

Central Valley Water Management Screening Model for Water Management Alternatives

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Abstract: The California Department of Water Resources (DWR) and the U.S. Bureau of Reclamation Mid-Pacific Region (Reclamation) have developed CalLite as an interactive screening model for evaluating various Central Valley water management alternatives. The CalLite model has been used as a negotiations tool in a variety of stakeholder processes for improved understanding of water system operations and for consensus based decision-making. The model has been applied to studies related to: the Bay Delta Conservation Plan, delta regulations, system reoperation, and other planning processes. CalLite was developed using the Water Resources Integrated Modeling System (WRIMS) software that uses a linear programming solver to simulate the system. The syntax of the model algorithms is written in Water Resources Simulation Language (WRESL). A Java-based graphical user interface (GUI) for CalLite was developed to facilitate ease of use by stakeholders. The GUI allows simplified modification of a variety of water management actions, including: alternative conveyance options, demand management, and Delta channel flow and salinity targets. CalLite maintains the hydrologic, operational, and institution integrity as represented in the companion model CalSim, DWR and Reclamation's more detailed water resources simulation model. The results obtained from a typical CalLite run (<10 minute run time) are within 1% of a corresponding CalSim run (30 minute run time). The short run time and straightforward interface encourages managers, policy makers, and others without extensive modeling backgrounds to use CalLite as a tool for exploring potential water resource management decisions in California.

Keywords: *CalLite; CalSim; Screening Model; California Water Resources; Planning and Management*

1 INTRODUCTION

California's spatiotemporal water supply and demand patterns have driven the local, State and federal government agencies to build a complex water management system consisting of reservoirs, pumps and conveyance canals. California's main water management systems, the State Water Project (SWP) and the federal Central Valley Project (CVP), are now experiencing increasing pressure due to population growth, environmental flow and quality restrictions, aging infrastructure, and climate change. To understand these issues and mitigate any possible effects, water resource planners need to be able to screen different alternatives for balancing water supply reliability and ecosystem health goals.

To capture the detail and complexity of California's water system, DWR and Reclamation have developed the California Water Resources Simulation Model (CalSim), a full-featured, Water Resources Integrated Modeling System (WRIMS)-based model to analyze different water management alternatives (Draper et al. 2004; Leaf and Arora 1996; Brekke et al. 2006; Ferreira and Lund 2006; Van Lienden et al. 2006; Vicuna et al. 2007).

While CalSim is an excellent tool for detailed final analysis and feasibility reports, it is not well-suited for exploratory analysis due to the long run time, difficulty for non-modeler stakeholders to perform

simulations (due to model complexity), and lack of immediate, interpretable results. To address these issues, DWR and Reclamation developed a rapid, interactive, transparent (i.e. free publicly-accessible code), and user-friendly screening model for Central Valley water management known as CalLite. CalLite uses a Java-based graphical user interface (GUI) paired with a simplified river network model and is based on the WRIMS engine. In addition to the simplification of model nodes, CalLite also uses output from standard CalSim runs to decrease run time. The ease of use of the CalLite model allows it to be a valuable tool for non-modeler stakeholders and policymakers while still maintaining the integrity of the full-featured parent model, CalSim. Even experienced modelers may use CalLite as a screening model to quickly sort out the important scenarios to critically analyze in CalSim, thus saving time while allowing a broader scope of investigation. The focus of this paper is on the CalLite GUI, its integration with the WRIMS engine and the interactive user experience. Islam et al. (2011) provides an in-depth discussion of the CalLite system description, regulations, hydrology, and operational criteria.

2 ROLE OF THE CALLITE MODEL

The intent of the CalLite screening model is not to replace full-featured models such as CalSim. Rather, it is developed to aid a variety of stakeholder processes to improve existing water management and to investigate proposed water supply projects or regulations.

