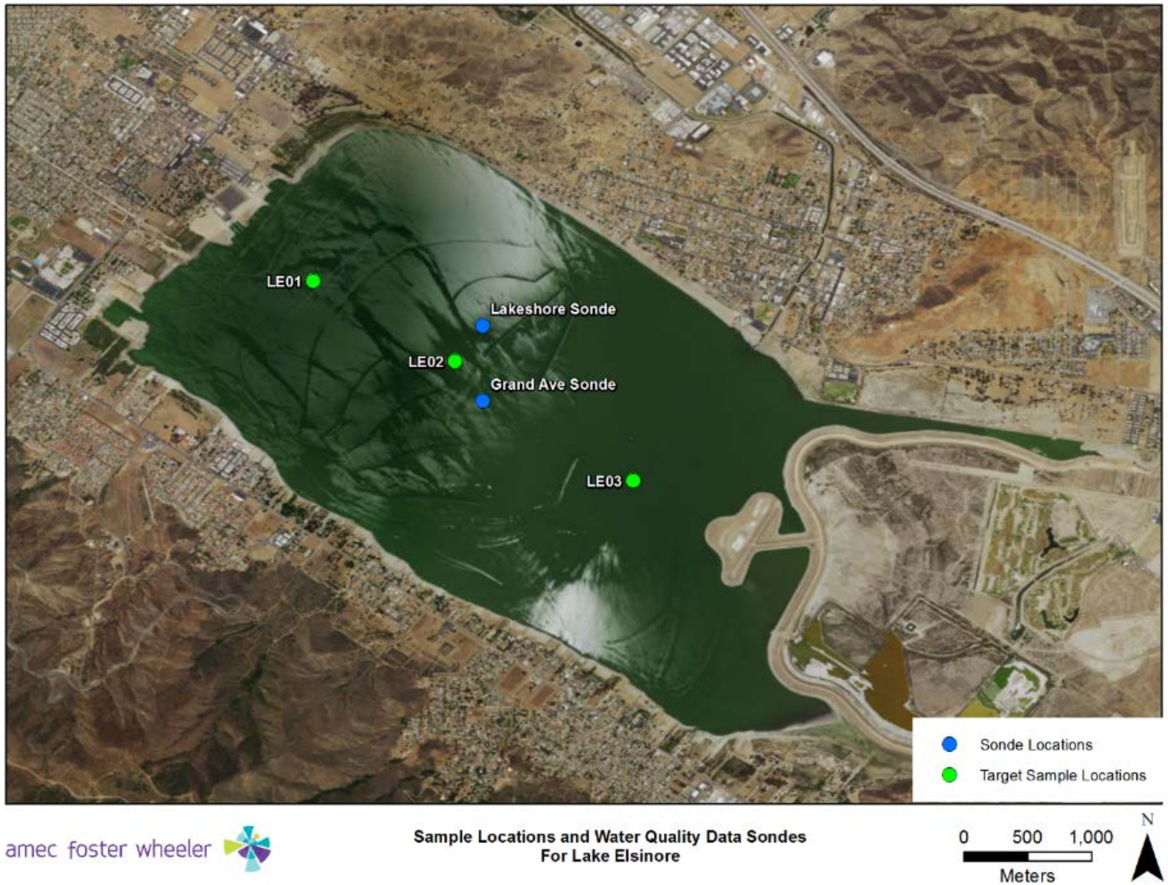


# Lake Elsinore and Canyon Lake TMDL Water Quality Monitoring Update

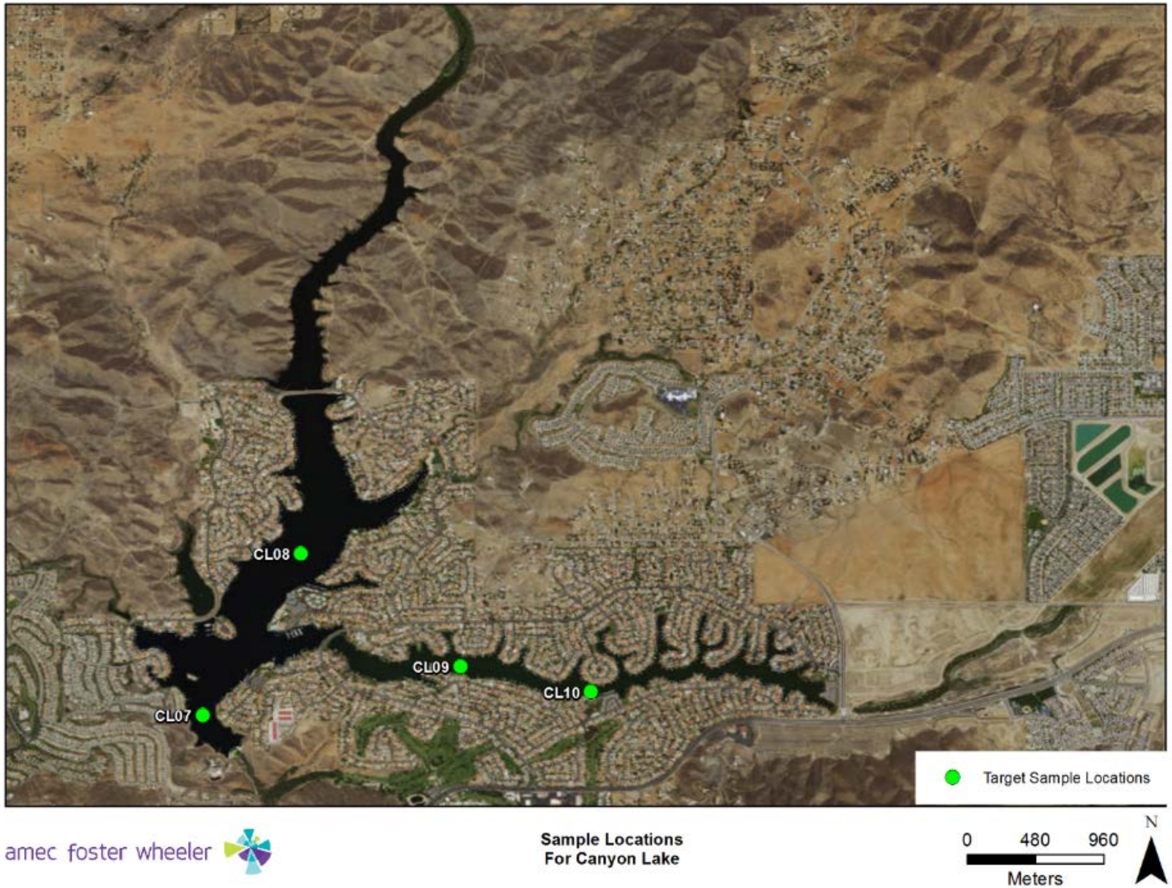
