REVIEW OF SELECTED WATER-MANAGEMENT MODELS AND RESULTS OF SIMULATIONS FOR THE TRUCKEE-CARSON RIVERS SYSTEM, CALIFORNIA AND NEVADA

U.S. Geological Survey

Open-File Report 90-393

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By Ernest D. Cobb, U.S. Geological Survey, Alan F. Olson, U.S. Bureau of Reclamation, and Otto Moosburner and Alex Pupacko, U.S. Geological Survey

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Open-File Report 90-393

Reston, Virginia
1990

U.S. DEPARTMENT OF THE INTERIOR

MANUEL LUJAN, Jr., Secretary

U.S. GEOLOGICAL SURVEY

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UNIT CONVERSION

[For the convenience of the readers who prefer to use metric (International System) units rather than the inch-pound units used in this report, values may be converted by using the following factors.]

Multiply inch-pound unit	By	To obtain metric unit
	Length	
foot (ft)	0.3048	meter (m)
	Area	
acre	4,047	square meter (m^2)
acre	0.4047	hectare
	Volume	
acre-foot (acre-ft)	1,233	cubic meter (m^3)
acre-foot (acre-ft)	0.001233	cubic hectometer (hm^3)
	Flow	
cubic foot per second (ft^3/s)	0.028317	cubic meter per second (m^3/s)

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By
Ernest.D. Cobb (1), Alan F. Olson (2), Otto Moosburner (3) and Alex Pupacko (3)

ABSTRACT

Sierra Pacific Power Company, a utility company in the Reno-Sparks, Nevada area and the Pyramid Lake Paiute Indian Tribe have negotiated an agreement, referred to as the Preliminary Settlement Agreement. The agreement provides for storage of water for use in the Reno-Sparks area during drought periods and for augmentation and modification of flows in the lower Truckee River at a time to improve spawning conditions for an endangered species of fish, the cui-ui.

Two uncalibrated models of the system are available, the Bureau of Reclamation (BOR) model and the Negotiation model. Both are monthly mass-balance accounting type models. The Negotiation model was used to study the effects of the Preliminary Settlement Agreement and various amounts of depletions from the upper Truckee River on selected parts of the system. Model simulations were made for the 80-year period, 1901-1980. Because the models are uncalibrated and lack documentation, conclusions drawn from model simulations contain an unknown degree of uncertainty.

Model simulations using the provisions of the Preliminary Settlement Agreement indicate small increases in water shortages in the Newlands Project. Increased water use in the Reno-Sparks area may reduce future downstream supplies whether or not the Preliminary Settlement Agreement is in place, making the effect of the Preliminary Settlement Agreement of probably negligible consequence to the Newlands Project.

Model analyses project a higher cui-ui index (an index related to the number of adult female cui-ui) with the Preliminary Settlement Agreement in place than without it, except when large depletions are made in the upper Truckee River. When there are large depletions, the modeled cui-ui index is about the same with or without the provisions of the Preliminary Settlement Agreement. Large depletions reduce the cui-ui index by 20 to 60 percent when compared with historical depletions.

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A program is ongoing to purchase water rights in the Newlands Project area for application of water to benefit fish and wildlife in the Lahontan Valley wetlands. Only a part of the purchased water would be applied to the wetlands, a part is not diverted out of the Truckee River and therefore flows to Pyramid Lake. According to model simulations, the purchase of 30,000 to 40,000 acre-feet of water rights for application to Lahontan Valley wetlands also results in increases to the cui-ui index by 7,000 to 29,000 and increases the levels of Pyramid Lake.

INTRODUCTION

The Truckee and Carson Rivers (fig. 1) drain from the Eastern slopes of the Sierra Nevada and flow into two separate closed basins. These basins are interconnected by the Truckee Canal creating the Truckee-Carson Rivers system (fig. 2). Some of the major issues involving this system include:

(1) The division of water between California and Nevada.
(2) The maintenance of Lake Tahoe levels and water rights in the Lake Tahoe area.
(3) Protection of the fishery and of water rights in the upper Truckee River.
(4) Maintenance of specified flow rates in the Truckee River at the California-Nevada State line at Farad, California for the production of hydro-electric power. These rates are defined by court decree.
(5) Provision of water for the growing Reno-Sparks area, including standby supplies for use during drought periods.
(6) Flow of water to Pyramid Lake to maintain lake levels critical to the maintenance of the fishery in the lake. Pyramid Lake contains an endangered fish, the cui-ui, and a threatened species of fish, the Lahontan cutthroat trout.
(7) Sufficient flow in the lower Truckee River, especially during January through July, so that the cui-ui and the Lahontan cutthroat trout can spawn in the river.
(8) Diversion of Truckee River water to the Newlands Project for irrigation and wetlands maintenance.
(9) Storage in Lahontan Reservoir for adequate irrigation release and for recreation.
(10) Water for irrigation for the Fallon Indian Tribe.
(11) Sufficient water of an acceptable quality to maintain fish and wildlife values in the Lahontan Valley wetlands.
(12) Water for Carson City, Lyon County, and Douglas County areas along the Carson River.
(13) Water of an acceptable quality for the communities of Fallon and Fernley.

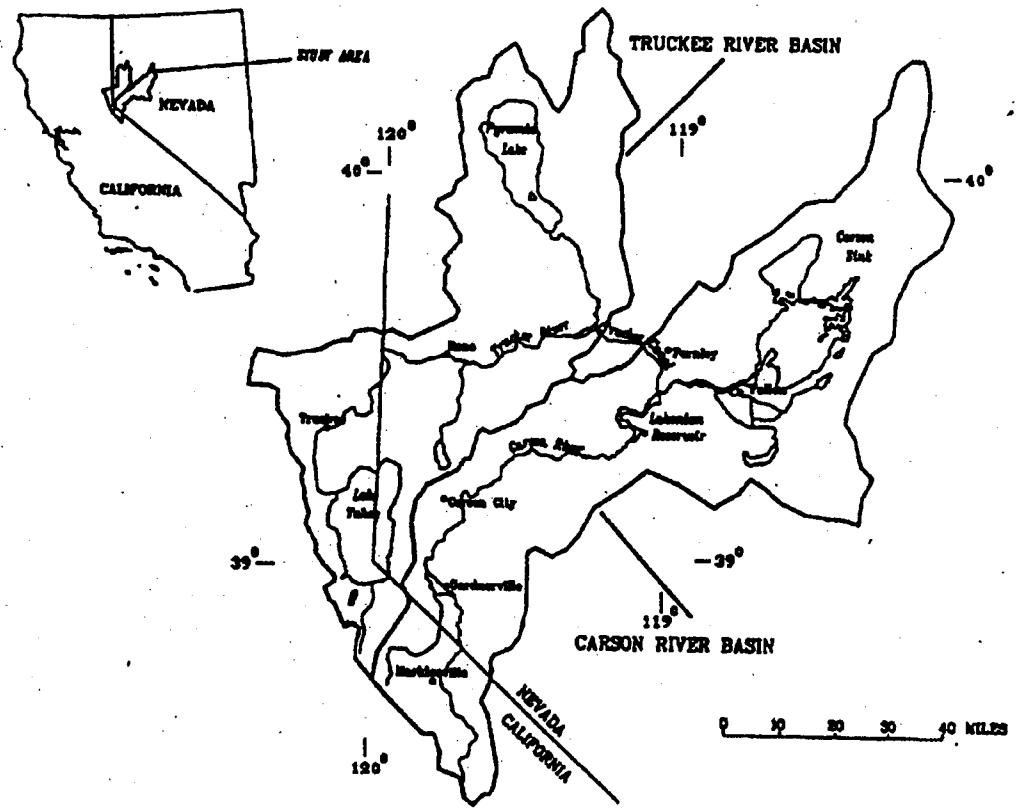

Figure 1--Location of the Truckee and Carson River basins

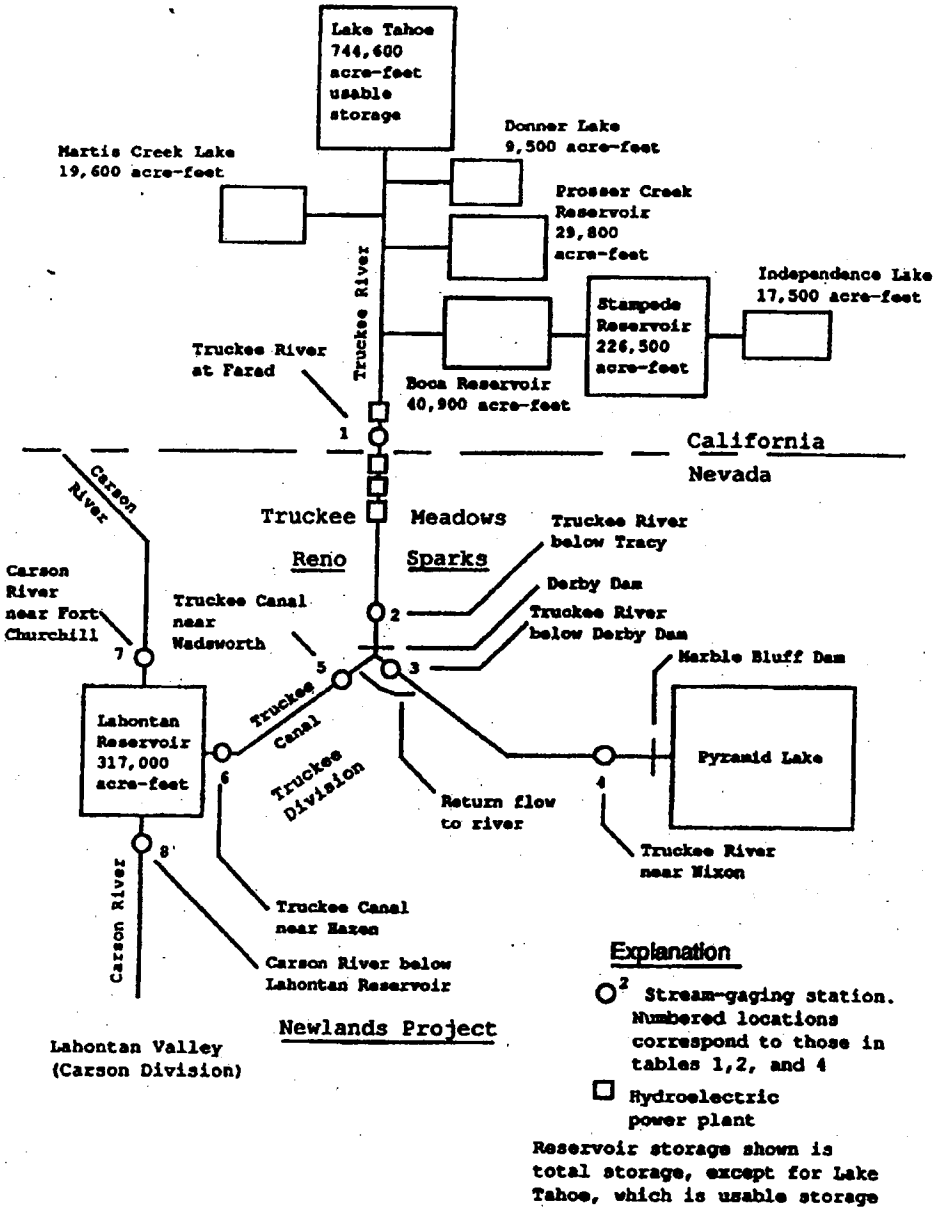

Figure 2. Truckee-Carson Rivers system.