Framing water management problems and developing alternative solutions involves repetitive model runs and continued stakeholder-modeler interaction. Performing numerous iterations with a highly complex model such as CalSim would be time consuming and resource intensive, and its output would not be readily interpretable by non-modelers. CalLite bridges the gap between more detailed system models and policymaker/stakeholder demand for rapid and interactive policy evaluations. Paired with a short run time, features such as Batch Run, Quick Results, and the External PDF report tool become especially useful for iterative decision-making. The role of the screening model along with key characteristics in terms of complexity and ease of use is depicted in Figure 1. The models at the top of the pyramid (i.e. CalLite) allow exploration, user interaction, and are accessible to non-expert modelers. In contrast, the models towards the bottom of the pyramid (i.e. CalSim) are highly complex and require expert modelers to operate and interpret results.

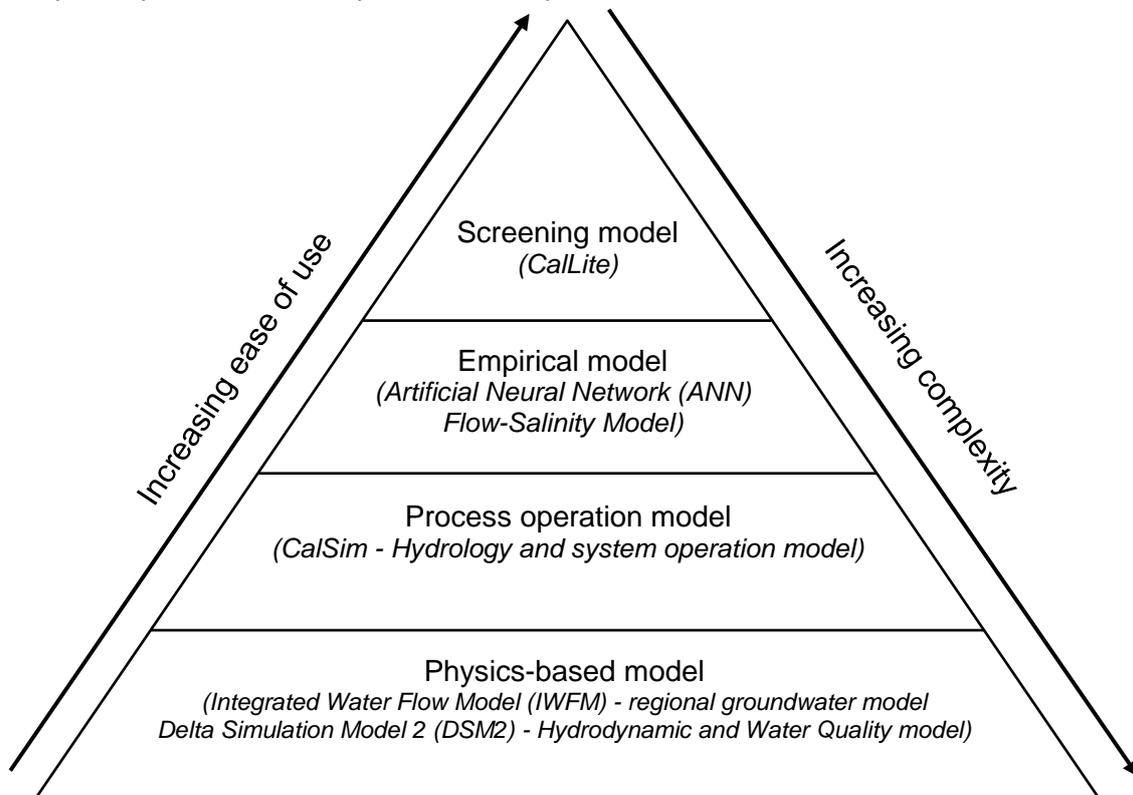


Figure 1. Conceptual diagram of the relative complexity and ease of model use (Islam et al. 2011).

