U.S. Geological Survey
Fact Sheet FS-165-95

Interactive Computer Program to Simulate and Analyze Streamflow, Truckee and Carson River Basins, Nevada and California

After decades of litigation and negotiation, the Truckee–Carson–Pyramid Lake Water Rights Settlement Act was passed in 1990. The law provides a foundation for developing operating criteria for interstate allocation of water to meet demands for municipal, irrigation, fish-and-wildlife, and recreational uses, as well as to meet water-quality standards, in the approximately 7,000-square-mile Truckee and Carson River Basins of western Nevada and eastern California (*fig. 1*). The Truckee–Carson Program of the U.S. Geological Survey (USGS) is supporting the Department of the Interior in implementing the Act by taking the lead to

- Develop a consolidated network of streamflow gaging stations and water-quality monitoring sites operated by several agencies to consistently document water resources and support river operations; and
- Calibrate, test, and apply interbasin hydrologic and hydraulic computer models to support the efficient planning, management, and allocation of water.

To help meet the first objective, streamflow, stream-temperature, and water-quality monitors have been established in the two basins by the USGS. To meet the second objective, a computer model simulating storage, flow, and quality of the water in both drainage basins and the Truckee Canal is being calibrated with measurable physical parameters and with data from geographic information systems. The model, based on the Hydrological Simulation Program–Fortran (HSPF; Bicknell and others[1]), is also being linked with an operations-and-allocations model to analyze alternative management scenarios at hourly, daily, monthly, or annual time scales. Use of such a comprehensive river-basin model to assess hydrologic consequences of reservoir and diversion operations or changes in land use requires advanced computer-processing capabilities to facilitate summarizing and analyzing the large volumes of input and output data.

This fact sheet summarizes current capabilities of the interactive computer program GENSCN (GENeration and analysis of model simulation SCeNarios) developed by J.L. Kittle, Jr., and coworkers (USGS, written commun., 1995). GENSCN creates one or more scenarios and compares the results all within a single integrated software package. Examples of GENSCN that follow are from a flow-routing model applied to the Truckee and Carson River Basins. GENSCN's utility as part of a larger decision-support modeling system has been demonstrated in other physical settings. In Maryland's Patuxent River Basin, GENSCN and HSPF have been used to study effects of best management practices on water quality.

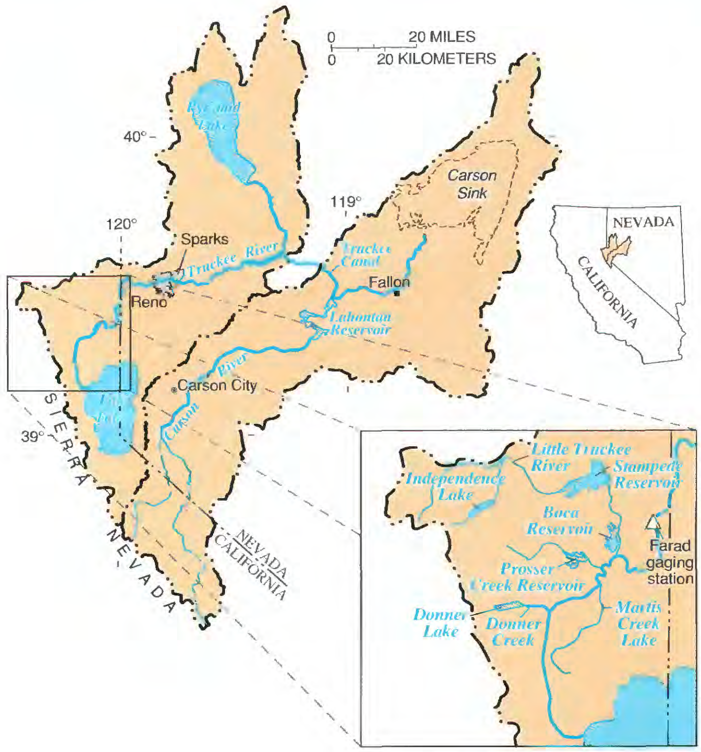

Figure 1. Urban and hydrologic features of the Truckee and Carson River Basins.