In general, the water supply is inadequate to meet all of the demands placed on the river system. Of primary concern in this report are the water-related effects of implementing a water-management agreement, called the "Preliminary Settlement Agreement" (1989), that was negotiated by Sierra Pacific Power Company (hereafter, often referred to as Sierra Pacific) and the Pyramid Lake Paiute Tribe of Indians.

The purposes of this report are: 1) to briefly examine two monthly mass-balance models that are currently used to analyze operating decisions in the Truckee-Carson Rivers system, and 2) to analyze some of the proposed changes in the operation of the system and of water use in the upper Truckee River, using the two models. The "upper Truckee River" as used in this report refers to the Truckee River and its tributaries between Lake Tahoe and Farad, California near the California-Nevada State line.

The two models are the Negotiation model and the Bureau of Reclamation (BOR) model. The Negotiation model can be run with or without the provisions of the Preliminary Settlement Agreement. The BOR model cannot be run with the provisions of the Preliminary Settlement Agreement without significant modifications to the model.

Sierra Pacific supplies water, power, and natural gas to the Reno-Sparks area and operates the hydroelectric power plants on the Truckee River in the vicinity of the California-Nevada border near Farad, California. Westpac Utilities (hereafter referred to as Westpac) is a Division of Sierra Pacific Power Company and is responsible for the water and natural gas utilities. The Pyramid Lake Paiute Tribe of Indians, hereafter referred to as the Pyramid Lake Tribe, is concerned with Pyramid Lake levels and with the Pyramid Lake fishery. The Pyramid Lake Tribe's livelihood is partly dependent on the well-being of the Pyramid Lake fishery.

Sierra Pacific and the Pyramid Lake Tribe entered into negotiations resulting in the Preliminary Settlement Agreement (1989). The primary provisions of the Preliminary Settlement Agreement (1989) allow Sierra Pacific to store water for drought supply in Stampede Reservoir and other upper Truckee River Reservoirs. The agreement provides for a relaxation, by Sierra Pacific, of the court-decreed flow rates in the Truckee River at Farad for hydroelectric power production. This allows for the storage of water for later release to improve spawning conditions for the cui-ui from Pyramid Lake into the lower Truckee River. During non-drought years, much of Sierra Pacific's stored drought-supply water will also be released at a time and rate to improve spawning conditions for the cui-ui. The effects of these proposed changes in the operation of the Truckee-Carson Rivers system, as simulated by the models, are discussed in this report.

The effect of the potential change in consumptive water use in the Truckee River between Lake Tahoe and the California-Nevada State line at Farad (figs. 1 and 2), from historical depletions to various proposed levels of depletions, are discussed in this report. Also discussed are the simulated effects of an alternative operating plan proposed by the Bureau of Reclamation (Frank Dimick, U.S. Bureau of Reclamation, Carson City, Nevada, written communication, April, 1990). This alternative plan is not currently (October, 1990) under consideration by the settlement negotiators.

Water right purchases in the Newlands Project area for application to the Lahontan Valley wetlands are expected to have effects on Pyramid Lake. These potential effects are examined.

The models use estimates of future demand in the Truckee Meadows area (Reno-Sparks metropolitan area). Model inputs are based on planned acquisition of water rights, changes in water use from agricultural to municipal and industrial, and estimated changes in runoff caused by changes in land use (urbanization).

Both models are monthly mass-balance accounting type models that add inputs, subtract outputs, and, as appropriate, account for changes in storage. They do not account for travel time through the system or account for evapotranspiration and ground-water/surface-water interactions in other than a gross statistical manner. The models use synthesized input data bases of 80-years (water years 1901-80) of monthly average flows at significant points in the system for simulations (Westpac Utilities, 1989a). These data bases, which differ for each model, are composites of historical records. Where no historical records exist, or for ungaged basins, flows were estimated using relations to known flows, precipitation-runoff relations, and judgement.

The Truckee-Carson flow models were developed as planning tools to provide simulations of approximate average monthly water yields in response to alternative management practices, not to simulate historical river flows. Formal documentation is lacking for both the computer programs and for the input data bases. Technical representatives of most of the principal entities involved in the litigation and negotiations (Westpac, Pyramid Lake Paiute Tribe, California Department of Water Resources, Nevada Division of Water Resources, the Truckee-Carson Irrigation District, the Bureau of Reclamation, and the U.S. Fish and Wildlife Service) are aware of the model limitations but have generally accepted the Negotiation model as a tool to evaluate potential changes in the operation of the Truckee-Carson Rivers system.

Because of the lack of documentation and the lack of calibration of the models, it is impossible to assess the accuracy of the models. Neither the authors nor their agencies endorse these models or their results but the report briefly discusses the models and the results of model simulations.

There is a consensus among the technical representatives that a physically-based hydrologic model with shorter time steps (daily or hourly) will be required to properly manage the Truckee-Carson system after a settlement has been reached. A source of funding for the development of a physically-based model has not been determined.

This report was prepared at the request of the Assistant to the Secretary of the U.S. Department of the Interior for use in defining the Administration's position with regard to Senate Bill S. 1554, "Truckee-Carson-Pyramid Lake Water Rights Settlement Act."

OVERVIEW OF NEGOTIATION AND BUREAU OF RECLAMATION MODELS

The computer programs and basic data inputs for the BOR model have been developed since about 1975. The initial code was developed prior to 1975 by BOR staffs in Carson City and Denver in an effort to formalize in a FORTRAN program the complex OCAP (Operating Criteria And Procedures) used in the Truckee-Carson Rivers system. The Negotiation model and its data base have been developed since 1987.

No single source of documentation for the two models discussed in this report and for the computer codes or the input data bases are available. Apparently, documentation exists in the form of informal notes, memorandums by various parties, portions of summaries and analysis of specific simulations, and the collective memory of staffs of the various agencies and consultants involved in the development of the models.

A Technical Advisory Committee (TAC), consisting of representatives of the Sierra Pacific Power Company, Pyramid Lake Paiute Tribe, Truckee-Carson Irrigation District, State of Nevada, Bureau of Reclamation, and the U.S. Fish and Wildlife Service, was formed to guide the development of the data set and revisions to the model. The decision was made to develop one version of the model to use in the evaluation of OCAP alternatives. The developed code for the model is in use and is maintained principally by BOR with input from the TAC. This model is referred to herein as the BOR model. The TAC has continued to serve as a technical group to coordinate the analysis of various proposals.

As attempts to achieve a negotiated settlement of the various conflicts progressed in the late 1980's, the BOR model was modified to include alternatives beyond OCAP that were being discussed in the negotiations. This modified version of the BOR model has been designated the "Negotiation Model." The current version (1990) was principally developed by consultants for Westpac in consultation with Pyramid Lake Tribe consultants and others. The primary alternatives of interest in this report are the provisions of the Preliminary Settlement Agreement which have been incorporated as an option into the Negotiation model.

Both models are operational models (complex water accounting programs) as opposed to hydrologic models (physically-based flow-routing programs). The models use a synthesized set of input streamflow and upstream or intervening runoff data (the 1901-1980 data base), superimpose a complex set of legal constraints, operating criteria and assumptions for development effects on surface- and ground-water returns, and perform an accounting procedure to simulate monthly average flows at a number of places in the system. See figure 2 for a schematic diagram of the Truckee-Carson Rivers system.

Although the accounting procedure is simple in concept (sum of inflows - diversions or losses - change in storage = outflows, where change of storage is "+" if storage increases and "-" if it decreases), the computer codes that replicate the many, and commonly conflicting, rules and procedures applying to the Truckee River, are complex. One listing of the program code and subroutines (Negotiation model) is about 360 pages long and the listing of one of the input data bases is about 2,000 lines long.

The data bases provide an 80-year (water years 1901-1980) set of synthesized monthly flows to the models for simulations. One data base was developed by BOR and Westpac consultants, Murray, Burns, and Kienlen Consultants (MBK) and used by the BOR model (BOR data base), and one data base was used for the Negotiation model with further enhancements by MBK (Negotiation data base).

Comprehensive calibration or sensitivity analyses of the models have not been made by any of the TAC members. Although participants have run numerous simulations for a variety of assumed operations and future conditions, apparently no documentation exists for a classic sensitivity analysis. Given the nature of the models and of the data, it would be difficult to structure a quantitative framework for such an analysis. Because the purpose of the models was to provide simulations for relative comparison of operational effects, not reproduction of real streamflows, a classic calibration is impossible with the current models and data bases.

Westpac has developed a proprietary model to predict flow depletions in the Truckee Meadows area (written communication, MBK Consultants, July, 1988). This proprietary model produces estimates of net flow changes between Farad and Derby Dam based on assumptions about future urban development in the Reno-Sparks Westpac service area. The modeled Truckee Meadows depletions are then incorporated into the data bases for running the Negotiation and BOR models.

COMPARISON OF THE MODELS

The Negotiation and BOR models were compared by examining the differences in results from similar inputs. Because the BOR model is the earlier model, and because only the Negotiation model is capable of computing the simulated effects of the Preliminary Settlement Agreement, a comparison of the two models was made to determine the similarity of the model outputs. These comparisons do not imply an accuracy of the models, only that they are providing some consistency in their simulations.

Both models were run using Westpac demands of 124,000 acre-feet per year and 119,000 acre-feet per year. The 124,000 acre-feet was what Westpac thought they could obtain with the resources available to them under Senate Bill 1558 (introduced in 1985) if that bill passed -- it did not. The 124,000 acre-feet included 5,000 acre-feet of water from Stampede Reservoir. The 119,000 acre-feet is the amount of water thought to be available without the Stampede Reservoir water (Westpac Utilities, 1985, 1989b). The use of these values for comparing the two models was a matter of convenience because both models were set up to use these two demands. Other inputs are also different for the two sets of simulations as shown in table 1.