3 MODEL PLATFORM AND SIMULATION ALGORITHM

The CalLite screening model and CalSim are based on WRIMS, a modeling engine developed by DWR. WRIMS uses a linear programming/mixed integer linear programming solver to determine an optimal set of decisions for each time period, given a set of relative weights and system constraints. Water Resources Simulation Language (WRESL) code, a flexible language interface to the linear programming solver and the database, is used to define variables and establish constraints. The WRIMS engine (DWR 2000a, 2000b) translates the system described by WRESL code into a linear programming problem which is submitted to a linked solution algorithm for each time step.

The primary objective in developing the CalLite model is improving user accessibility. This is attained by linking the complex WRIMS/WRESL engine with an intuitive GUI package (referred to as the CalLite WRIMS engine and the CalLite GUI). This linkage improves model accessibility by separating the end-user from technical model components while maintaining CalSim compatibility and the transparency of the WRESL/WRIMS implementation. A secondary goal is to retain developer accessibility within the CalLite WRIMS and the CalLite GUI sub components to seamlessly accommodate future regulation changes and model capabilities. The connectivity between these two modules and developer accessibility respectively are discussed in the next two sections.

3.1 Link tables and Lookup Tables

The CalLite WRIMS engine obtains run parameters by reading in data from space-delimited text files (lookup tables) and input time series files (DSS). The purpose of the CalLite GUI is to facilitate the process of modifying the lookup tables through interactive GUI elements such as check boxes, radio buttons and text input fields and to specify the particular input DSS files to use. This is done as follows:

- (1) Users select options from GUI elements.
- (2) These options are translated to text and written to the lookup table. A GUI link input table explains to the CalLite GUI how to translate actions from GUI elements to text and which lookup table to write to.
- (3) The CalLite WRIMS engine then reads in the values from the lookup tables. The lookup tables may contain text, binary switches, option switches, or user-defined values.

These values (along with those from static lookup tables) make up the system's goals and constraints, defining the solution space for the output decision variables. Static lookup tables cannot be modified through the GUI, as they represent set rules and constraints. However, they can be modified manually by editing the .table file in the file-based directory.

3.2 Changing the GUI via XML and Link Tables

The contents and layout of the CalLite GUI is defined by an external .xml file (GUI.xml), which is read in at runtime by the Java code. This allows even non-programmers to quickly modify or add basic GUI elements and integrate them with the CalLite WRIMS engine through the link tables. Generally, an end-user such as a stakeholder or policymaker will not modify the .xml file—this feature is intended to allow typical model developers who are not Java experts to efficiently update and modify relevant aspects of the GUI, thereby reducing the need to involve Java-proficient developer for every task. Conversely, the GUI coders do not need WRESL expertise, as both model and GUI developers can collaborate through the XML and link tables.