Overview of GENSCN

A *scenario* is a unique set of water-management operations and climate and physical characteristics that simulate a proposed situation. A model scenario is defined by a coded input sequence containing user specifications, data regarding the river-system configuration and input and output time series, applicable legal and operational constraints, and physically based parameters that govern hydraulic or water-quality processes selected for simulation. Current (1995) USGS plans are to provide a "library" of commonly requested scenarios for users who have little modeling expertise. These scenarios may be edited to create new ones.

Three criteria (constituent, location, and scenario) are used in GENSCN to select data to be analyzed. Data selected can range from all constituents at all locations for all scenarios to the smallest subset, such as observed stream temperature at a single gaging station. The user chooses the type of analysis to apply to the data selected. Tables, plots, or statistical analyses may be viewed on the display screen or printed as output files.

[1] Bicknell, B.R., Imhoff, J.C., Kittle, J.L., Jr., Donigian, A.S., Jr., and Johanson, R.C., 1993, Hydrological simulation program--FORTRAN user's manual for release 10: U.S. Environmental Protection Agency document EPA/600/R-93, 660 p.

Description of GENSCN Functions

GENSCN was designed so that several "windows" can appear on a single screen, as shown by the menu and map windows in *figure 2*. Simpler, single-window displays in *figures 3–9* show available analytical options and are intended to illustrate the features of GENSCN, rather than to convey citable or quantitative model results.

Locations along the rivers, including gaging stations, may be selected through a series of menus or by clicking on map locations with a computer mouse. Areas of interest may be enlarged using the zoom capability of the map option. Models currently linked to GENSCN allow analysis of data from more than 100 sites in the Truckee and Carson River Basins.

Simple lists or formal tables of the data may be viewed on the screen or printed. Graphs can be plotted next to the data lists so that the user can scan and analyze results quickly. Graphics created can compare daily streamflow for different scenarios at a particular site, such as the Truckee River gaging station at Farad, or for the same scenario at different sites. Hydrographic comparisons help the user evaluate accuracy of simulated water quantity (*fig. 3A*) or quality and distinguish differences between scenarios. Furthermore, time-series values for two dif-ferent categories of data—for example, daily average streamflow and daily average stream temperature—can be plotted on the same graph. Daily data may be aggregated into monthly (*fig. 3B*) or annual time intervals. Thus, results from different models can be compared using like time scales.