Table 1 shows selected model inputs and outputs. Model outputs are the result of running the model for the 80 years (1901-1980) of simulated inputs.

Differences in the model outputs for the same inputs is an indication of the differences that result from the simulations using the 2 models. The greatest differences occur in the cui-ui index (10 percent) and in the maximum shortages for the Newlands Project (6 percent of the demand) for the model simulations using a Westpac demand of 124,000 acre-feet per year. The simulations for the two models for the cui-ui index, with a Westpac demand of 119,000 acre-feet per year, are the same as for the previous set of model simulations and considerably closer for the maximum Newlands Project shortage (less than 1 percent).

COMPARISON OF MODEL OUTPUTS WITH HISTORICAL RECORDS

The only place that model outputs can be readily and meaningfully compared with historical records is for the Truckee River at Farad. Comparisons of historical records are made only with the Negotiation model without the provisions of the Preliminary Settlement Agreement and for historical consumptive use from the Truckee River between Lake Tahoe and Farad.

Table 1. Comparisons of Negotiation and BOR model simulations.

All model simulations are without the provisions of the Preliminary Settlement Agreement but includes estimated historical depletions from the Truckee River between Lake Tahoe and the State line at Farad.

Model simulations are identified as follows. The prefix defines the model used: "N" indicates the Negotiation model and "BOR" indicates the BOR model. The numbers following the prefix refers to the Westpac water demand. A "124" refers to model simulations using a Westpac demand of 124,000 acre-feet per year and a "119" refers to model simulations using a Westpac demand of 119,000 acre-feet per year.

(Figures are in 1,000's of acre-feet per year except where otherwise noted)

	N-124	BOR-124	N-119	BOR-119
Selected Inputs				
Newlands Project demands	320	320	320	320
Westpac demand	124	(a)124	119	(a)119
Truckee Meadows irrigation demand	86.5	(a)86.5	63.6	(a)63.6
Westpac acquired irrigation rights	70.8	(a)70.8	72.1	(a)72.1
Westpac ground-water pumping	12.0	(a)12.0	15.6	(a)15.6
Truckee Meadows sewage return	71.7	(a)71.7	67.1	(a)67.1
Irrigation demand downstream from Derby Dam (from the Truckee River)	19.1	19.1	19.1	19.1
Selected Outputs				
Truckee River at Farad average (Site no. 1)	557.5	557.9	557.2	557.9
Farad-Derby depletion average	10.6	11.5	10.0	10.1
Total flow at Derby Dam average (Site no. 2)	546.9	546.4	547.2	547.9
Diversion to Truckee Canal average (Site no. 5)	128.4	127.8	128.3	128.8
Canal Delivery to Lahontan Reservoir, average (Site no. 6)	79.9	79.7	79.9	80.1
Lahontan Reservoir release or spill Average (Site no. 8)	320.6	320.8	320.6	321.1
Truckee River at Pyramid Lake, average (Site no. 4)	425.1	425.2	425.4	425.7
Pyramid Lake elevation, in feet (b)				
Beginning	3,812.4	3,812.4	3,812.4	3,812.4
Average	3,825.9	3,825.9	3,826.0	3,826.0

Table 1 (continued)

	N-124	BOR-124	N-119	BOR-119
Cui-ui index (c)	55,000	61,000	55,000	61,000
Newlands Project				
Average shortage	6.6	6.7	6.6	6.0
Maximum 1-year shortage	136	152	136	135
Max. (percent of demand)	42	48	42	42

Note: The site numbers refer to sites where flows are simulated by modeling, the locations of which are near the stream-gaging station with the same number as shown on figure 2 and listed in tables 2 and 4. The simulated flows are not expected to approximate historical flows because of the assumptions concerning water use and system operations used in the models.

(a) Input values to the Truckee Meadows proprietary model; the model then derived Farad-Derby depletions. The depletions were then used as input values to the BOR model for subsequent computations.

(b) The beginning elevation is an input value but is shown here for the convenience of the reader. The beginning elevation is the average historical Pyramid Lake elevation for 1984-88.

(c) The cui-ui index is an index of the relative abundance of adult female cui-ui fish in Pyramid Lake and is shown here for the end of the 80-year model simulations. The index was developed by Chester C. Buchanan, U.S. Fish and Wildlife Service and by Thomas A. Strekal, U.S. Bureau of Reclamation (1988).

Historical flow data were obtained from published reports (U.S. Geological Survey, 1960, 1963, 1970) or annual data reports of the U.S. Geological Survey (USGS) (1966-1980a,b, 1987a,b) or from USGS computer files unless otherwise indicated. Comparisons are made at a number of locations to demonstrate the magnitude of the differences between simulated and historical flows as a result, in part, of the model assumptions and the differences in management and water use for the model and for the historical period.

The average annual 1901-1980 flow at Farad is 572,000 acre-feet and the model-computed flow is about 558,000 acre-feet. Even at Farad, there are problems with comparisons. The models assume that the various lakes and reservoirs existed as they are at present throughout the 80-year period. Thus, evaporation from the reservoirs is subtracted from flows for the entire period in the models. However, several of the reservoirs and lakes have been built or modified during this period. The historical record reflects the changing conditions of these lakes and reservoirs, not a constant condition as assumed in the models. This results in smaller model flows at Farad than is shown by the historical record.

An analysis made by Murray, Burns and Kienlen Consultants, (written communication, 1990) shows that if losses associated with reservoirs constructed between 1930 and 1980, development in the Lake Tahoe area, and changes in California depletions from the upper Truckee River are considered, the modeled and the historical flows at Farad closely agree. Figure 3 provides a graph of historical flows at Farad for the purpose of illustrating historical flow variations.

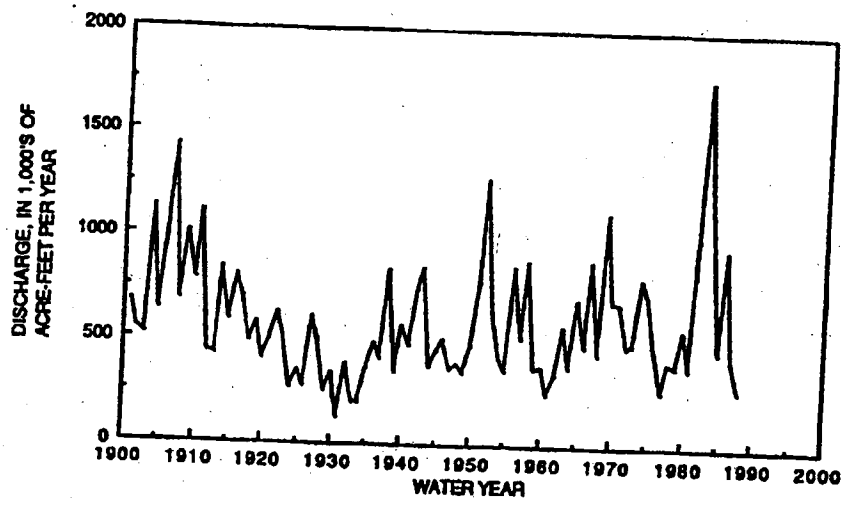

Figure 3. Annual discharge for the Truckee River at Farad, California

Water withdrawals and operations downstream from Farad have changed to such an extent over the years that direct comparisons of streamflow below Farad have little meaning. Nevertheless, comparisons are provided at selected sites in the system, using the model outputs for a Westpac demand of 119,000 acre-feet per year.

Flows at the stream-gaging station Truckee River below Tracy, which has been operated by the USGS since May 1972, are nearly equivalent to the flow of the Truckee River at Derby Dam. The average annual flow for the 8 years, 1973-80, is 488,000 acre-feet and the simulated average annual flow for the same years is 468,000 acre-feet.

Flows at the gaging station Truckee Canal near Wadsworth, which has been operated by the USGS since October 1966, are nearly equivalent to the flows diverted to the Truckee Canal. Records are available from the Truckee River Watermaster for the water years 1910-1966. There are 3 structures on the canal between the watermaster gaging station and the Survey gaging station that spill water back into the river, so the records for the two periods indicated are not completely equivalent. The average annual flow at the watermaster station for the 57 years, 1910-1966, is 240,000 acre-feet and the average annual simulated flow for the same years is 140,000 acre-feet. The average annual flow at the USGS station for the 14 years, 1967-1980 is 204,000 acre-feet and the average annual simulated flow, assuming that the current OCAP was in place, for the same years is 122,000 acre-feet.

Flows at the gaging station Truckee Canal near Hazen, which has been operated by the USGS since October 1966, are nearly equivalent to the Truckee Canal flows to Lahontan Reservoir. There are a few diversions and some canal losses between the station and Lahontan Reservoir. The average annual flow for the 14 years, 1967-1980, is 154,000 acre-feet and the average annual simulated flow, assuming that the current OCAP was in place, for the same years is 74,000 acre-feet.

Flows for the gaging station Truckee River near Nixon, which has been operated by the USGS since October 1957, are nearly equivalent to the Truckee River flows to Pyramid Lake. There are a few small diversions from the Truckee River between the station and the lake. The average annual flow for the 23 years, 1958-1980, is 312,000 acre-feet and the average annual simulated flow, assuming that the current OCAP was in place, for the same years is 399,000 acre-feet.

Flows at the gaging station Carson River below Lahontan Reservoir, which has been operated by the USGS since October 1966, are nearly equivalent to Lahontan Reservoir releases. There is one diversion of approximately 2,500 acre-feet per year from the Carson River between the reservoir and the station. The average annual flow for the 14 years, 1967-1980, is 378,000 acre-feet and the average annual simulated flow, assuming that the current OCAP was in place, for the same years is 296,000 acre-feet.

The relative magnitudes of flow at various places throughout the Truckee-Carson Rivers system during a recent year (water year 1987) are shown in table 2. A water year begins October 1 and ends September 30. The relative locations of the gaging stations, shown in the schematic in figure 2, generally correspond to the model output sites indicated in tables 1, 2, and 4.

Table 2. Annual flows at various locations in the Truckee-Carson Rivers system for water year 1987.