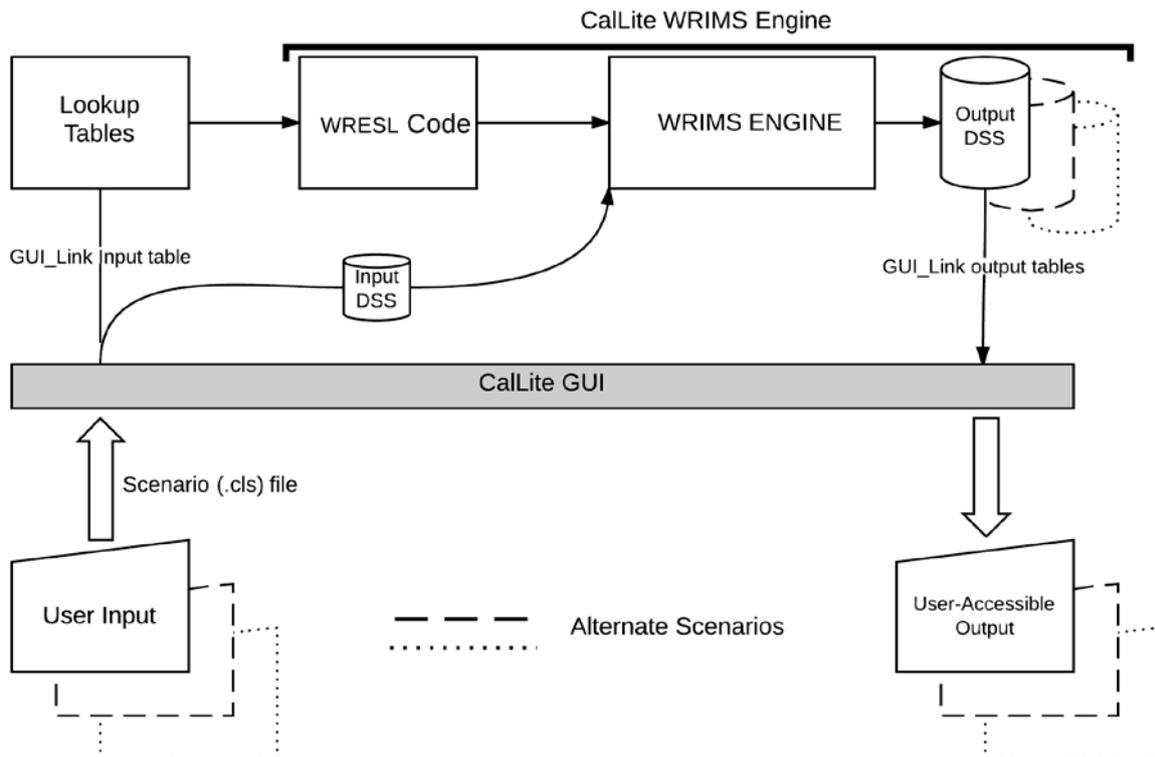


Figure 2. Design of WRIMS-based CalLite, illustrating the CalLite GUI as an interface between the user and the technical model components.

4 MODEL GRAPHICAL USER INTERFACE

The CalLite GUI serves as the primary entry point for most users. The GUI has a series of dashboards which allow the user to control, edit, run scenarios, and view results (Figures 3, 4). The first six dashboards — known as the scenario modification dashboards — are Run Settings, Hydroclimate, Demands, Facilities, Regulations, and Operations (Figure 3). These dashboards allow the user to: (1) load, run and save scenarios, and (2) select options such as level of land use development, climate change, water supply demands, regulations, and operations. The scenario modification dashboards are linked to the CalLite WRIMS engine by the GUI links input tables.

4.1 Running the Model and Outputs

The CalLite GUI generates and saves CalLite scenario files (.cls files) based on user-specified run settings from the GUI modification dashboards. These files do not contain any time series data, but serve instead as a template for saving user-defined parameters that are accessed by the CalLite GUI only, not the CalLite WRIMS engine. The user can save multiple scenario files and load or modify them for later use. Figure 2 shows how alternate scenarios can be loaded into the CalLite WRIMS engine through the CalLite GUI and run to produce corresponding output files.

A typical CalLite run for one scenario takes less than ten minutes and produces an output file with the monthly time series data for the 82 year planning period (1921-2003). The user can also use the Batch Run feature, where up to four successive scenarios can be loaded and simulated at once. Once a scenario is run, the output and scenario files are saved.