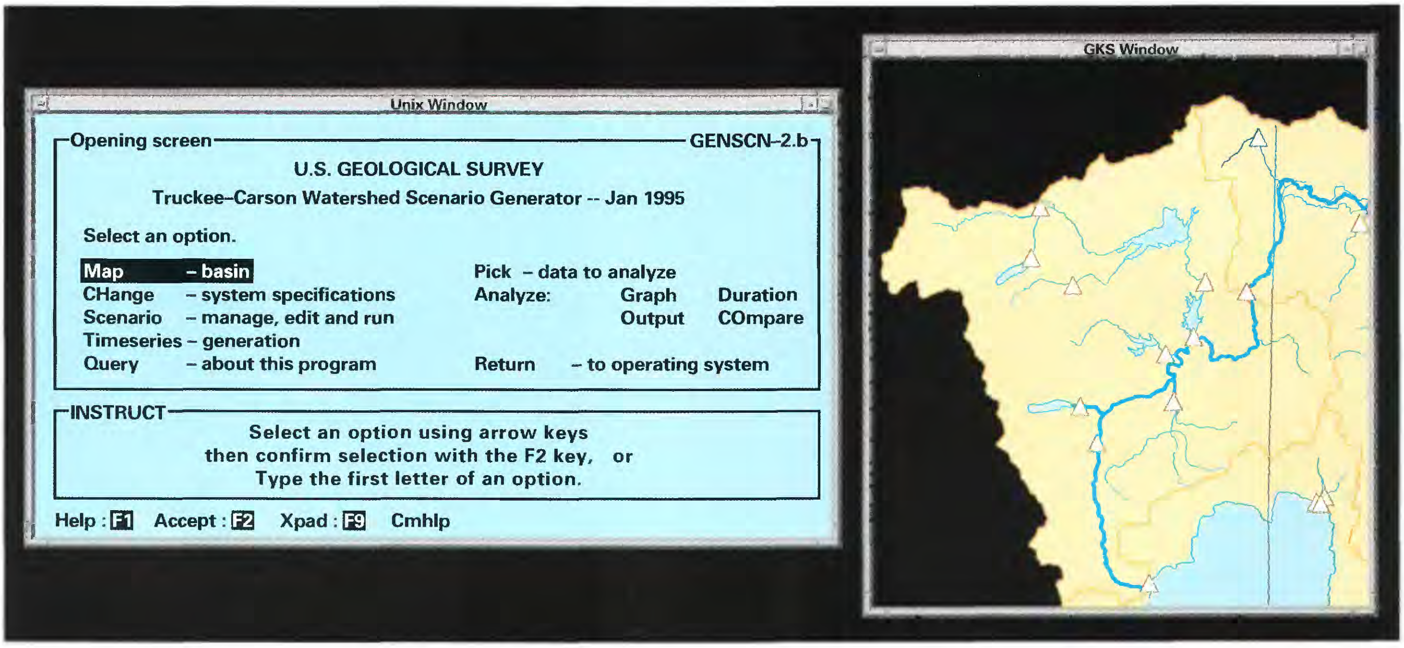

Figure 2. Multi-window screen showing GENSCN menu window and map with selected gaging-station sites in upper Truckee River Basin.

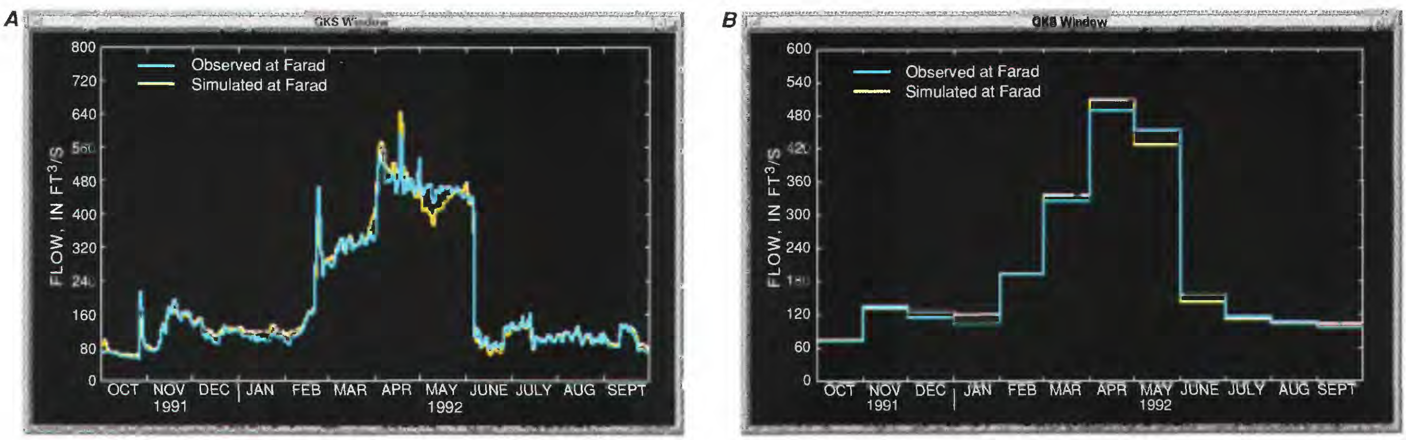

Figure 3. Observed and simulated daily average streamflow for Farad gaging station (A). Daily data can be aggregated to provide results at monthly (B) or other time intervals.

GENSCN contains the option of plotting a regression line and calculating the regression equation for the relation between observed and simulated streamflow (*fig. 4*) so that the user may assess variance (scatter) and bias over the simulation period. Curves of flow duration (*fig. 5*) may be plotted to detect simulation bias or identify differences between scenarios at various ranges of flow. The same plot could be generated for data other than streamflow.