Gaging Station Numbers (refer to fig. 2)	Gaging Station Name	1987 Annual Discharge (in acre-feet)
1.	Truckee River at Farad	419,000
2.	Truckee River below Tracy (Located between Truckee Meadows and Derby Dam)	421,000
3.	Truckee River below Derby Dam	166,000
4.	Truckee River near Nixon (9.42 miles upstream from Marble Bluff Dam)	179,000
5.	Truckee Canal near Wadsworth	222,000
6.	Truckee Canal near Hazen (Approximate inflow to Lahontan Reservoir.	167,000
7.	Carson River near Fort Churchill (Inflow to Lahontan Reservoir)	111,000
8.	Carson River below Lahontan Reservoir (Includes one diversion of about 2,500 acre-feet between the Dam and the stream-gaging station)	328,000

Notes:

1. There are some flows upstream from the Truckee Canal station out of the canal flowing back into the river downstream from the Truckee River station below Derby Dam. There are some irrigation diversions out of the Truckee Canal upstream from the Wadsworth station. There are also minor accretions and irrigation return flows between the Tracy station (station number 2) and Derby Dam. Therefore, the sum of the canal flow and the river flow below Derby Dam will not equal the flow upstream from Derby Dam. In 1987, the difference was slightly more than 30,000 acre-feet.

A part of these differences may be due to rounding and errors resulting from taking the differences of numbers, each of which contain uncertainty. The uncertainty resulting from taking differences of numbers, each of which contain error, applies to each of the footnotes.

2. There are both diversions and return flows downstream from Derby Dam on the Truckee River, including the return flows from the Truckee Canal mentioned earlier and other accretions to the Truckee River. In 1987, these resulted in a measured increase of about 14,000 acre-feet at the Nixon station. There are also small diversions, minor ground-water accretions, and return flows between the Nixon site and Pyramid Lake.

3. Storage was decreased by about 95,000 acre-feet of water in Lahontan Reservoir during 1987. Part of this was evaporation and part was reflected in the flows downstream from Lahontan Reservoir which were larger than the sum of the inflows of 278,000 acre-feet. Based on the inflows and outflows to Lahontan Reservoir, approximately 46,000 acre-feet of water was lost to evaporation from Lahontan Reservoir during water year 1987.

MUNICIPAL AND INDUSTRIAL WATER SUPPLY

Four alternative sets of Westpac M&I (Municipal and Industrial) water-supply resources, described in table 3, are used in model simulation analyses. Each resource set provides essentially the same water supply during historical drought months when Truckee River diversion rights would not supply normal Westpac demand.

Drought period conservation, equal to 10-percent of monthly Westpac demand, was applied in all studies. In Preliminary Settlement Agreement studies, this conservation was applied through drought years and any surplus conserved water was used to accumulate credit storage. In non-Preliminary Settlement Agreement studies, conservation was applied during those months when Truckee River flows were too small to supply Westpac demands.

Table 3 does not indicate the existence of a reserve water supply available for use in a drought that would continue longer than any historically experienced drought periods. The reserve water supply that may be available in the non-Preliminary Settlement Agreement studies cannot be quantified because there is no definition of the "New supplies."

The Preliminary Settlement Agreement studies indicate that in excess of 20,000 acre-feet of stored water would be available for use during an additional drought year. The non-Preliminary Settlement Agreement studies, "Alt-119," provide a Stampede Reservoir storage reserve of about 12,000 acre-feet. Although there is no definition of reserve associated with "New supplies," the "N-119" study without the Preliminary Settlement Agreement, indicates about 3,000 acre-feet of storage remaining in Independence Lake at the end of the historical drought period.

Table 3. Westpac water-supply resources (a)

	N-124 and BOR-124	N-119 and BOR-119	N-119 (with PSA)	BOR (b) Alt-119
Acquired irrigation rights	70,800 AF	72,100 AF	87,700 A	72,100 AF
Orr Ditch 40 ft^3/s Decree right (c)	40 cfs	40 cfs	40 cfs	40 cfs
Hunter Creek right (d)	13.6 cfs	13.6 cfs	13.6 cfs	13.6 cfs
Potential additional Donner Lake storage	No	No	Yes	No
Potential Sparks Pit supply (e)	No	No	Yes	No
Annual ground water	12,000 AF	15,600 AF	15,600 AF	15,600 AF
Annual extra drought ground water	0 AF	3,000 AF	0 AF	0 AF
Additional new supply for all years (f)	5,000 AF	6,000 AF	0 AF	0 AF
New supply for drought years (f)	10,000 AF	9,000 AF	0 AF	0 AF
Stampede Reservoir Federal water-right water	No	No	No (g)	Yes
PSA credit storage	No	No	Yes (h)	No

(a) Table supplied by Murray, Burns, and Kienlen Consultants (1990, written communication).

(b) Bureau of Reclamation alternative providing Westpac with 40,000 acre-feet for storage of Federal water and its use as an M&I drought supply.

(c) The Orr Ditch Decree refers to the final decree entered on September 8, 1944, in the case of United States v. Orr Water Ditch Co., et al., Equity No. A-3, in the United States District Court for the District of Nevada.

(d) Hunter Creek is a tributary to the Truckee River in the Truckee Meadows area.

(e) Sparks Pit is a sand and gravel pit in Sparks, Nevada.

(f) "New supply" for all years and for drought years are arbitrarily established values. These supplies reflect what Westpac might develop from unspecified sources in the absence of a negotiated settlement. "New supply for drought years" is in addition to the "New supply for all years."

(g) Under the Preliminary Settlement Agreement, the Westpac credit water is stored in Stampede and other Truckee River reservoirs. Up to 19,500 acre-feet of Stampede Reservoir capacity is dedicated as "firm" storage that may be used by Westpac during a drought. "Firm" storage is not lost by evaporation unless it is the only water remaining in the reservoir. The Preliminary Settlement Agreement also provides for additional storage of "non-firm" water. Evaporation is charged against "non-firm" water in storage.

(h) The Westpac storage limit as applied in all studies in table 3 is that associated with full allowed California depletions from the upper Truckee River. The Preliminary Settlement Agreement provides for reduced credit storage when the California depletions are less than the maximum allowed.

MODEL SIMULATION RESULTS

Analyses have been made of model simulation summaries for the 80-years of model input data as well as for yearly model outputs for selected model simulations. A variety of assumptions can be made concerning some aspects of the operation of the system, or in the case when the conditions of the Preliminary Settlement Agreement are not in place, of alternative measures to provide supplies for certain demands. The use of alternatives, other than those used for this analysis, may provide somewhat different results than are shown in this report.

The model simulations assume that water use and system operating criteria are stabilized. In fact, it is anticipated that there will be a phase-in period during which not all of the water indicated will be used by Westpac. Water use is anticipated to increase over a period of about 35-40 years to the values indicated in the model simulations. The models are not capable of being easily modified to consider this phase-in period. As a result, modeled Pyramid Lake levels and the cui-ui index (table 1) are probably lower than they would be if the phase-in conditions were evaluated.

The purpose of these model simulations is to attempt to provide insights into the effects of decisions concerning management of parts of the Truckee-Carson Rivers system and of variable water use in parts of the system. These insights are based on uncalibrated model simulations and are, therefore, subject to some degree of uncertainty.

80-Year Summaries

Observations of the effects of various water demands and operating schemes were made using only the Negotiation model. Simulation summaries are given in table 4.

Simulated average flows at Farad, Diversions to Truckee Canal, Truckee Canal deliveries to Lahontan Reservoir, and Lahontan Reservoir releases are all equal to or less with the provisions of the Preliminary Settlement included in the model as compared with simulated flows without those provisions regardless of the upper Truckee River depletions. The differences are, however, small.

The Farad-Derby depletions calculated by the Negotiation Model are for the Preliminary Settlement Agreement condition under which 15,600 acre-feet of water rights (table 3, 87,700 acre-feet - 72,100 acre-feet = 15,600 acre-feet) are acquired with the historical consumptive-use portion stored in Stampede and other

Table 4. Selected Negotiation Model simulation outputs

Model simulations are identified as follows. The prefix "N" indicates that the Negotiation model was used. The middle number refers to the Westpac water demand. For example, the "119" indicates that the Westpac demand for the model simulation was 119,000 acre-feet per year. The last number refers to the increase in depletions over the historical depletions from the Truckee River between Lake Tahoe and Farad. For example, the 12.8 indicates that the model simulation used depletions that were 12,800 acre-feet per year more than the historical depletions. The columns "with PSA" in the heading, indicate that the model simulation included the provisions of the PSA (Preliminary Settlement Agreement). Model simulations without the statement "with PSA" do not include the provisions of the Preliminary Settlement Agreement. Model outputs are the result of running the model for the 80 years (1901-1980) of simulated inputs.

(All values are in 1,000's of acre-feet per year except where otherwise noted)

	N-119-0	N-119-0 with PSA	N-119-8	N-119-8 with PSA	N-119-10	N-119-10 with PSA	N-119-12.8	N-119-12.8 with PSA
Selected Outputs								
Truckee River at Farad, Avg. (Site 1)	557	556	551	549	549	548	547	545
Farad-Derby depletion, Avg.	10.0	8.3	9.9	8.1	9.8	8.1	9.7	8.0
Total flow at Derby Dam Avg. (Site 2)	547	548	541	541	539	539	537	537
Diversion to Truckee Canal Avg. (Site 5)	128	128	128	127	128	127	128	127
Canal delivery to Lahontan Reservoir, Avg. (Site 6)	80	79	80	79	79	79	79	79
Lahontan Res. release (Site 8)	321	320	320	320	320	320	320	320
Truckee River at Pyramid Lake Avg. (Site 4)	425	426	420	420	418	419	416	417
Pyramid Lake elevation (ft.)								
Beginning	3812.4	3812.4	3812.4	3812.4	3812.4	3812.4	3812.4	3812.4
Average	3826.8	3826.2	3824.6	3824.7	3824.2	3824.4	3823.6	3823.8
Cui-ui index	55,000	65,000	35,000	44,000	31,000	40,000	28,000	29,000

Table 4 (continued)

	N-119-0	N-119-0 with PSA	N-119-8	N-119-8 with PSA	N-119-10	N-119-10 with PSA	N-119-12.8	N-119-12.8 with PSA
Drought period conservation (a) (Avg. annual)								
Westpac municipal	.21	1.49	.23	1.49	.23	1.49	.23	1.49
Shortages (b)								
Newlands Project (b) irrigation	6.64	7.09	6.99	7.40	7.07	7.48	7.17	7.57
Newlands, maximum season Max. (percent of demand)	136	151	145	159	147	160	150	163
	42	47	45	50	46	50	47	51

Model inputs for the model simulations shown in table 4 are as follows. Values are in 1,000's of acre-feet per year.