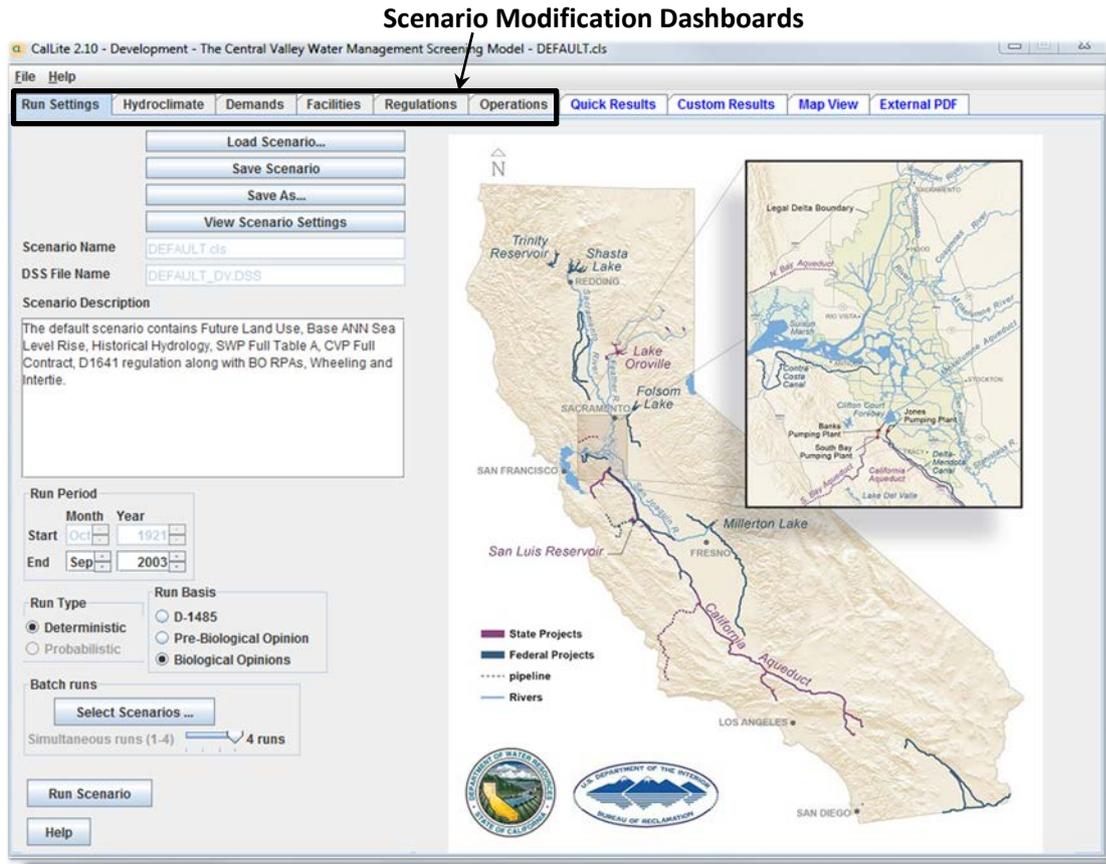


Figure 3. The scenario modification dashboards (#1-6) allow users to modify and run scenarios.

4.2 Results Dashboards

The second set of Callite dashboards consists of Quick Results, Custom Results, Map View, External PDF, and Web Map (see Figure 4). The Quick Results dashboard allows the user to view a variety of pre-selected model outputs in either graphical or tabular format, for single or for multiple scenarios. Monthly timeseries and exceedance graphs, tables of monthly and annual values, and statistics for different water year types and periods are available on this tab. In addition, the GUI has a built-in scenario manager that allows the user to view differences between scenarios without any limit on the number of scenarios. The External PDF dashboard allows the user to generate a standardized PDF report comparing the results of two scenarios (Callite or CalSim or a mix). The Map View dashboard shows the Callite schematic, and the Web Map dashboard contains an embedded internet browser that allows the user to view Callite features overlaid on Google Maps. On both of these dashboards the user can view Callite results by clicking on the schematic or Callite feature.

Callite users can also access the output files directly. Each Callite run generates and saves the output time series files in HEC-DSS format, a database storage system designed by the U.S. Army Corps of Engineers Hydraulic Engineering Center. DSS files allow efficient storage and retrieval of a large amount of time series data and can be viewed and plotted independently of Callite using the free HEC-DSSVue software (U.S. Army Corps of Engineers 2009) or other data analysis software (such as Microsoft Excel).