An example of residual values (difference between observed and simulated values or between values for two scenarios) over a given period is shown for the Farad gaging station (*fig. 6*). Differences in flow for two scenarios also may be plotted against flow instead of time for either scenario to help the user see how differences vary with the magnitude of flow.

GENSCN can provide several standard statistical measures for checking differences between observed data and model simulations or for comparing scenarios—even within specified ranges of flow. For example, a preliminary model run (*fig. 7*) indicates that the root mean square error for daily flows between 100 cubic feet per second (ft^3/s) and 1,000 ft^3/s at the Farad gaging station is 36.9 ft^3/s, or 7.8 percent of observed daily flows.

A unique function of HSPF and GENSCN is the capability to track and display ownership of water. For example, releases made from Donner Lake are assigned ownership (indicated by a chosen color) and the water can be tracked as it moves downstream by plotting hydrographs. *Figure 8A* shows simulated hydrographs for Donner Creek above its confluence with the Truckee River. The yellow line represents Donner Lake releases. In late summer, such releases are a large part of the total flow (represented by the blue line), which includes intervening tributary inflows along Donner Creek between Donner Lake and the Truckee River. *Figure 8B* shows simulated hydrographs for the Farad gaging station about 20 miles downstream from the Donner Creek confluence with the Truckee River. Because of outflow to the Truckee River from Lake Tahoe and the numerous regulated and unregulated inflows between Lake Tahoe and the Farad gaging station, the Donner Lake releases (yellow line) become less significant. This ability to track ownership of water will be useful for modeling water operations and allocations.

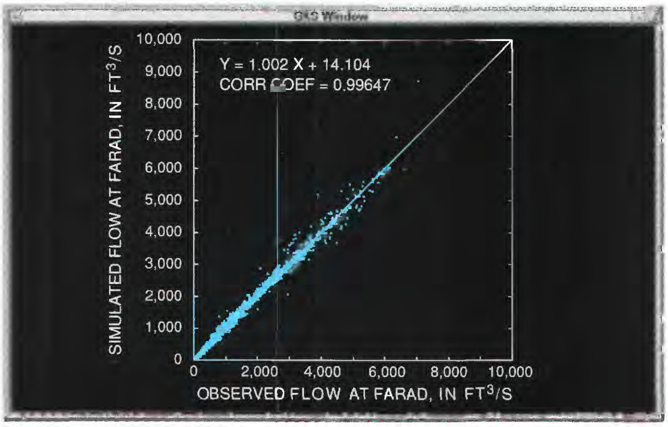

Figure 4. Scatter plots with regression lines and equations can be used for visually assessing variance and bias of modeling results.

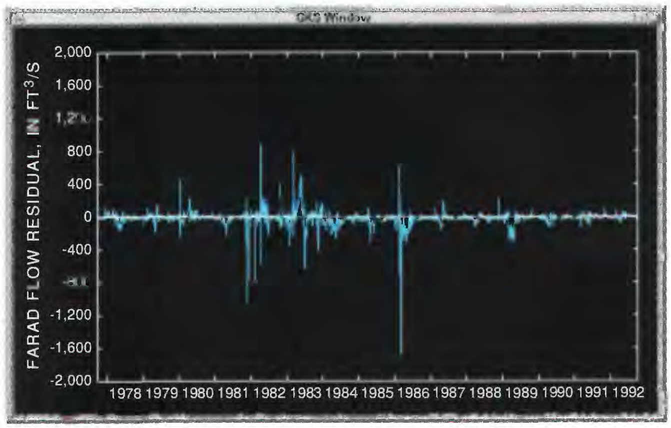

Figure 6. Differences between scenarios (residuals) can be magnified for analysis by plotting them over time.

