SACRAMENTO MUNICIPAL UTILITY DISTRICT
UPPER AMERICAN RIVER PROJECT
(FERC Project No. 2101)

and

PACIFIC GAS AND ELECTRIC COMPANY
CHILI BAR PROJECT
(FERC Project No. 2155)

CHILI BAR RESERVOIR
INCREMENTAL STORAGE MODIFICATION
TECHNICAL REPORT

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1.0 Chili Bar Reservoir Incremental Storage Modification Study Plan

This study is designed to investigate the feasibility, benefits and costs associated with improving water management between the UARP and Chili Bar Project by increasing Chili Bar Reservoir storage capacity using two alternatives: 1) adding a seasonally-operated crest-gate to Chili Bar Dam; and 2) potential sediment removal in Chili Bar Reservoir. The study would be conducted in two phases.

Phase One will be an initial modeling analysis using the UARP/Chili Bar Water Balance Model (and possibly spreadsheet models) that would quantify improvements in water management associated with increased storage at Chili Bar Reservoir. All improvements would be quantified against current operating assumptions, and would include items such as: 1) reductions in spill events at Chili Bar Reservoir; 2) increases in water available for power generation at White Rock or Chili Bar powerhouses; and 3) increased potential for controlled releases for beneficial uses in the Reach Downstream of Chili Bar, including whitewater recreation. If the benefits analysis indicates that reasonable benefits might occur, the study would move to Phase Two.

In Phase Two, a feasibility analysis will be performed. The analysis would focus on the two alternatives for increasing storage at Chili Bar Reservoir. Consistent with the potential benefits provided by the two alternatives, the study will conclude with an evaluation of operational coordination between White Rock and Chili Bar Powerhouses in a manner to provide similar water management benefits. The feasibility analysis will include but not be limited to developing costs related to engineering, procurement, construction and maintenance of the storage capacity alternatives. This analysis will also address potential environmental considerations; jurisdictional implications; dam safety, financial feasibility, and impacts to the Chili Bar Project and UARP (land use and operations).

1.1 Pertinent Issue Questions

The Chili Bar Reservoir Incremental Storage Modification Study Plan would be used to address the following Issue Questions reviewed by the Aquatic Technical Working Group (TWG) on March 11, 2004:

- Has PG&E looked into the alternative of raising Chili Bar Reservoir?
- How does the idea of raising Chili Bar Dam cross-jurisdictional boundaries with the UARP?
- What are viable options for increasing Chili Bar Reservoir storage capacity to allow for more flexibility in the management of flows from the UARP? The study should consider increase in dam height.

1.2 Background

Interested parties in SMUD's UARP Relicensing and Pacific Gas and Electric Company's Chili Bar Relicensing have postulated that increasing storage in Chili Bar Reservoir would allow the Licensees to better coordinate UARP and Chili Bar operations, thereby improving water management of the two projects. This has been raised as a possibility because, at times, releases by SMUD from White Rock Powerhouse have resulted in uncontrolled spills over Chili Bar Dam. The parties felt that if additional storage capability occurred in Chili Bar Reservoir, the operators might have been able to capture some or all of the spilled water and release it in a controlled fashion. Also, the parties postulated that at times in the future Pacific Gas and Electric Company might not have adequate water stored in Chili Bar Reservoir to meet requests for future water releases. Therefore, the interested parties would like to know the potential benefits, costs and feasibility of increased storage in Chili Bar Reservoir and/or improving operational coordination.

1.3 Study Objective

The study objectives are to: 1) determine if a reasonable increase in storage at Chili Bar Reservoir could result in improvements in water management between the projects that would protect beneficial uses, 2) if so, evaluate how this increase in storage could be best accomplished, and 3) determine whether the cost and other considerations (e.g., generation impacts to Whiterock powerhouse) make the increased storage a viable option compared to operational coordination as an alternative.

1.4 Study Area

The study area would include the entire UARP and Chili Bar projects for the purpose of modeling (Phase One). The feasibility analysis (Phase Two) will focus on Chili Bar Dam and reservoir related-storage enhancements and potential water management improvements of the South Fork American River in the Reach Downstream of Chili Bar.

1.5 Information Needed From Other Studies

Information needed from other studies includes runs of the UARP/Chili Bar CHEOPS™ Water Balance Model, the results from the Chili Bar Reservoir Sediment Study (i.e., reservoir bathymetric information), and various environmental reports. Note that all analyses will be compared against the current operating assumptions model run.

1.6 Study Methods, Analyses, and Schedule

As described above, the study would be described in two sequential phases, each of which is described below.