- Westpac demand = 119
- Truckee Meadows sewage return = 67.1
- Newlands Project demand = 320
  - (Carson Division = 292)
  - (Truckee Division = 28)
  - Based on provisions of OCAP submitted to Federal District Court, Reno, Nevada, on April 18, 1988.
- Irrigation demand downstream from Derby Dam along the Truckee River = 19.1

Notes: Site numbers refer to sites where the flows are simulated by modeling and which sites are approximated by the locations of the stream-gaging stations listed in tables 1 and 2 whose locations are shown in the schematic in figure 2. There may be minor differences in the flows at the simulated flow sites and the gaged sites because of inflows or diversions and losses between the model simulation sites and the stream-gaging station locations.

(a) Drought period conservation is the average annual conservation obtained during drought years. With the Preliminary Settlement Agreement, a 10-percent monthly reduction in demand during drought years is assumed and with non-Preliminary Settlement Agreement analyses, a 10-percent reduction in demand is assumed only for months when Truckee River flows are too small to supply Westpac demands.

(b) Shortages refer to the difference between the simulated volume of water delivered to the area or use indicated and the normal demand or the volume stipulated by compact, decree, or by operating rules.

(c) The Newlands Project includes both the areas served by the Truckee Canal (Truckee Division) and the Lahontan Valley (Carson Division) downstream from Lahontan Reservoir (figs. 1 and 2).

upper Truckee River Reservoirs. Virtually all of this credit storage would be consumptively used for:

1) Upper Truckee River reservoir evaporation
2) Reno-Sparks municipal and industrial purposes in drought years
3) Pyramid Lake fishery purposes in non-drought years
4) Pyramid Lake evaporation.

It has not been determined if any Reno-Sparks return flow from credit storage water use would be available for appropriation by downstream water users.

Selected water demands for model simulations "without the PSA," assumed that the 15,600 acre-feet would be used for irrigation. Without the PSA, it is probably less likely that the 15,600 acre-feet would be used because of the increased competition for and the limited availability of drought-year supplies to firm up water rights for municipal use.

The average simulated flow to Pyramid Lake is generally slightly larger with the Preliminary Settlement Agreement in effect than without it, resulting in slightly higher average lake levels. The cui-ui index is larger with the Preliminary Settlement Agreement in effect than it is without it although only slightly larger with the larger upper Truckee River depletions. The modeled cui-ui index seems to be especially sensitive to reductions in flow that, for example, occur when there are increased upper Truckee River depletions. Studies to date have not been able to determine how much of a change in the cui-ui index is required to indicate a significant change in the health or numbers of the cui-ui fishery.

Year-by-Year Analyses

Year-by-year analyses of Negotiation model outputs were made for Westpac demands of 119,000 acre-feet per year and for historical depletions and for increased depletions of 12,800 acre-feet per year in the upper Truckee River between Lake Tahoe and Farad. Comparisons are made for model simulations with and without the conditions of the Preliminary Settlement Agreement (PSA).

Reno-Sparks municipal and industrial water use is expected to increase whether or not an agreement such as the Preliminary Settlement Agreement is implemented. To the extent that growth of Reno-Sparks water demand will utilize Truckee River water rights and reduce downstream water supplies, the effect on water supplies in the Newlands Project area may be about the same whether or not the Preliminary Settlement Agreement is implemented.

Truckee Meadows

Only Westpac service area supplies were considered in the Truckee Meadows area. Following are simulation years in which drought-period conservation was assumed and the magnitudes of the drought period conservation calculated. Drought period conservation is described in the section entitled "Municipal and Industrial Water Supply Resources."

Model simulations are identified as follows. The prefix "N" indicates that the Negotiation model was used. The middle number refers to a Westpac water demand of 119,000 acre-feet per year. The last number refers to the increase in depletions over the historical depletions from the Truckee River between Lake Tahoe and Farad. For example, the 12.8 indicates that the model simulation used depletions that were 12,800 acre-feet per year more than the historical depletions. The columns "with PSA" in the heading, indicate that the model simulation included the provisions of the PSA (Preliminary Settlement Agreement). Model simulations without the statement "with PSA" do not include the provisions of the Preliminary Settlement Agreement. Model outputs are the result of running the model for the 80 years (1901-1980) of simulated inputs.

Simulation Water Year	N-119-0		N-119-0 (with PSA)		N-119-12.8		N-119-12.8 (with PSA)	
	Drought conservation in acre-feet and in percent of demand							
	Ac-Ft	%	Ac-Ft	%	Ac-Ft	%	Ac-Ft	%
1926			7,640	6.4			7,640	6.4
1927			4,260	3.6			4,260	3.6
1929			7,640	6.4			7,640	6.4
1930			4,260	3.6			4,260	3.6
1931	5,550	4.7	7,640	6.4	5,550	4.7	7,640	6.4
1932	430	.4	11,900	10.0	910	.8	11,900	10.0
1933	2,660	2.2	11,900	10.0	2,660	2.2	11,900	10.0
1934	5,700	4.8	11,900	10.0	6,080	5.1	11,900	10.0
1935	2,100	1.8	11,900	10.0	2,100	1.8	11,900	10.0
1936			4,260	3.6			4,260	3.6
1961			7,640	6.4			7,640	6.4
1962			11,900	10.0			11,900	10.0
1963			4,260	3.6			4,260	3.6
1977	90	<.1	7,640	6.4	1,050	.1	7,640	6.4
1978			4,300	3.6	410	<.1	4,260	3.6

Model simulations with the PSA assume drought-period conservation during more years and for longer duration than do model simulation without the Preliminary Settlement Agreement. However, all model simulations experience the same maximum conservation of 10-percent per month.

Truckee Canal

Demands directly from the Truckee Canal to the Truckee Division are expected to be 28,000 acre-feet per year based on the current OCAP projection for 1992. Following are years in which shortages occur and the magnitudes of those shortages. Shortages are defined as the amount that simulated flows to the Truckee Division are less than the 28,000 acre-feet per year demand during simulations for the years 1901-1980.

Model simulations are identified as follows. The prefix "N" indicates that the Negotiation model was used. The middle number refers to a Westpac water demand of 119,000 acre-feet per year. The last number refers to the increase in depletions over the historical depletions from the Truckee River between Lake Tahoe and Farad. For example, the 12.8 indicates that the model simulation used depletions that were 12,800 acre-feet per year more than the historical depletions. The columns "with PSA" in the heading, indicate that the model simulation included the provisions of the PSA (Preliminary Settlement Agreement). Model simulations without the statement "with PSA" do not include the provisions of the Preliminary Settlement Agreement. Model outputs are the result of running the model for the 80 years (1901-1980) of simulated inputs.

Simulation Water Year	N-119-0		N-119-0 (with PSA)		N-119-12.8		N-119-12.8 (with PSA)	
	Shortages in acre-feet and in percent of demand							
	Ac-Ft	%	Ac-Ft	%	Ac-Ft	%	Ac-Ft	%
1931	13,200	47	13,800	49	13,300	48	14,700	52
1933	4,100	15	4,500	16	4,400	16	4,850	17
1934	13,100	47	12,500	45	13,000	46	12,800	46
1935	840	3	890	3	1,580	6	1,570	6
1961							250	1
1977			1,280	5	2,360	8	1,550	6

With the PSA in effect, simulated shortages in the Truckee Division are slightly more frequent and generally of only slightly larger magnitudes than for model simulations without the Preliminary Settlement Agreement. Some years have shortages that are slightly less with the PSA than without it. The effect of increased depletions from the upper Truckee River show maximum increased shortages of 8 percent.

Lahontan Valley

Demands in the Lahontan Valley (Carson Division) from Lahontan Reservoir based on the current OCAP projection for 1992 are expected to be 292,000 acre-feet per year. Following are the years when the shortages occurred and the simulated magnitudes of those shortages. Shortages are defined as the amount that simulated flows to the Lahontan Valley are less than the 292,000 acre-feet per year demand during simulations for the years 1901-1980.

Model simulations are identified as follows. The prefix "N" indicates that the Negotiation model was used. The middle number refers to a Westpac water demand of 119,000 acre-feet per year. The last number refers to the increase in depletions over the historical depletions from the Truckee River between Lake Tahoe and Farad. For example, the 12.8 indicates that the model simulation used depletions that were 12,800 acre-feet per year more than the historical depletions. The columns "with PSA" in the heading, indicate that the model simulation included the provisions of the PSA (Preliminary Settlement Agreement). Model simulations without the statement "with PSA" do not include the provisions of the Preliminary Settlement Agreement. Model outputs are the result of running the model for the 80 years (1901-1980) of simulated inputs.

Simulation Calendar Year	N-119-0		N-119-0 (with PSA)		N-119-12.8		N-119-12.8 (with PSA)	
	Shortages in acre-feet and in percent of demand							
	Ac-Ft	%	Ac-Ft	%	Ac-Ft	%	Ac-Ft	%
1929	10,800	4	12,200	4	17,200	6	19,000	7
1931	123,000	42	137,000	47	137,000	47	148,000	51
1933							810	< 1
1934	117,000	40	124,000	42	123,000	42	129,000	44
1960	9,310	3	14,900	5	12,400	4	19,300	7
1961	116,000	40	121,000	41	124,000	42	127,000	43
1977	125,000	43	125,000	43	126,000	43	126,000	43

Model simulations with the PSA have shortages that are no more than 5 percent larger than for model simulations without PSA. The effect of increased depletions from the upper Truckee River is 5 percent or less for any year.

Lahontan Reservoir

According to the "Final environmental impact statement for the Newlands Project proposed operating criteria and procedures," (URS Corporation, 1987, p. S-15), reservoir contents of 100,000 acre-feet or more are needed from May through September for normal recreational purposes. Less storage during these months reduces recreational use at the reservoir. Following is a listing of the

number of periods when shortages (storage less than 100,000 acre-feet during May through September) occurred for different operational policies and water use during simulations for the years 1901-1980.

Model simulations are identified as follows. The prefix "N" indicates that the Negotiation model was used. The middle number refers to a Westpac water demand of 119,000 acre-feet per year. The last number refers to the increase in depletions over the historical depletions from the Truckee River between Lake Tahoe and Farad. For example, the 12.8 indicates that the model simulation used depletions that were 12,800 acre-feet per year more than the historical depletions. The columns "with PSA" in the heading, indicate that the model simulation included the provisions of the PSA (Preliminary Settlement Agreement). Model simulations without the statement "with PSA" do not include the provisions of the Preliminary Settlement Agreement. Model outputs are the result of running the model for the 80 years (1901-1980) of simulated inputs.