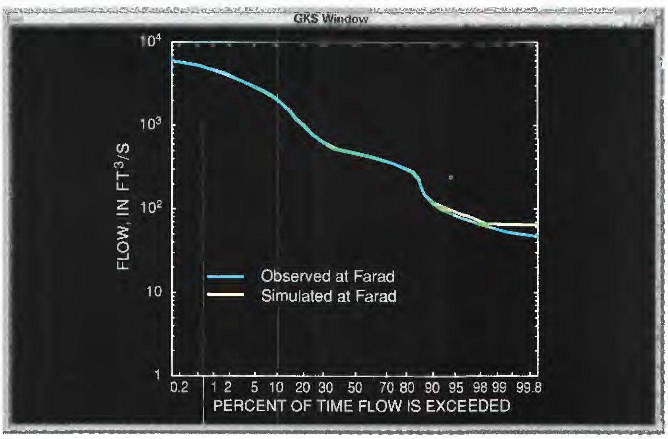

Figure 5. Duration-analysis plots can provide important information about frequency and distribution of data at various locations.

Unix Window

OBSERVED at FARAD GAGING STATION
SIMULATED at FARAD GAGING STATION

Lower class limit	Number of cases	Root mean square error (1) Average	Root mean square error (1) Percent	Bias (2) Average	Bias (2) Percent
0.00	433	14.706	19.7	10.932	15.1
100.00	3953	36.901	7.8	12.029	2.6
1,000.00	1093	167.474	7.1	32.756	2.0
10,000.00	0	0.000	0.0	0.000	0.0
	5479	81.207	9.2	16.077	3.5

Standard error of estimate = 79.61

(1) Average = square root(sum ((S-O)**2) /n
Percent = 100 * square root(sum (((S-O) /O)**2) /n) for all O > 0
(2) Average = sum (S-O) /n
Percent = 100 * sum (((S-O) /O) /n) for all O > 0

Figure 7. Tables of standard statistical measures are available for specified ranges of data.

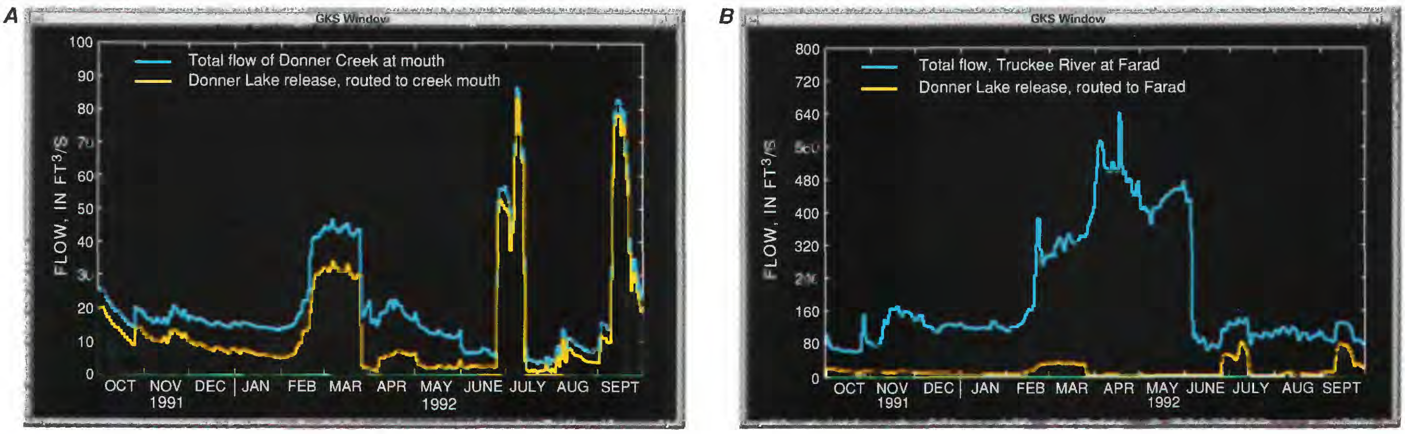

Figure 8. Tracking water ownership is a unique function HPSF and GENSCN. Releases from Donner Lake can be a significant part of Donner Creek inflow to Truckee River (A). For most of the year, however, releases from Donner Lake are only a small fraction of the total flow measured at Farad gaging station (B).