Phase One - Model Analysis

Using historical records, Pacific Gas and Electric Company estimates that the current Chili Bar Reservoir usable storage volume is 1,339 acre-feet (ac-ft). In this context, "usable" means the volume of water between the preferred minimum operating elevation of 984 feet and the spill crest elevation of 997.5 feet that can be used by the Chili Bar Powerhouse during routine, unattended operation.). The Licensees acknowledges that another 320 ac-ft of water is potentially available between the preferred 984 feet water elevation and mandatory Powerhouse-shutdown water elevation of 980 feet. There is an additional 1,480 ac-ft of storage between 980 feet water elevation and the 5-foot diameter, low-level outlet, but this storage is not available for routine operation. Note that this Chili Bar Reservoir usable storage volume is the volume currently included in current operating assumptions runs (one with and one without the Iowa Hill Development) of the UARP/Chili Bar CHEOPS™ Water Balance Model. To perform the Phase One Analysis, the Licensees would make four runs of the model with the Iowa Hill Development to simulate increasing storage in approximately 225 ac-ft increments. The only difference from the current operating assumptions run will be that the Chili Bar Reservoir usable storage will be 1,563 ac-ft in Run 1, 1,792 ac-ft in Run 2, 2,027 ac-ft in Run 3, and 2,268 ac-ft in Run 4. The Licensees will then repeat this analysis using the model without the Iowa Hill Development. The maximum usable storage (2,268 ac-ft, or 929 ac-ft more than the current usable storage) to be included in the final model run would equate to the usable storage when the Chili Bar Reservoir was constructed (based on project drawings) plus the additional storage associated with raising Chili Bar Dam by approximately 8 feet. The output from each model run would be compared to the current operating assumptions by Agencies' Proposed Water Types and overall, and include: 1) gains in the amount of water (daily median, minimum and maximum) that would be available for downstream releases from Chili Bar Powerhouse; 2) changes in White Rock and Chili Bar powerhouses' generation; and 3) number of Chili Bar Dam spill days and magnitude of spills. The effect of the recovery of lost storage capacity due to potential sediment removal from Chili Bar Reservoir would be evaluated based on the same three criteria and based on reasonable incremental sediment volume estimates derived from the results from the Chili Bar Reservoir Sediment Study**.**

A feasibility analysis will be performed in Phase Two, unless the Aquatic and Recreation TWGs agree that the analyses in Phase Two is not needed.

Phase Two - Feasibility Analysis

The feasibility analysis would focus on alternatives to increase usable storage in Chili Bar Reservoir to a level that the Phase One analysis indicated reasonable benefits. The analysis would include dam safety, financial feasibility and environmental considerations (i.e. permitting, impacts, effects on privately owned lands and impacts due to inundation of additional riverine habitat upstream of Chili Bar Reservoir); jurisdictional implications (i.e. affect to BLM land and impacts on the UARP); and affects on electrical generation at the White Rock and Chili Bar powerhouses. The feasibility analysis may include results from the Chili Bar Reservoir Sediment Study Plan and other engineering investigations to better assess potential impacts caused by the inundation of the White Rock Powerhouse tailrace and operational coordination approaches. The analysis would consist of a comparison of the frequency and magnitude of spills and volume of available water between each model run and the current operating assumptions, including the cost of providing equal water management benefits in the Downstream Reach through coordinated operations between White Rock Powerhouse and Chili Bar Powerhouse without project modifications.

The Licensee would implement the study plan upon approval by the UARP Relicensing Plenary Group, and expects to complete the study in about 90 days, if no unforeseen complications arise.

1.7 Study Output

The study plan output would be a technical report prepared in the same format as the UARP Relicensing technical reports have been prepared to date, unless requested to be revised by the TWGs. It is anticipated that the report would be summarized in SMUD's UARP license application and Pacific Gas and Electric Company's Chili Bar Project license application, and appended to each application.

1.8 Aquatic TWG and Plenary Group Endorsement

The Aquatics TWG approved this plan on March 25, 2004. The participants at the meetings who said they could "live with" this study plan were CDFG, BLM, SWRCB, Camp Lotus, PG&E and SMUD. None of the participants at the meeting said they could not "live with" this study plan. This study plan will be presented to the April 7, 2004 Plenary Group meeting for consideration for approval.

1.9 Literature Cited

Pacific Gas and Electric Company, May 2003. Chili Bar Project, FERC No. 2155, First Stage Consultation Document for Application for New License.

