The Texas A&M University and U.S. Bureau of Reclamation Hydrologic Modeling Inventory (HMI) Questionnaire

January 2010

Name of Model, Date, Version Number: Water Rights Analysis Package (WRAP), 2010 Version

Contact: Texas Water Resources Institute, Texas A&M University System, http://twri.tamu.edu/, (979)845-1851, Ralph Wurbs, r-wurbs@tamu.edu, (979)845-3079

Brief Description: The WRAP modeling system simulates water resources development, management, regulation, and use in a river basin or multiple-basin region under a priority-based water allocation system. The model facilitates assessments of hydrologic and institutional water availability and reliability in satisfying requirements for municipal, industrial, and agricultural water supply, hydroelectric energy generation, environmental instream flows, and reservoir storage. In WRAP terminology, water use requirements, water control infrastructure, and reservoir/river system operating strategies are called water rights. Basin-wide impacts of water resources development projects and management practices are modeled. Earlier versions of WRAP were designed specifically for water availability and reliability analyses based on the results of a simulation using a monthly computational time step. The 2010 version also includes daily time step modeling capabilities that include flow forecasting, flow routing methods, disaggregation of monthly naturalized flows to daily flows, and simulation of flood control reservoir system operations. Salinity simulation capabilities have also been recently added.

Model Type: Simulation of river/reservoir system management.

Model Objective(s): The objective is to provide flexible user-oriented generalized modeling capabilities for assessing hydrologic and institutional water availability and reliability for water supply, instream flow, hydroelectric power, and reservoir storage requirements under various scenarios of river/reservoir system development and management. Flood control reservoir operations and salinity tracking capabilities are included in the latest version of the modeling system. Basinwide impacts of water resources development projects and management strategies may be evaluated. The model is generalized for application to any river-reservoir-use system, with input files being developed for the particular river basin of concern.

Model Structure or Mathematical Basis: The water accounting model combines water management requirements with hydrology represented by sequences of historical naturalized stream flows and reservoir net evaporation rates. Stream flow and reservoir storage are allocated to specified water use requirements during each month (or day) of a hydrologic period-of-analysis. Stream flow and reservoir storage frequency relationships and water supply reliability indices are determined from the results of the simulation. A conventional long-term simulation is based on a hydrologic simulation period of typically many years. Alternatively, an analysis of reliabilities conditioned on preceding storage is

based on many short-term simulations starting with the same storage conditions. The package includes features for converting gaged flows to naturalized flows and distributing the adjusted flows from gaged to ungaged locations. Sequences of monthly naturalized flows may also be dissaggregated to daily flows for a daily time step simulation. Routing and forecasting options may be activated with a daily simulation. A post-simulation program performs a variety of frequency and reliability analyses. A salinity simulation component tracks salinity inflow loads through the system, and salinity concentration frequency statistics are computed.

Spatial Scale Employed in the Model: A river basin, sub-basin, or multiple-basin region may be modeled. Spatial location and connectivity of all components of the river-reservoir-use system are represented by control points. Any number of control points, reservoirs, and other system components may be included in a simulation.

Temporal Scale Employed in the Model: Earlier versions of WRAP were based on a monthly computational time step. The latest version has the additional option of a daily time step or other sub-monthly time steps ranging between daily and monthly. There is no limit on the number of years in the hydrologic period-of-analysis.

Input Data Requirement: Two sets of simulation input data represent (a) hydrology and (b) water rights. The hydrology input data include: (1) sequences of naturalized stream flows covering a multiple-year period-of-analysis for selected control point locations, (2) watershed parameters for distributing flows from gaged (known-flow) to ungaged (unknown-flow) control point locations, (3) channel loss factors, and (4) sequences of monthly net reservoir evaporation-precipitation rates. A pre-simulation utility facilitates development of the naturalized stream flow and net evaporation-precipitation input data for the simulation. Water rights input data include: (1) water supply diversion and return flow, instream flow, and hydroelectric energy targets and/or specifications for determining targets as a function of storage or streamflow, (2) reservoir storage capacities and elevation-volume-area relationships, (3) hydroelectric power plant characteristics, (4) data specifying river/reservoir system operating rules, and (5) data defining priorities governing allocation of water among water rights.