May 3, 2016



# Station Locations – Lake Elsinore

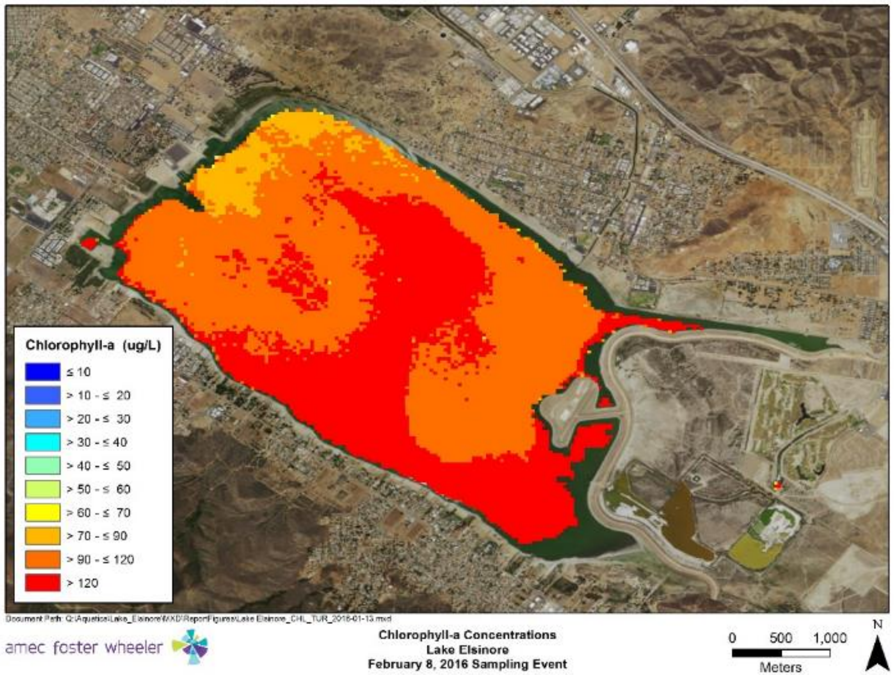


# Station Locations – Canyon Lake

