Revision of the Lake Elsinore & Canyon Lake Nutrient TMDL

Chapter 3: Numeric Targets
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

<table>
<thead>
<tr>
<th>Fraction of Water Column &gt; 5 mg/L</th>
<th>Less than 25%</th>
<th>26% – 50%</th>
<th>51% - 75%</th>
<th>76% - 99%</th>
<th>Full</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modeled Days when Depth Average Target Met</td>
<td>0</td>
<td>43</td>
<td>267</td>
<td>213</td>
<td>30094</td>
</tr>
</tbody>
</table>
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 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
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
Station Locations – Lake Elsinore
Station Locations – Canyon Lake
Satellite Imagery – Lake Elsinore Chlorophyll-a
February 2016 and April 2016

February 2016

April 2016
Satellite Imagery – Canyon Lake Chlorophyll-a
February 2016 and April 2016

February 2016

April 2016
Canyon Lake – Field Photos

February

East Basin

Main Basin

April

Floating, aggregated algae
Water Column Profiles – Lake Elsinore

February

Morning

Lake Elsinore - LE02 0800

April

Afternoon

Lake Elsinore - LE02 1430

- Temperature
- Conductivity
- pH
- Dissolved Oxygen

Depth (m)

Surface 1 2 3 4 5 6

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

Conductivity (mS/cm)

Surface 1 2 3 4 5 6
<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>pH</th>
<th>Dissolved Oxygen (mg/L)</th>
<th>Temperature (°C)</th>
<th>pH</th>
<th>Dissolved Oxygen (mg/L)</th>
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<tbody>
<tr>
<td>Afternoon</td>
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## Water Column Profiles – Canyon Lake Main Basin

### April

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<thead>
<tr>
<th></th>
<th>Morning</th>
<th>Afternoon</th>
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<tbody>
<tr>
<td>Temperature (°C)</td>
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<tr>
<td>pH</td>
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<tr>
<td>Dissolved Oxygen (mg/L)</td>
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<tr>
<td>Conductivity (mS/cm)</td>
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<tr>
<td>Temperature (°C)</td>
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<td>pH</td>
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<tr>
<td>Dissolved Oxygen (mg/L)</td>
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<td>Conductivity (mS/cm)</td>
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# Water Column Profiles – Canyon Lake
## East Basin

**February**

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<th>Morning</th>
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<tr>
<td>Temperature (°C)</td>
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<td>pH</td>
<td>Conductivity (mS/cm)</td>
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<td>Dissolved Oxygen (mg/L)</td>
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<tr>
<td>Temperature (°C)</td>
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<td>pH</td>
<td>Conductivity (mS/cm)</td>
</tr>
<tr>
<td>Dissolved Oxygen (mg/L)</td>
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# Water Column Profiles – Canyon Lake East Basin

## April

<table>
<thead>
<tr>
<th>Time</th>
<th>Temperature (°C)</th>
<th>pH</th>
<th>Dissolved Oxygen (mg/L)</th>
<th>Conductivity (mS/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning</td>
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<table>
<thead>
<tr>
<th>Time</th>
<th>Temperature (°C)</th>
<th>pH</th>
<th>Dissolved Oxygen (mg/L)</th>
<th>Conductivity (mS/cm)</th>
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<tbody>
<tr>
<td>Morning</td>
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## Water Chemistry – Lake Elsinore and Canyon Lake – February 2016 and April 2016

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Units</th>
<th>Lake Elsinore</th>
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<td></td>
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<td>LE02</td>
<td>CL Main Basin</td>
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<td>April</td>
</tr>
<tr>
<td><strong>Nitrate</strong></td>
<td>mg/L</td>
<td>ND</td>
<td>0.37</td>
<td>0.39</td>
<td>ND</td>
<td>0.29</td>
<td>ND</td>
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<tr>
<td><strong>Nitrite</strong></td>
<td>mg/L</td>
<td>ND</td>
<td>ND</td>
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<tr>
<td><strong>Kjeldahl Nitrogen</strong></td>
<td>mg/L</td>
<td>9.8</td>
<td>6.9</td>
<td>1.1</td>
<td>2.2</td>
<td>1.3</td>
<td>1.3</td>
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</tr>
<tr>
<td><strong>Total Ammonia</strong></td>
<td>mg/L</td>
<td>0.6</td>
<td>0.71</td>
<td>ND</td>
<td>0.25</td>
<td>ND</td>
<td>0.35</td>
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<tr>
<td><strong>Ortho Phosphate</strong></td>
<td>mg/L</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>0.098</td>
<td>ND</td>
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<tr>
<td><strong>Total Phosphorus</strong></td>
<td>mg/L</td>
<td>0.38</td>
<td>0.34</td>
<td>ND</td>
<td>0.11</td>
<td>0.05</td>
<td>0.09</td>
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<tr>
<td><strong>Sulfide</strong></td>
<td>mg/L</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
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<td>ND</td>
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<tr>
<td><strong>Total Dissolved Solids</strong></td>
<td>mg/L</td>
<td>2700</td>
<td>2700</td>
<td>710</td>
<td>680</td>
<td>700</td>
<td>650</td>
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</tr>
<tr>
<td><strong>Surface Chl-a</strong></td>
<td>µg/L</td>
<td>187</td>
<td>*</td>
<td>88</td>
<td>*</td>
<td>86</td>
<td>*</td>
<td>76</td>
<td>*</td>
</tr>
<tr>
<td><strong>Depth Integrated Chl-a</strong></td>
<td>µg/L</td>
<td>323</td>
<td>*</td>
<td>31</td>
<td>*</td>
<td>54</td>
<td>*</td>
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</tr>
</tbody>
</table>

All samples depth integrated, except surface Chl-a (top 2m only)

* = Data not yet available
-- = Not measured