Results Dashboards

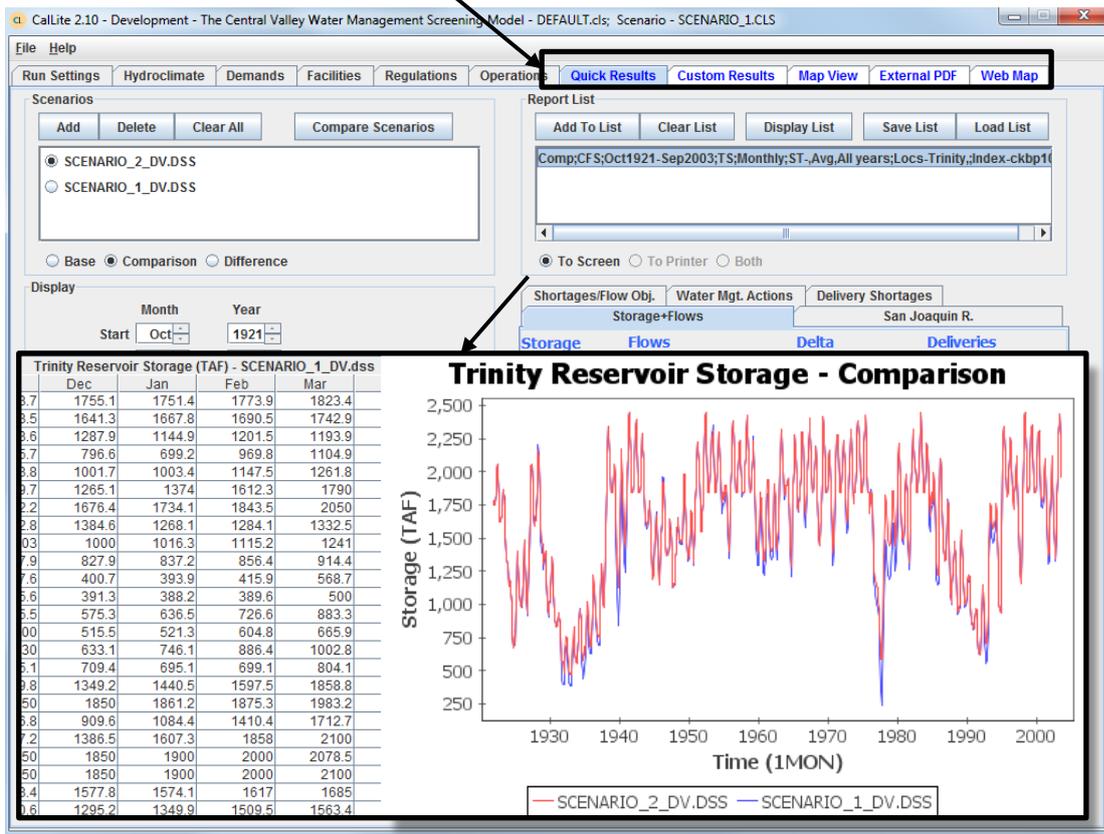


Figure 4. The results dashboards (#7-10) allow users to view graphical or tabulated data based on previously run scenarios. A comparison plot and tabulated data are shown for 'Trinity Storage' under the 'Quick Results' dashboard.

5 CONCLUSIONS

Callite is a policy neutral, transparent, and user-friendly screening model developed by DWR and Reclamation to investigate alternatives for the operation, management and planning of the California Central Valley water resource system. Unlike its full-featured parent model, CalSim, Callite may be easily operated by non-modelers and modelers alike. Policymakers and stakeholders can use Callite to better inform policy or management decisions, while modelers can utilize it as a screening model to rapidly investigate a broad range of scenarios. A single run of Callite takes under ten minutes to complete but simulates system operations results to within 1% of CalSim results. Callite achieves faster runtime by representing the Central Valley water resource system based on a simplified river network and by pre-processing certain data output from CalSim. The ease of use stems from an interactive Java-based GUI that links users to the powerful WRIMS engine; users can modify a range of parameters and view model outputs directly from the GUI. Since Callite is based on the same WRIMS engine as CalSim, corroboration studies, system updates, and code modifications can be implemented by the same staff. From a development perspective, the modular design allows typical modelers without Java expertise to easily update and modify Callite through the XML and GUI link tables.

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