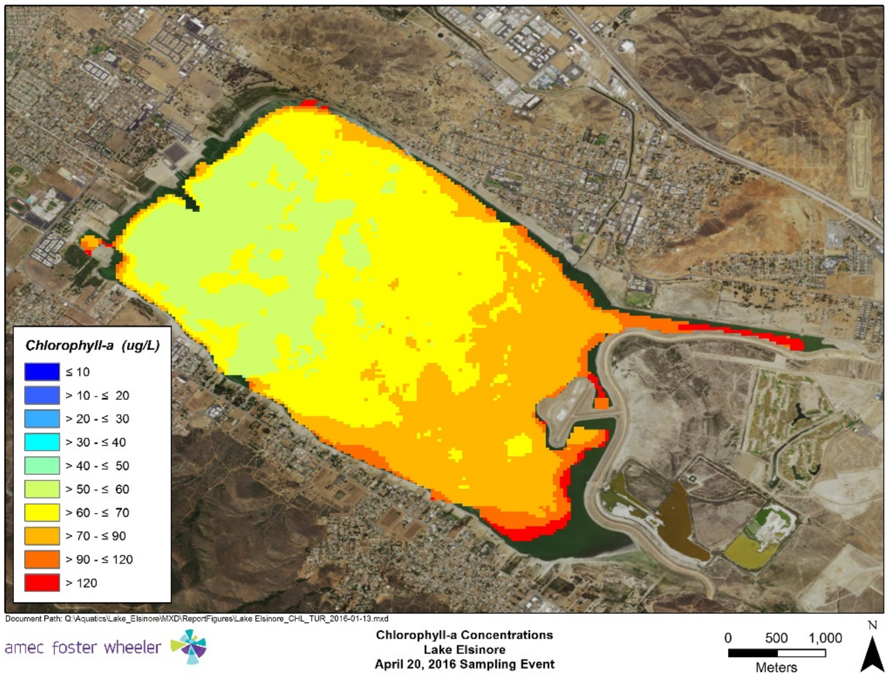


# Satellite Imagery – Lake Elsinore Chlorophyll-a February 2016 and April 2016

## February 2016




## April 