CHILI BAR RESERVOIR INCREMENTAL STORAGE MODIFICATION TECHNICAL REPORT

SUMMARY

This technical report presents the results of an analysis that used the UARP/Chili Bar Project (CHEOPS™) Water Balance (Model) to evaluate the potential benefits to water management of increasing the usable storage in Chili Bar Reservoir. Two alternatives for increasing usable storage were evaluated: adding a seasonally-operated crest-gate to Chili Bar Dam; and removal of accumulated sediment in Chili Bar Reservoir. As part of Phase 1 of the Study Plan, quantification of the amount of sediment in the reservoir was completed, the CHEOPS™ model was configured to evaluate changes in storage and to use the Base Case to represent a lack of coordination between the UARP and Chili Bar Project operations. Modifications were then made to the Model's configuration to represent coordinated operations.

Three attributes were used to evaluate the benefits of increased storage on water management: changes in the provision of whitewater recreation flows, changes in annual spill frequency and volume, and shifts of generation between on-peak and off-peak. The attributes were evaluated for the combined relicensing Hydrology Record and with the Record divided into the current four water year types.

The results showed that minor increases in the provision of recreation flows resulted from increases in storage associated with simulated sediment removal or crest-gate installation. Operational coordination resulted in 100 percent of the recreation flows being provided, compared to between 70 percent and 86 percent being provided without coordination. Spill frequency and volume generally decreased with both increased storage and coordination across all water year types. Off-peak generation at White Rock Powerhouse typically increased a few tenths of a percent and Chili Bar Powerhouse generation decreased a similar amount due to coordination, but no consistent or significant effect was associated with increased storage.

Phase 2 of this study would be a feasibility analysis of the costs and benefits of implementing alternatives found to provide reasonable benefits during the Phase 1 analysis. The results reported here indicate that coordinated operations appear to provide greater benefits than sediment removal or crest-gate installation. Consultation with the Aquatic TWG is the next step. Verification of the current findings should be done when the CHEOPS™ Model is reconfigured with protection, mitigation & enhancement measures instead of the Base Case conditions.

1.0 INTRODUCTION

This technical report is one in a series of reports prepared by Devine Tarbell and Associates, Inc., (DTA) for the Sacramento Municipal Utility District (SMUD) and Pacific Gas and Electric Company (jointly referred to as the Licensees) to support the relicensings of SMUD's Upper American River Project (UARP) and Pacific Gas and Electric Company's Chili Bar Project. The Licensees intend to append this technical report to their respective applications to the Federal Energy Regulatory Commission (FERC) for new licenses. This report investigates the feasibility, benefits and costs associated with improving water management between the UARP and Chili Bar Project by increasing Chili Bar Reservoir storage capacity using two alternatives: 1) adding a seasonally-operated crest-gate to Chili Bar Dam; and 2) potential sediment removal in Chili Bar Reservoir. This report includes the following sections:

- **BACKGROUND** – Includes when the applicable study plan was approved by the UARP Relicensing Plenary Group; a brief description of the issue questions addressed, in part, by the study plan; the objectives of the study plan; and the study area. In addition, requests by resource agencies for additions to and modifications of this technical report are described in this section.

- **METHODS** – A description of the methods used in the study.
- **RESULTS –** A description of the data obtained during the study.

This technical report does not include a detailed description of the UARP Alternative Licensing Process (ALP) or the UARP, which can be found in the following sections of the Licensee's application for a new license: The UARP Relicensing Process, Exhibit A (Project Description), Exhibit B (Project Operations), and Exhibit C (Construction). Nor does this technical report include a detailed discussion of Pacific Gas and Electric Company's relicensing process or Chili Bar Project.

Also, this technical report does not include a discussion regarding the effects of the UARP and Chili Bar Project on environmental resources, nor does the report include a discussion of appropriate protection, mitigation, and enhancement (PM&E) measures. An impacts discussion regarding the UARP is included in SMUD's applicant-prepared preliminary draft environmental assessment (PDEA) document, which is part of the SMUD's application for a new license for the UARP. Similarly, an impacts discussion regarding the Chili Bar Project will be included in Pacific Gas and Electric Company's Chili Bar Project license application. Development of PM&E measures will occur in settlement discussions in 2004, and will be reported on in the UARP application PDEA and the Chili Bar Project license application.

