ReMetrix℠

3D Resource Management Tool for Lake Elsinore
Documentation
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Background

This documentation describes the key purpose, features, and parameters for the GIS-based, three-dimensional resource management tool (3D-RMT) that ReMetrix LLC created for the Lake Elsinore & San Jacinto Watersheds Authority (LESJWA).

The 3D-RMT was created to better enable the quantification, analysis, and visualization of impacts resulting from lake management activities. The tool is able to quantify the annual and cumulative impacts using both current and historical data, as well as impacts that might arise or be mitigated by proposed future activities.

The core of the mapping tool was designed using ESRI® ArcGIS and Google Earth™ software. Customized database structures were created and linked to the three-dimensional GIS cells to enable the data analyses. The final part of the development process was a finding a practical technique to export the three-dimensional analysis grid into a common, inexpensive, easy-to-use format for end-user visualization purposes. Google Earth™ was selected as that format after the evaluation of a variety of low-cost geospatial data viewers.

Features

General description of the tool

The 3D-RMT consists of two components: 1) GIS layers and data from which detailed calculations and analyses are done, and 2) the visualization layers exported for viewing in three dimensions within Google Earth™. The tool development involved creating several highly-detailed GIS data layers from various ortho-imagery, oblique images, digital elevation data and CAD contour data. A dense Triangulated Irregular Network (TIN) was modeled from single-beam hydroacoustic survey data collected in 2010 by Dr. Michael Anderson (U.C. Riverside) and used to perform very accurate volumetric calculations. These data were then used to populate attributes of a three-dimensional grid of cells throughout the lake. The cell sizes are 200-meters by 200-meters in the *x* and *y* dimensions, and 1-foot in the *z* dimension (height). Thus each cell has a volume of 430,556 cubic feet (~9.9 acre-feet). The only cells that are smaller in size are those that intersect with the shoreline and/or the bottom of the lake, which are clipped to fit their localized geomorphology. The grid of cells are queried and displayed according to the desired attributes and exported to display as an individual layer in Google Earth™.

The one-foot depth of each cell allows for the display of areas of interest at the various water levels that occur at the lake over time. It further allows for comparison of conditions between scenarios, such as changes in aquatic characteristics over time.

GIS layers have been created for the time-of-data-collection condition of the lake. (A list of layers is provided below in this document.) A key feature of the tool is that the attributes for various layers are expressed in three-dimensional volumetric space, rather than just the two-dimensional space more typical of GIS analyses. This volumetric approach enables the important calculation of three-dimensional effects from both natural factors and factors influenced by lake management activities. A two-dimensional analysis approach often overestimates or underestimates actual, real-world effects.

The value of the three dimensional viewing environment is evident in the following hypothetical example: Submerged vegetation that covers 300 acres in the lake (approximately 10% of the surface area, and 15% of the littoral habitat) may only inhabit 1,200 acre-feet of space within the lake (approximately 1.6% of the lake volume and 2.7% of the littoral habitat volume). Realities such as this example become much more apparent and intuitive when the data are viewed in three dimensional contexts.

The modeling process of the 3D-RMT incorporates the fourth dimension of time into the equation, thereby enabling the estimation of cumulative long-term effects of natural variations and lake management activities.

Layers in the tool
Layers in the tool consist of characteristics such as lake sediment properties, Chl-α and phosphorus data, sampling locations, laboratory data, field biological data, and other relevant geospatial parameters that contribute to management decisions at the lake.

Some layers consist of polygons (e.g., SAWPA analyte data), and some are rasters (e.g., Chl-a values from Blue Water Satellite imagery analysis). A sample of the layers currently in the tool are:

• SAWPA Total Nitrogen (mg/L)	• SAWPA Total Dissolved Solids (mg/L)
• SAWPA Total Phosphorous (µg/L)	• SAWPA Secchi Depth (cm)
• SAWPA Dissolved Oxygen (mg/L)	• UCR Percent Organic Carbon
• SAWPA Chlorophyll-α (µg/L)	• UCR Sediment Oxygen Demand (g O_2 m^{-2} d^{-1})
• SAWPA Temperature (°C)	• BWSI Chlorophyll-α (µg/L)
• SAWPA Ammonium as N (mg/L)	• BWSI Total Phosphorous (µg/L)

Layers are created for the time-of-collection pool condition taken from the historical water level database. Significant time was invested in positioning and dimensioning the layers accurately. After the layers are finalized, their boundaries and attributes are able to be extrapolated to three-dimensional space for each key time period and lake level.