2016



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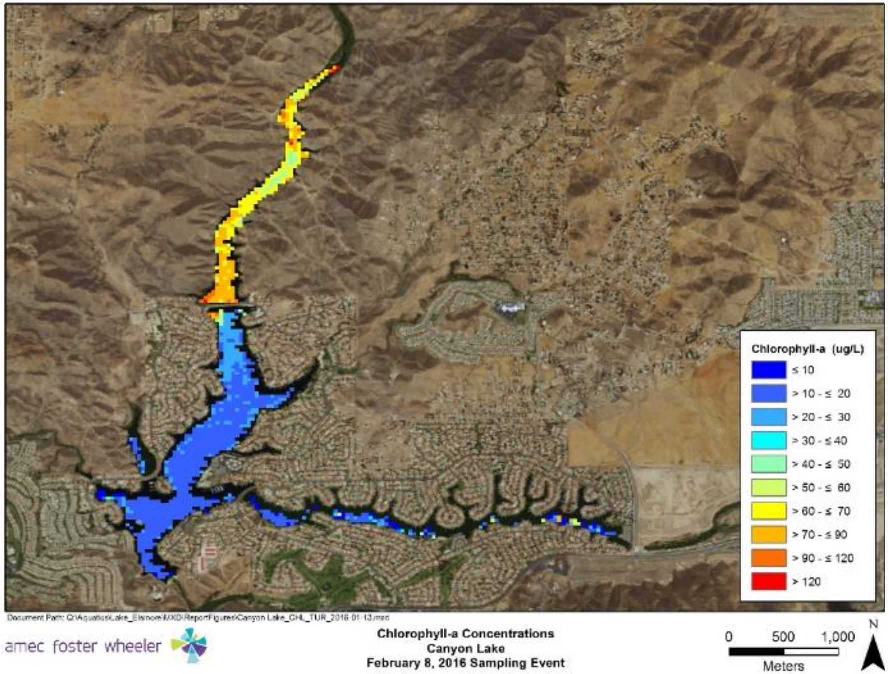
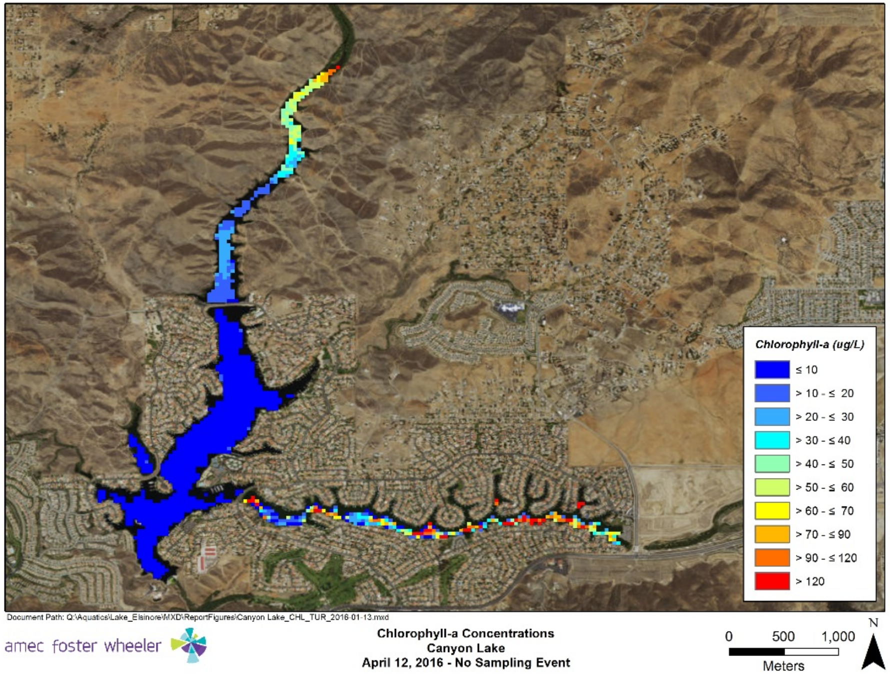