GENSCN also has an animation option for viewing time-series data. Critical thresholds may be set for each river segment and for virtually any category of data, including flow magnitude, flow magnitudes of a particular water ownership, or any of the various water-quality constituents that are modeled. The user may specify that the river segments be displayed in different colors or line thicknesses for up to three ranges of data. For example, simulated flows greater than 200 ft^3/s might be shown in yellow, flows between 100 and 200 ft^3/s in orange, and flows less than 100 ft^3/s in red. As thresholds are exceeded in segments along the river, the color changes to show *where, when,* and *how long* critical conditions exist. Using the above criteria, the Truckee River is shown in red for October 1, 1991 (*fig. 9A*), indicating that the flow was less than the threshold of 100 ft^3/s. On March 4, 1992 (*fig. 9B*), the negligible outflow from Lake Tahoe is indicated by red between Lake Tahoe and the mouth of Donner Creek. Between Donner Creek and Little Truckee River, flows were between 100 and 200 ft^3/s (orange); downstream from Little Truckee River, flows were greater than 200 ft^3/s (yellow).

A final GENSCN capability closely related to the concept of critical thresholds is an option to produce lists of the number of times a threshold is exceeded and the length and percentage of time during the simulation period that data are within a user-specified range. This option can be further controlled to count only the occurrences that last longer than a specified duration. For example, the question "How many times was dissolved oxygen less than 4 milligrams per liter for longer than 3 hours?" can be answered. This option is especially useful in toxicity analyses for various biota in simulations of water quality.

The USGS Truckee–Carson Program is using the GENSCN interface in building and calibrating physically based models to examine interrelated hydrologic issues in the two river basins. The models—simulating flow, stream temperature, dissolved-solids concentration, and precipitation and runoff characteristics, as well as operational and allocation constraints—are currently (1995) being tested. When the models are documented and manuals completed, the modular framework of models linked with the GENSCN user interface will be

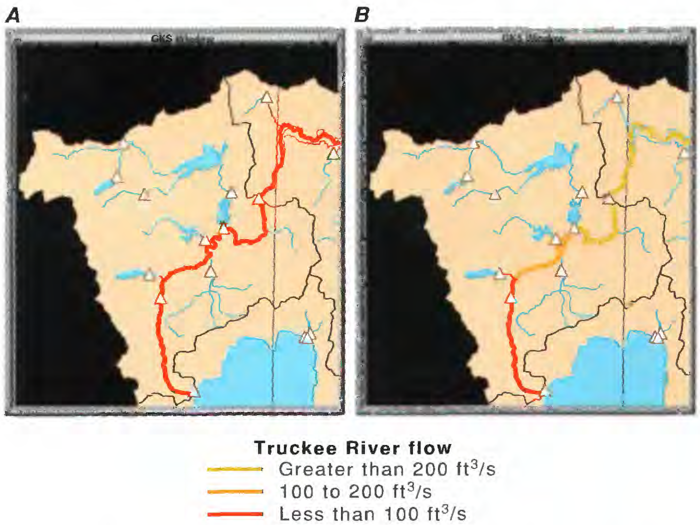

Figure 9. Animation aids user in seeing where, when, *and* how long *critical thresholds are exceeded. October 1, 1991 (A), and March 4, 1992 (B).*

distributed for public use. With modification, most models developed by other agencies can be added because of the modular nature and the flex ibility for data exchange designed into the software. By using GENSCN, modelers and water managers can learn more about the Truckee and Carson River Basins by exploring how regulatory constraints and changes in land use affect streamflow and water quality throughout the system.

—Larry R. Bohman, Steven N. Berris, and Glen W. Hess

For more information, please contact:
Public Information Assistant
U.S. Geological Survey
333 W. Nye Lane, Rm 203
Carson City, NV 89706
(702) 887-7600, ext. 7649
mfogle@dnvcr1.wr.usgs.gov

U.S. Department of the Interior
U.S. Geological Survey
Fact Sheet FS-165-95
July 1995