Months	N-119-0	N-119-0 (with PSA)	N-119-12.8	N-119-12.8 (with PSA)
	Number of periods with shortages			
September only	12	12	12	11
August - September only	9	10	9	10
July - September only	4	3	4	4
June - September only	0	0	0	0
May - September only	4	4	4	4
	Percent of time criteria met			
May	95	95	95	95
June	95	95	95	95
July	90	91	90	90
August	80	80	80	78
September	64	64	64	64

The model simulations indicate that the likelihood of meeting the goal of 100,000 acre-feet storage is about the same with the Preliminary Settlement Agreement as it is without it.

Lower Truckee River

The cui-ui index shown in tables 1 and 4 is the currently used indicator of the effects of various policies on the cui-ui (Buchanan and Strekal, 1988). The model was run for the period 1901-1980 to provide simulations of the cui-ui index and to determine years of insufficient flows for cui-ui spawning.

It is noted that with historical upper Truckee River use and without the provisions of the Preliminary Settlement Agreement (model simulation N-119-0), there were 18 years when flow was insufficient for cui-ui spawning. This model simulation shows that there were seven consecutive simulated years, 1929-1935, when flows were insufficient for spawning.

With historical upper Truckee River depletions and with the provisions of the Preliminary Settlement Agreement in effect (model simulation N-119-0, with PSA), there were 15 years with insufficient flows for spawning. The maximum number of consecutive years without sufficient flows for spawning was three, but six years out of the seven year period 1929-1935, had insufficient flows for spawning.

With the maximum allowed depletion in the upper Truckee River and without the Preliminary Settlement Agreement (model simulation N-119-12.8), there were 20 years without sufficient flows for spawning. There were seven consecutive years, 1929-1935, without sufficient flows for spawning.

With the maximum allowed depletion in the upper Truckee River and with the Preliminary Settlement Agreement in effect (model simulation N-119-12.8, With PSA), there were 16 years without sufficient flows for spawning. The maximum number of consecutive years without sufficient flows for spawning was seven, 1929-1935.

In general, the model simulations show that there are three or four more years with sufficient water for spawning with the provisions of the Preliminary Settlement Agreement in effect than there would be if it were not in effect. Of perhaps greater significance with the Preliminary Settlement Agreement in effect is the possibility of reducing the number of consecutive years without sufficient flow for spawning. An example is the years 1929-1935. With the Preliminary Settlement Agreement in effect and without additional upper Truckee River depletions, flows sufficient for spawning occur in the middle of this period whereas they do not otherwise.

The cui-ui index at the beginning of 1928 is 138,000 and at the end of 1935 for model simulation N-119-0 without the Preliminary Settlement Agreement is 118,000, a decrease of 20,000. For model simulation N-119-0 with the Preliminary Settlement Agreement, the cui-ui index at the end of 1928 is 144,000 and at the end of 1935 it is 133,000, a decrease of 11,000.

As simulated by the model simulations, the effect of increased upper Truckee River depletions is to increase the number of years with insufficient flows for spawning by one to two years.

Water years with model simulated flows insufficient for cui-ui spawning

Model simulations are identified as follows. The prefix "N" indicates that the Negotiation model was used. The middle number refers to a Westpac water demand of 119,000 acre-feet per year. The last number refers to the increase in depletions over the historical depletions from the Truckee River between Lake Tahoe and Farad. For example, the 12.8 indicates that the model simulation used depletions that were 12,800 acre-feet per year more than the historical depletions. The columns "with PSA" in the heading, indicate that the model simulation included the provisions of the PSA (Preliminary Settlement Agreement). Model simulations without the statement "with PSA" do not include the provisions of the Preliminary Settlement Agreement. Model outputs are the result of running the model for the 80 years (1901-1980) of simulated inputs.

N-119-0	N-119-0 (with PSA)	N-119-12.8	N-119-12.8 (with PSA)
1913		1913	
1925		1925	
1926	1926	1926	1926
1929	1929	1929	1929
1930	1930	1930	1930
1931	1931	1931	1931
1932		1932	1932
1933	1933	1933	1933
1934	1934	1934	1934
1935	1935	1935	1935
		1947	
1948	1948	1948	1948
1949	1949	1949	1949
1955	1955	1955	1955
1960	1960	1960	1960
1961	1961	1961	1961
1962	1962	1962	1962
		1964	
1977	1977	1977	1977
1978	1978	1978	1978

Pyramid Lake

Following are the results of the various model simulations on the elevations of Pyramid Lake. The significance of the percentiles, as listed below, is to provide an indication of the percent of the 80-year simulation period, that the elevations are less than those shown. For example, with the conditions indicated by model simulation N-119-0 without PSA, 10 percent of the time the elevation of Pyramid Lake is equal to or less than 3,813.9 feet or 90 percent of the time, elevations are higher than 3,813.9 feet.

With the conditions indicated by model simulation N-119-12.8, with PSA, 10 percent of the time the elevation is 3,811.8 feet or less.

Model simulations are identified as follows. The prefix "N" indicates that the Negotiation model was used. The middle number refers to a Westpac water demand of 119,000 acre-feet per year. The last number refers to the increase in depletions over the historical depletions from the Truckee River between Lake Tahoe and Farad. For example, the 12.8 indicates that the model simulation used depletions that were 12,800 acre-feet per year more than the historical depletions. The columns "with PSA" in the heading, indicate that the model simulation included the provisions of the PSA (Preliminary Settlement Agreement). Model simulations without the statement "with PSA" do not include the provisions of the Preliminary Settlement Agreement. Modal outputs are the result of running the model for the 80 years (1901-1980) of simulated inputs.

	Elevations, in feet			
Characteristic	N-119-0	N-119-0 (with PSA)	N-119-12.8	N-119-12.8 (with PSA)
Beginning elev.	3,812.4	3,812.4	3,812.4	3,812.4
Maximum elev.	3,851.1	3,851.4	3,849.7	3,850.0
Minimum elev.	3,810.4	3,810.2	3,807.4	3,807.4
Average elev.	3,826.0	3,826.2	3,823.6	3,823.8
10 percentile	3,813.9	3,814.0	3,811.7	3,811.8
30 percentile	3,817.8	3,818.0	3,815.1	3,815.1
50 percentile	3,821.5	3,821.8	3,818.5	3,818.9
70 percentile	3,829.6	3,829.8	3,828.2	3,828.3
90 percentile	3,846.0	3,845.9	3,844.7	3,844.4

The effect of the PSA is very small on the simulated elevations of Pyramid Lake. The effects of increased depletions in the upper Truckee River, however, shows an average simulated decrease in lake elevation of about 2.4 feet.

ALTERNATIVE TO THE PRELIMINARY SETTLEMENT AGREEMENT

The Bureau of Reclamation (BOR) has proposed an alternative operating plan for providing drought storage for Westpac and for improving the cui-ui fishery. This plan is not under active consideration but is presented to provide information on the alternative. Some of the features and assumptions of the alternative plan are presented below.

1. The Bureau of Reclamation would sell 40,000 acre-feet of storage to Sierra Pacific from Stampede Reservoir to be used for municipal purposes only during a severe drought. All other water rights owned by Sierra Pacific would have to be exercised and used before the Sierra Pacific water is withdrawn from Stampede Reservoir. When refilling Stampede Reservoir, the 40,000 acre-feet of Sierra Pacific water would have priority over refilling the remaining capacity of Stampede Reservoir. Evaporation would not be applied to the 40,000 acre-feet of Sierra Pacific water unless it is the only water in the pool. These conditions are the

same conditions that would apply to the use of 19,500 acre-feet of Sierra Pacific water in Stampede Reservoir with the Preliminary Settlement Agreement.

2. Sierra Pacific would waive its rights to require releases or pass through of water from Truckee River Reservoirs solely for the generation of hydroelectric power. Any single purpose Sierra Pacific water that would have been released or bypassed at Lake Tahoe, Stampede Reservoir, or Prosser Reservoir, would be stored as credit water and would be released whenever needed to provide water for cui-ui spawning.

3. Whenever, based upon the April 1 seasonal runoff forecast, a drought situation exists as defined in the Preliminary Settlement Agreement, conservation procedures would be implemented as necessary to reduce the Sierra Pacific demand by 10 percent during the following May through November. Model simulations to simulate the Preliminary Settlement Agreement conditions assume a 10-percent reduction in the normal demand from April through March in a drought situation. The Negotiation model with the Preliminary Settlement Agreement and the alternate plan both limit the maximum Sierra Pacific shortage to 10 percent.

4. It was assumed that all Truckee Meadows irrigation rights were used for irrigation or converted to municipal use for the running of the models. It was assumed that Sierra Pacific would acquire 72,100 acre-feet of water rights with the alternate plan compared to 87,700 acre-feet of water rights with the Preliminary Settlement Agreement. Sierra Pacific would acquire an additional 15,600 acre-feet of irrigation rights with the Preliminary Settlement Agreement specifically to credit store the consumptive use part of these rights for municipal use. With the alternate plan, it was assumed that the 15,600 acre-feet of water rights would be acquired by another entity and developed for municipal use.

5. Some of the features of the Preliminary Settlement Agreement that were not included in the alternate plan are:

   a. Credit storage of unused irrigation rights for municipal use.

   b. Credit storage of Independence Lake and Donner Lake water in Lake Tahoe, Prosser, Stampede, and Boca Reservoirs.

   c. Pumping from Sparks Pit (a sand and gravel pit located in the City of Sparks) of 2,000 acre-feet in severe drought years for municipal use.

   d. Sierra Pacific's use of the Truckee-Carson Irrigation District's water rights in Donner Lake.

COMPARISON OF THE ALTERNATIVE PLAN AND THE PRELIMINARY SETTLEMENT AGREEMENT

The alternative plan results are compared with the N-119-0 and N-119-12.8 model simulations, both with the Preliminary Settlement Agreement in effect. The BOR alternate plan is labeled in this report "ALT".

Drought Conservation in Truckee Meadows

Only Westpac service area supplies were considered in the Truckee Meadows area. Following are simulation years in which drought-period conservation was assumed and the magnitudes of the drought-period conservation calculated. Drought period conservation is described in the section entitled "Municipal and Industrial Water Supply Resources."

Model simulations are identified as follows. The prefix "N" indicates that the Negotiation model was used while the prefix "ALT" refers to the alternate plan. The middle number refers to a Westpac water demand of 119,000 acre-feet per year. The last number refers to the increase in depletions over the historical depletions from the Truckee River between Lake Tahoe and Farad. For example, the 12.8 indicates that the model simulation used depletions that were 12,800 acre-feet per year more than the historical depletions. The columns "with PSA" in the heading, indicate that the model simulation included the provisions of the PSA (Preliminary Settlement Agreement). Model simulations without the statement "with PSA" do not include the provisions of the Preliminary Settlement Agreement. Model outputs are the result of running the model for the 80 years (1901-1980) of simulated inputs.