Model Output: The main simulation model outputs naturalized, regulated, and unappropriated streamflows, reservoir storage content and net evaporation, diversions and diversion shortages, hydroelectric energy generated and energy shortages, instream flow shortages, and other variables for each time step of the multiple-year simulation for each appropriate control point, reservoir, and/or water demand. A post-simulation program reads the simulation output file, computes frequency and reliability indices, and organizes the voluminous simulation results into a variety of user-specified tables.

Input Data Format: The component executable programs of the modeling system read input data from text files in ASCII format. The programs also read hydrology data from binary Hydrologic Engineering Center Data Storage System (HEC-DSS) files.

Output Data Format: Simulation results may be stored optionally as text files or HEC-DSS files. WRAP includes a post-simulation utility for organizing simulation results in a variety of different tables. HEC-DSS files may be read with HEC-DSSVue for developing graphs or performing other data manipulations.

Parameter Estimation/Model Calibration: An optional set of routines is provided for calibrating routing parameters.

Model Testing and Verification:

Model Sensitivity:

Model Reliability:

Model Application/Case Studies: WRAP is generalized for application anywhere in the world, with model-users developing input datasets for the particular river basins of concern. In WRAP simulation studies in Texas, datasets from the Texas Water Availability Modeling (WAM) System are altered as appropriate to reflect proposed water management plans of interest. Although WRAP has been applied in other countries, the Texas WAM System represents its most extensive application. The WAM System maintained since the late 1990's by the Texas Commission on Environmental Quality (TCEQ) in collaboration with the Texas water management community consists of the generalized WRAP along with input datasets for all of the river basins of Texas. The WRAP hydrology and water right input datasets for the 23 river basins of Texas include naturalized stream flows at about 500 gauged sites, watershed parameters for distributing these flows to over 12,000 ungauged locations, 3,435 reservoirs, water use requirements associated with about 8,000 water right permits reflecting two very different water right systems, two international treaties, and five interstate compacts. The WAM System models for the individual river basins are applied routinely by water management agencies and consulting engineering firms in regional and statewide planning studies, administration of the water right permit system, and other water management activities.

Platform/Operating System: WRAP is executed on personal computers with Microsoft Windows.

Programming language and software: The executable programs were compiled from Fortran 95 source code. However, no special software other than Microsoft Windows is required to execute the model.

Web-based or desk-top application? Desk-top.

Is the application flexible to couple with external programs and user created executables? The HEC-DSS Library is embedded within the WRAP programs allowing the model to optionally create and read DSS files. The Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers developed the Data Storage System (DSS) for use with HEC simulation models but provides other model developers access to their

DSS software. WRAP is also designed to facilitate use with spreadsheet programs such as Microsoft Excel. An ArcGIS based tool is available for spatial display of WRAP simulation results.

Are system and user documentation available? A set of five reference and users manuals are available at https://ceprofs.civil.tamu.edu/rwurbs/wrap.htm. These manuals reference other Texas Water Resources Institute technical reports describing WRAP applications (http://twri.tamu.edu/reports.php).

Are example applications available? WRAP input datasets for the 20 examples presented in the manuals are available at: https://ceprofs.civil.tamu.edu/rwurbs/wrap.htm. This website also links with the TCEQ WAM System website that includes WRAP datasets for all of the river basins of Texas.

Is there a user group or hotline-type support? One-day WRAP User Group Conferences have been held twice a year since 2006. A 2.5 day short course is offered annually by the Texas Water Resources Institute (http://twri.tamu.edu/).

Other Comments: none