Shoreline delineation
The boundary for the full-pool lake shoreline was carefully interpreted in the GIS using a combination of public and restricted aerial imagery from numerous years, digital elevation model contours, and input from individuals familiar with the lake geography. While the final boundaries are quite accurate in most instances, end-users of the tool and data outputs should recognize that because interpretation and estimation were necessary

in some boundary segments, the boundaries should not be assumed to be legal definitions without further inquiry.

Outputs from the tool

Upon completion of analyses, the data outputs (e.g., the volumetric space from where data points were sampled) were exported from the GIS into Google Earth for viewing. The Google Earth software enables the end-user to interactively visualize and understand the data outputs. The software's functionality allows users to easily zoom, rotate, and pan around the three dimensional space of the lake.

Although calculations using the tool are best performed and visualized in three dimensions, the analysis outputs can often be summarized in a two-dimensional format. This is an important factor in the overall usefulness of the tool, since the analytical results will often need to be incorporated into hard copy reports and communications.

Using the Visualization Layers

Opening the visualization layers in Google Earth™

When the need arises for displaying data in three dimensions, the appropriate .kml or .kmz file should be located by file name from the storage location holding the pre-rendered layers. When found, the user should open the file using Google Earth™. Once the main software program is fully loaded and the data are displayed, the user may adjust the color and transparency of the cells by using the Properties dialog box of the appropriate layer. The user is advised to be patient while loading or modifying display characteristics as many of the layers contain an enormous amount of data and may require several moments to display.

Some program adjustments may help the performance of the display. First, one should set the *Memory Cache* and *Local Disk Cache* settings to their maximum values, (found in the Google Earth™ *Tools>Options* dialog box, then access the *Cache* tab). At the time of this documentation, the maximum settings for these adjustments are 500 MB and 2000 MB respectively. Under the *3D View* tab, *Graphics Mode* should be set to *DirectX*, Terrain Quality should be set towards the Lower (faster) 1/4 side on the slider bar, and Elevation Exaggeration should be set to 1.5. After using the visual tool for a while, you may wish to make an adjustment to the Mouse Wheel Speed in order to make the zooming adjustments more manageable (found under the Navigation tab). One may also wish to disable the "Automatically tilt while zooming" feature to assist with navigation while zoomed in close to the model. Fine tuning the computer's system settings for the mouse (specifically the pointer speed and checkbox for "Enhance Pointer Precision") may also assist with fine control of panning and tilting while zoomed in close to the model.

When viewing the "time aware" features the Google time slider toolbar automatically appears. Some adjustment to the properties of this toolbar may be necessary to achieve optimum viewing. Since the data is organized by a specific date with one data collection date within one calendar year, it may be best to set the 'start date' 1 year behind the 'end date'. In doing this, the 'play' feature may be used to display the sequence of time steps automatically with a 1-year moving window with minimum overlap between data collections.

Depending upon the kind of data being represented, different export methods were used to obtain the desired "look" of the layer. Some export methods stripped the analyte value from the feature. Where this was the case, a color ramp and legend are provided as an overlay to help the user identify analyte values. For the other data, the values are available directly within Google Earth™ by left-clicking a particular cell. The balloon attribute window will display the cell's information.

Status, Progress and Updates

This is an ongoing project and additional sections will be periodically added to this document as new segments are completed. As of the time of this documentation, layers have been created for the following dates: 8/28/2002, 2/20/2003, 6/14/2004, 2/9/2005, 6/20/2006, 8/20/2008, 3/24/2009, and 7/31/2010*. These dates were chosen since there were data available from both the SAWPA database and satellite imagery analysis. (* note, 7/31/2010 data represents the two UC Riverside sediment data analyses only, since no SAWPA data was provided for this date). As the project moves forward, additional layers representing these features can be created for the other dates and lake levels to assist with analyses at historical and future lake conditions. Additional layers can be created to display commonly requested scenarios such as lake-wide water quality variation over a five-year period. It is impractical to render and store all of dates and layers for visualization (which would result in 1600+ output layers using the current eight-analyte subset). Therefore when a need for analyses and visualization arises, the client should contact ReMetrix to describe the visualization and calculations needed and have the specific features rendered on an as-needed basis. Perhaps an alternative to this would be for ReMetrix to provide access to the 3D model in native ESRI format so that the client could perform and evaluate various combinations of calculations and scenarios on their own. ReMetrix could then render the desired final outputs in Google Earth as needed.