Simulation Calendar Year	N-119-0 (with PSA)		N-119-12.8 (with PSA)		ALT-119-0		ALT-119-12.8	
	Drought conservation in acre-feet and in percent of demand							
	Ac-Ft	%	Ac-Ft	%	Ac-Ft	%	Ac-Ft	%
1926	7,640	6.4	7,640	6.4				
1927	4,260	3.6	4,260	3.6			6,750	5.7
							1,620	1.4
1929	7,640	6.4	7,640	6.4	6,750	5.7	6,750	5.7
1930	4,260	3.6	4,260	3.6	1,720	1.4	1,720	1.4
1931	7,640	6.4	7,640	6.4	6,750	5.7	6,750	5.7
1932	11,900	10.0	11,900	10.0	8,360	7.0	8,360	7.0
1933	11,900	10.0	11,900	10.0	8,330	7.0	8,330	7.0
1934	11,900	10.0	11,900	10.0	8,420	7.1	8,420	7.1
1935	11,900	10.0	11,900	10.0	8,330	7.0	8,330	7.0
1936	4,260	3.6	4,260	3.6	1,690	1.4	1,640	1.4
1961	7,640	6.4	7,640	6.4	6,750	5.7	6,750	5.7
1962	11,900	10.0	11,900	10.0	8,420	7.1	8,420	7.1
1963	4,260	3.6	4,260	3.6	1,650	1.4	1,650	1.4
1977	7,640	6.4	7,640	6.4	6,800	5.7	6,800	5.7
1978	4,300	3.6	4,260	3.6	1,720	1.4	1,790	1.5
Avg.	1,490		1,490		1,000		1,110	

Model simulations with the alternate plan indicate little differences in drought conservation compared to simulations with the Preliminary Settlement Agreement.

Water Shortages

Truckee Canal

Demands directly from the Truckee Canal to the Truckee Division for the current OCAP, are 28,000 acre-feet per year. Following are simulation years in which shortages occur and the magnitude of those shortages.

Model simulations are identified as follows. The prefix "N" indicates that the Negotiation model was used while the prefix "ALT" refers to the alternate plan. The middle number refers to a Westpac water demand of 119,000 acre-feet per year. The last number refers to the increase in depletions over the historical depletions from the Truckee River between Lake Tahoe and Farad. For example, the 12.8 indicates that the model simulation used depletions that were 12,800 acre-feet per year more than the historical depletions. The columns "with PSA" in the heading, indicate that the model simulation included the provisions of the PSA (Preliminary Settlement Agreement). Model simulations without the statement "with PSA" do not include the provisions of the Preliminary Settlement Agreement. Model outputs are the result of running the model for the 80 years (1901-1980) of simulated inputs.

Simulation Calendar Year	N-119-0 (with PSA)		N-119-12.8 (with PSA)		ALT-119-0		ALT-119-12.8	
	Shortages in acre-feet and in percent of demand							
	Ac-Ft	%	Ac-Ft	%	Ac-Ft	%	Ac-Ft	%
1924					470	2	470	2
1926					430	2		
1931	13,800	49	14,700	52	14,200	51	14,800	53
1933	4,500	16	4,850	17	4,160	15	4,410	16
1934	12,500	45	12,800	46	13,800	49	14,300	51
1935	890	3	1,570	6	620	2	1,270	5
1961			250	1			190	1
1968					250	1	250	1
1977	1,280	5	1,550	6	560	2	1,740	6
Avg.	410		450		430		470	

Simulated shortages are generally slightly larger and a little more frequent with the alternate plan.

Lahontan Valley

Demands in the Lahontan Valley (Carson Division) from Lahontan Reservoir under the current OCAP are 292,000 acre-feet per year. Following are the simulation years when the shortages occurred and the simulated magnitudes of those shortages.

Model simulations are identified as follows. The prefix "N" indicates that the Negotiation model was used while the prefix "ALT" refers to the alternate plan. The middle number refers to a Westpac water demand of 119,000 acre-feet per year. The last number refers to the increase in depletions over the historical depletions from the Truckee River between Lake Tahoe and Farad. For example, the 12.8 indicates that the model simulation used depletions that were 12,800 acre-feet per year more than the historical depletions. The columns "with PSA" in the heading, indicate that the model simulation included the provisions of the PSA (Preliminary Settlement Agreement). Model simulations without the statement "with PSA" do not include the provisions of the Preliminary Settlement Agreement. Model outputs are the result of running the model for the 80 years (1901-1980) of simulated inputs.

Simulation Calendar Year	N-119-0 (with PSA)		N-119-12.8 (with PSA)		ALT-119-0		ALT-119-12.8	
	Shortages in acre-feet and in percent of demand							
	Ac-Ft	%	Ac-Ft	%	Ac-Ft	%	Ac-Ft	%
1929	12,200	4	19,000	7	9,690	3	16,400	6
1931	137,000	47	148,000	51	124,000	42	138,000	47
1933			810	<1	3,940	1		
1934	124,000	42	129,000	44	133,000	46	127,000	43
1960	14,900	5	19,300	7	12,400	4	16,000	5
1961	121,000	41	127,000	43	120,000	41	128,000	44
1977	125,000	43	126,000	43	125,000	43	127,000	43
Avg.	6,680		7,120		6,590		6,890	

Simulated shortages are sometimes larger and sometimes smaller with the alternate plan. On the average, however, shortages are a little smaller with the alternate plan.

Lahontan Reservoir

According to the "Final environmental impact statement for the Newlands Project proposed operating criteria and procedures", dated December 1987, page S-15, reservoir contents of 100,000 acre-feet or more are needed from May through September for normal recreational purposes. Less storage during these months reduces recreational use at the reservoir. Following is a listing of the number of periods when shortages (storage less than 100,000 acre-feet during May through September) occurred for different operational policies and water use.

Model simulations are identified as follows. The prefix "N" indicates that the Negotiation model was used while the prefix "ALT" refers to the alternate plan. The middle number refers to a Westpac water demand of 119,000 acre-feet per year. The last number refers to the increase in depletions over the historical depletions from the Truckee River between Lake Tahoe and Farad. For example, the 12.8 indicates that the model simulation used depletions that were 12,800 acre-feet per year more than the historical depletions. The columns "with PSA" in the heading, indicate that the model simulation included the provisions of the PSA (Preliminary Settlement Agreement). Model simulations without the statement "with PSA" do not include the provisions of the Preliminary Settlement Agreement. Model outputs are the result of running the model for the 80 years (1901-1980) of simulated inputs.

Months	N-119-0 (with PSA)	N-119-12.8 (with PSA)	ALT-119-0	ALT-119 -12.8
	Number of periods with shortages			
September only	12	11	12	12
August - September only	10	10	8	9
July - September only	3	4	5	4
June - September only	0	0	0	0
May - September only	4	4	4	4
	Percent of time criteria met			
May	95	95	95	95
June	95	95	95	95
July	91	90	89	90
August	80	78	79	79
September	64	64	64	64

The model simulations indicate that the likelihood of meeting the goal of 100,000 acre-feet storage is about the same with the Preliminary Settlement Agreement as it is without it.

Adequacy of Water for Cui-ui Spawning in the Lower Truckee River

Flows for the years 1901-1980 were simulated. Years when there was insufficient water for cui-ui spawning, as indicated by the model, are shown.

Model simulations are identified as follows. The prefix "N" indicates that the Negotiation model was used while the prefix "ALT" refers to the alternate plan. The middle number refers to a Westpac water demand of 119,000 acre-feet per year. The last number refers to the increase in depletions over the historical depletions from the Truckee River between Lake Tahoe and Farad. For example, the 12.8 indicates that the model simulation used depletions that were 12,800 acre-feet per year more than the historical depletions. The columns "with PSA" in the heading, indicate that the model simulation included the provisions of the PSA (Preliminary Settlement Agreement). Model simulations without the statement "with PSA" do not include the provisions of the Preliminary Settlement Agreement. Model outputs are the result of running the model for the 80 years (1901-1980) of simulated inputs.

Water years with model simulated flows insufficient for cui-ui spawning

N-119-0 (with PSA)	N-119-12.8 (with PSA)	ALT-119-0	ALT-119-12.8
		1913	1913
		1925	1925
1926	1926	1926	1926
1929	1929	1929	1929
1930	1930	1930	1930
1931	1931	1931	1931
	1932		1932
1933	1933	1933	1933
1934	1934	1934	1934
1935	1935	1935	1935
1948	1948	1948	1948
1949	1949	1949	1949
1955	1955	1955	1955
1960	1960	1960	1960
1961	1961	1961	1961
1962	1962	1962	1962
1977	1977	1977	1977
1978	1978	1978	
			1979

The model simulations indicate that there are a few more years with the alternate plan, that cannot sustain cui-ui spawning than there are with the Preliminary Settlement Agreement.

The cui-ui index at the end of the 80-year model simulations are shown below.

N-119-0 (with PSA)	N-119-12.8 (with PSA)	ALT-119-0	ALT-119-12.8
65,000	29,000	55,000	24,000

The alternate plan results in a reduced cui-ui index.

Elevation of Pyramid Lake

Following are the results of the various model simulations on the elevations of Pyramid Lake.

Model simulations are identified as follows. The prefix "N" indicates that the Negotiation model was used while the prefix "ALT" refers to the alternate plan. The middle number refers to a Westpac water demand of 119,000 acre-feet per year. The last number refers to the increase in depletions over the historical depletions from the Truckee River between Lake Tahoe and Farad. For example, the 12.8 indicates that the model simulation used depletions that were 12,800 acre-feet per year more than the historical depletions. The columns "with PSA" in the heading, indicate that the model simulation included the provisions of the PSA (Preliminary Settlement Agreement). Model simulations without the statement "with PSA" do not include the provisions of the Preliminary Settlement Agreement. Model outputs are the result of running the model for the 80 years (1901-1980) of simulated inputs.