April 2016



# Canyon Lake – Field Photos



**February** | **April**

← East Basin →

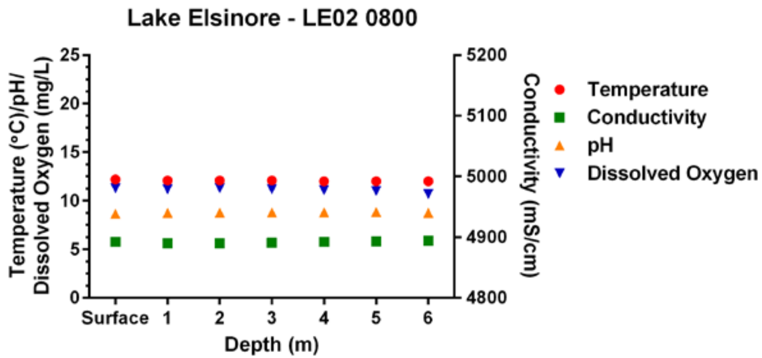
← Main Basin →

Floating, aggregated algae

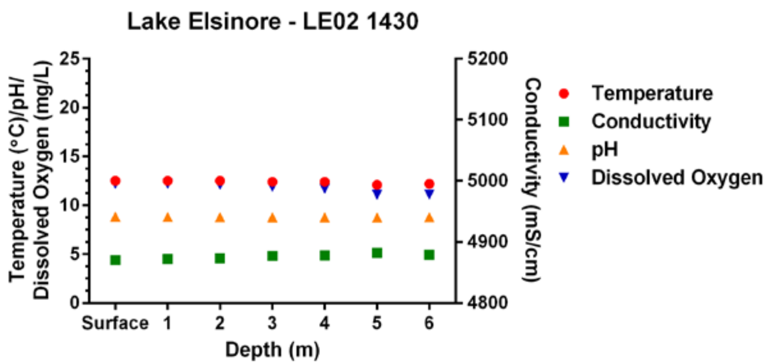
# Water Column Profiles – Lake Elsinore

## February

### Morning




### Afternoon




## April

# Water Column Profiles – Canyon Lake Main Basin

## February

### Morning

Temperature (°C)/pH/
Dissolved Oxygen (mg/L)

Conductivity (mS/cm)

### Afternoon

Temperature (°C)/pH/
Dissolved Oxygen (mg/L)

Conductivity (mS/cm)

# Water Column Profiles – Canyon Lake Main Basin

## April

### Morning

Temperature (°C)/pH/ Dissolved Oxygen (mg/L)

Conductivity (mS/cm)

### Afternoon

Temperature (°C)/pH/ Dissolved Oxygen (mg/L)

Conductivity (mS/cm)

# Water Column Profiles – Canyon Lake East Basin

## February

### Morning

Temperature (°C)/pH/
Dissolved Oxygen (mg/L)

Conductivity (mS/cm)

### Afternoon

Temperature (°C)/pH/
Dissolved Oxygen (mg/L)

Conductivity (mS/cm)

# Water Column Profiles – Canyon Lake East Basin

## April

### Morning

Temperature (°C)/pH/
Dissolved Oxygen (mg/L)

Conductivity (mS/cm)

### Afternoon

Temperature (°C)/pH/
Dissolved Oxygen (mg/L)

Conductivity (mS/cm)

# Water Chemistry – Lake Elsinore and Canyon Lake – February 2016 and April 2016

| Analyte | Units | Lake Elsinore | | CL Main Basin | | | | CL East Basin | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | LE02 | | CL07 | | CL08 | | CL09 | | CL10 | |
| | | Feb | April | Feb | April | Feb | April | Feb | April | Feb | April |
| **Nitrate** | mg/L | ND | 0.37 | 0.39 | ND | 0.29 | ND | -- | -- | 0.42 | ND |
| **Nitrite** | mg/L | ND | ND | ND | ND | ND | ND | -- | -- | ND | ND |
| **Kjeldahl Nitrogen** | mg/L | 9.8 | 6.9 | 1.1 | 2.2 | 1.3 | 1.3 | -- | -- | 1.7 | 1.3 |
| **Total Ammonia** | mg/L | 0.6 | 0.71 | ND | 0.25 | ND | 0.35 | -- | -- | ND | ND |
| **Ortho Phosphate** | mg/L | ND | ND | ND | 0.098 | ND | ND | -- | -- | 0.18 | ND |
| **Total Phosphorus** | mg/L | 0.38 | 0.34 | ND | 0.11 | 0.05 | 0.09 | -- | -- | 0.36 | 0.12 |
| **Sulfide** | mg/L | ND | ND | ND | ND | ND | ND | -- | -- | ND | ND |
| **Total Dissolved Solids** | mg/L | 2700 | 2700 | 710 | 680 | 700 | 650 | -- | -- | 640 | 800 |
| **Surface Chl-a** | µg/L | 187 | * | 88 | * | 86 | * | 76 | * | 65 | * |
| **Depth Integrated Chl-a** | µg/L | 323 | * | 31 | * | 54 | * | -- | -- | 79 | * |

All samples depth integrated, except surface Chl-a (top 2m only)
* = Data not yet available
-- = Not measured