Characteristic	N-119-0 (with PSA)	N-119-12.8 (with PSA)	ALT-119-0	ALT-119-12.8
		Elevations, in feet		
Beginning elev.	3,812.4	3,812.4	3,812.4	3,812.4
Maximum elev.	3,851.4	3,850.0	3,851.4	3,850.0
Minimum elev.	3,810.2	3,807.4	3,809.8	3,806.9
Average elev.	3,826.2	3,823.8	3,825.8	3,823.4
10 percentile	3,814.0	3,811.8	3,813.6	3,811.2
30 percentile	3,818.0	3,815.1	3,817.4	3,814.8
50 percentile	3,821.8	3,818.9	3,821.6	3,818.4
70 percentile	3,829.8	3,828.3	3,829.5	3,828.3
90 percentile	3,845.9	3,844.4	3,845.8	3,844.2

The alternate plan reduces average simulated lake levels by about 0.4 foot.

EFFECTS OF TRANSFERRING WATER RIGHTS TO WETLANDS

Model studies to show the effect on Pyramid Lake of transferring 30,000 acre-feet or 40,000 acre-feet of Newlands Project water to the Lahontan Valley wetlands are based on the following assumptions.

1. Water rights transferred to the wetlands would all be from the Carson Division and have a 3.5 acre-feet per acre water duty.

2. Only 2.99 acre-feet per acre of the 3.5 acre-feet per acre is to be transferred to the wetlands as stipulated in the transfers approved in the past by the Nevada State Engineer. It is assumed that the remaining 0.51 acre-feet per acre or a part thereof will not be diverted into the Truckee Canal and would, therefore, flow to Pyramid Lake.

3. The conveyance efficiency for delivery of the 0.51 acre-feet per acre of project water to the present place of use was estimated to be 66 percent, the efficiency projected for the Carson Division for 1992 under the 1988 OCAP.

4. Newlands Project water demand with transfers of 30,000 and 40,000 acre-feet are computed as follows:

- Project water transfer to wetlands	(Ac-Ft)	30,000	40,000
- Water right acreage at 2.99 acre-feet per acre	(Acres)	10,033	13,378
- Inactive water right at 0.51 acre-feet per acre	(Ac-Ft)	5,100	6,800
- Reduction in Lahontan Reservoir releases at 66 percent efficiency	(Ac-Ft)	7,700	10,300
- Carson Division demand without transfers	(Ac-Ft)	292,000	292,000
- Carson Division demands with transfers	(Ac-Ft)	284,300	281,700
- Truckee Division demand	(Ac-Ft)	28,000	28,000
- Newlands Project demand with transfer	(Ac-Ft)	312,300	309,700

Model inputs for this analyses are similar to those for model simulations N-119-0 and N-119-12.8 except that the annual Newlands Project demand drops from 320,000 acre-feet to 312,300 acre-feet for a transfer of 30,000 acre-feet of water rights and to 309,700 acre-feet for a transfer of 40,000 acre-feet of water rights. All Negotiation model simulations in this analysis are with the Preliminary Settlement Agreement in effect.

Elevation of Pyramid Lake

Following are results from the various model simulations on the elevation of Pyramid Lake. Elevations are in feet. All model simulation starting elevations were 3,812.4 feet.

Model simulations are identified as follows. The prefix "N" indicates that the Negotiation model was used. The middle number refers to a Westpac water demand of 119,000 acre-feet per year. The last number refers to the increase in depletions over the historical depletions from the Truckee River between Lake Tahoe and Farad. For example, the 12.8 indicates that the model simulation used depletions that were 12,800 acre-feet per year more than the historical depletions. Model outputs are the result of running the model for the 80 years (1901-1980) of simulated inputs.

With no water rights transferred		With 30,000 ac-ft of water rights transferred		With 40,000 ac-ft of water rights transferred	
N-119 -0	N-119 -12.8	N-119 -0	N-119 -12.8	N-119 -0	N-119 -12.8
		Maximum Elevations			
3,851.4	3,850.0	3,851.7	3,850.3	3,851.8	3,850.4
		Minimum Elevations			
3,810.2	3,807.4	3,811.6	3,808.7	3,811.9	3,809.2
		Average Elevations			
3,826.2	3,823.8	3,827.2	3,824.8	3,827.5	3,825.2
		10-Percentile Elevations			
3,814.0	3,811.8	3,815.0	3,812.9	3,815.5	3,813.2
		30-Percentile Elevations			
3,818.0	3,815.1	3,818.7	3,816.4	3,819.0	3,816.9
		50-Percentile Elevations			
3,821.8	3,818.9	3,823.5	3,820.4	3,823.9	3,820.9
		70-Percentile Elevations			
3,829.8	3,828.3	3,830.3	3,828.8	3,830.5	3,829.0
		90-Percentile Elevations			
3,845.9	3,844.4	3,846.3	3,844.7	3,846.4	3,844.9

Purchase of 30,000 acre-feet of water rights in the Newlands Project creates a simulated increase in the average lake level of about 1.0 foot. The purchase of 40,000 acre-feet of water rights creates a simulated increase in the average lake level of about 1.4 feet.

Cui-ui index

Following are listings of the simulated water years without sufficient flows for cui-ui spawning

Model simulations are identified as follows. The prefix "N" indicates that the Negotiation model was used. The middle number refers to a Nestpac water demand of 119,000 acre-feet per year. The last number refers to the increase in depletions over the historical depletions from the Truckee River between Lake Tahoe and Farad. For example, the 12.8 indicates that the model simulation used depletions that were 12,800 acre-feet per year more than the historical depletions. Model outputs are the result of running the model for the 80 years (1901-1980) of simulated inputs.

With no water rights transferred		With 30,000 ac-ft of water rights transferred		With 40,000 ac-ft of water rights transferred	
N-119 -0	N-119 -12.8	N-119 -0	N-119 -12.8	N-119 -0	N-119 -12.8
1926	1926	1926	1926	1926	1926
1929	1929	1929	1929	1929	1929
1930	1930	1930	1930	1930	1930
1931	1931	1931	1931	1931	1931
	1932				
1933	1933	1933	1933	1933	1933
1934	1934	1934	1934	1934	1934
1935	1935	1935	1935	1935	1935
1948	1948	1948	1948	1948	1948
1949	1949	1949	1949	1949	1949
1955	1955	1955	1955	1955	1955
1960	1960	1960	1960	1960	1960
1961	1961	1961	1961	1961	1961
1962	1962	1962	1962	1962	1962
1977	1977	1977	1977	1977	1977
1978	1978	1978	1978	1978	1978

The purchase of water rights in the Newlands Project has little effect on the simulated number of years when cui-ui spawning can take place.

Following is the cui-ui index at the end of the 80-year model simulations.

With no water rights transferred		With 30,000 ac-ft of water rights transferred		With 40,000 ac-ft of water rights transferred	
N-119 -0	N-119 -12.8	N-119 -0	N-119 -12.8	N-119 -0	N-119 -12.8
65,000	29,000	73,000	45,000	73,000	58,000

The purchase of water rights in the Newlands Project results in an increase of the cui-ui index but most significantly increases the index when high depletions occur in the upper Truckee River.

SUMMARY

Sierra Pacific, a utility company in the Reno-Sparks, Nevada area and the Pyramid Lake Paiute Indian Tribe have negotiated an agreement, referred to as the Preliminary Settlement Agreement. The agreement provides for storage of water for use in the Reno-Sparks area during drought periods and for augmentation and modification of flows in the lower Truckee River at a time to improve spawning conditions for an endangered species of fish, the cui-ui. This report discusses the probable effects in the Truckee and Carson Rivers system of implementing the Preliminary Settlement Agreement and discusses effects resulting from changes in water use in the upper Truckee River and in the Lahontan Valley.

Two models have been examined in this report: the Negotiation model and the Bureau of Reclamation (BOR) model. Both models are monthly mass-balance type models. The BOR model does not consider the provisions of the Preliminary Settlement Agreement whereas the Negotiation model can include the provisions of the Agreement. Model results discussed in this report are the result of running the models using a simulated 80 years of data, 1901-1980. The models are undocumented and uncalibrated. Therefore, accuracies of the models cannot be determined and conclusions drawn from model simulations are subject to some degree of uncertainty.

Most of the parties involved in the Truckee-Carson Rivers system realize that the models use some approximations but accept the model results. The involved parties realize a need for a detailed hydrologic model for future use.

Model outputs are constrained by current OCAP goals (requirements) and by anticipated demands. Therefore, the model outputs do not reflect historical flow records.

A cui-ui index provides an index of the number of adult female cui-ui in Pyramid Lake at the end of the 80-year modeling period. With the provisions of the Preliminary Settlement Agreement in the Negotiation model, an increase in the cui-ui index is computed. An increase in consumptive use in the upper Truckee River of 12,800 acre-feet per year reduces the computed cui-ui index by 20 to 60 percent when compared with historical depletions in the upper Truckee River.

A year-by-year analysis of the model outputs was done to obtain meaningful information on simulated shortages and lake levels or storage. In general, the modeled provisions of the Preliminary Settlement Agreement result in slightly greater and slightly more frequent shortages in the Newlands Project area but also increases the cui-ui index by 1,000 to 10,000 depending on the level of upper Truckee River depletion. Other conditions, however, that were assumed to be different for the "with PSA" and "without PSA" model simulations may also affect the Newlands Project water supply.

Computed long-term levels of Pyramid Lake are a little higher with the Preliminary Settlement Agreement in effect. The goal of 100,000 acre-feet of storage in Lahontan Reservoir from May through September for recreational use is effected very little by the implementation of the Preliminary Settlement Agreement, based on model results.

The Bureau of Reclamation developed an alternative operating plan. Model results of this alternative plan were compared to model simulations with the Preliminary Settlement Agreement in effect. Simulated shortages are little changed in the Newlands Project area with the Bureau of Reclamation's alternate plan. The model simulations show little difference in meeting the storage goals for recreation at Lahontan Reservoir. Depending on the amount of the upper Truckee River depletion, the cui-ui index with the Bureau of Reclamation's alternate plan is 5,000 to 10,000 less than the cui-ui index with the Preliminary Settlement Agreement.

When water rights are purchased in the Newlands area for transfer of water to the wetlands in the Lahontan Valley, part of the water will be delivered to the wetlands but part may be left in the Truckee River and not diverted into the Truckee Canal. Consequently, more water could flow into Pyramid Lake. The modeled results of purchasing 30,000 to 40,000 acre-feet of water rights are to increase Pyramid Lake levels by 1.0 to 1.4 feet assuming the Preliminary Settlement Agreement is in effect. With 30,000 acre-feet transferred to the wetlands, the cui-ui index increased by 7,000 to 16,000 depending on the increase in upper Truckee River depletion which was assumed to range from zero to 12,800 acre-feet respectively. With 40,000 acre-feet transferred, the cui-ui index increased by 8,000 to 29,000 compared to the indices with no transfer and depending on the amount of upper Truckee River depletion increase.

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