2.0 BACKGROUND

2.1 Chili Bar Reservoir Incremental Storage Modification Study Plan

On April 7, 2004, the UARP Relicensing Plenary Group approved the Chili Bar Reservoir Incremental Storage Modification Study Plan that was developed by the relicensing Aquatic Technical Working Group (TWG) and approved by the TWG on March 25, 2004. The study plan was developed to address the following issue questions developed by the Plenary Group:

- Has PG&E looked into the alternative of raising Chili Bar Reservoir?

- How does the idea of raising Chili Bar Dam cross-jurisdictional boundaries with the UARP?

- What are viable options for increasing Chili Bar Reservoir storage capacity to allow for more flexibility in the management of flows from the UARP? The study should consider increase in dam height.

The objectives of this study were to:

- Determine if a reasonable increase in storage at Chili Bar Reservoir could result in improvements in water management between the projects that would protect beneficial uses.
- If so, how could this increase in storage best be accomplished?
- Determine whether the cost and other considerations (e.g. generation impacts at White Rock Powerhouse) make the increased storage a viable option compared to operational coordination as an alternative.

The study area included the entire UARP and Chili Bar Project for the purpose of modeling. The feasibility level analysis focused on Chili Bar Dam and Reservoir.

2.2 Water Year Types

As described in the *Water Temperature Technical Report*, the UARP Relicensing Water Balance Model Subcommittee established five water year types to be applied to all preliminary analysis with the understanding that the UARP Relicensing Plenary Group, with cause, may modify the current water year types in the future. This study uses the UARP/Chili Bar Water Balance Model over the entire relicensing period of record.

2.3 Agency Requested Information

The agencies have not requested any specific information be included in this technical report other than the information required by the study plan.

3.0 Methods

The Plenary Group-approved methods included two phases: 1) an analysis of the potential benefits of increasing storage at Chili Bar Reservoir through the use of the UARP/Chili Bar CHEOPS™ Water Balance (Model); and 2) an analysis of the feasibility of such increases in storage. The Licensees' methods were generally consistent with the Plenary Group approved methods. Minor modifications were made to the levels of incremental increases in Chili Bar Dam spillway crest height that were specified in the study plan. These modifications were made to improve the realism and value of the analysis (see Section 3.2 of this report). In addition, the Licensees added an additional task to the Phase I activities of this study. Specifically, PG&E and SMUD performed a bathymetric survey of Chili Bar Reservoir to evaluate the accuracy of the historic capacity table. This bathymetric survey also provided information for the *Chili Bar Reservoir Sediment Deposition Study* (DTA 2004a).

3.1 Phase 1 – Bathymetry Survey

The Chili Bar Reservoir bathymetric survey was conducted by DTA on June 10, 2004 between about 9:00 AM and 1:30 PM. During the survey, the sky was clear and the Chili Bar Reservoir surface elevation decreased by 2.6 feet (ft) from elevation 995.4 ft to 992.8 ft. Chili Bar Reservoir's normal full pool (top of spillway) elevation is 997.5 ft, 2.1 ft above the survey starting elevation.

The survey was performed from an 18-foot-long motor-driven boat using a Standard Communication Corporation DS50 transducer and a Trimble PRO-XRS global positioning system (GPS) unit. The DS50 transducer was mounted to the stern of the boat. The PRO-XRS GPS unit, which included a GPS dome antenna, was connected to the transducer. The accuracy of the DS50 transducer is ± 0.1 foot of depth and the accuracy of the PRO-XRS is less than one meter of linear distance.

Prior to initiating the survey, bottom depth at two locations was manually measured by rope soundings and the results were compared to the DS50 transducer readings at the locations to confirm that the transducer was working accurately (no problems due to salinity, turbidity, etc.).

The GPS unit used a National Maritime Electronics Association (NMEA) data stream from the transducer to embed depth data into the GPS data unit once every 5 seconds. This provided depth data during the survey at a linear sequence of approximately 25-foot-long intervals with the normal boat speed of about 3-4 miles per hour. Data were collected as a GPS line feature.

Survey readings were taken as the boat was driven at about 3-4 miles per hour across the reservoir in transects roughly perpendicular to the longest shoreline, generally a north-south orientation. Transects were spaced roughly 100 to 200 ft apart beginning at the downstream end of the reservoir for a total of 85 transects. Figure 3.1-1, located in Appendix B, shows the specific location of each transect.

As described above, the Chili Bar Reservoir surface elevation decreased by 2.6 ft during the 4.5-hour survey period. To compensate for this change, Pacific Gas and Electric Company provided a spreadsheet to prorate the water depth measured during the survey to the water surface elevation at the time the measurement was made. These spreadsheet data were imported into an Autodesk software package called Field Survey, which was used to create the Chili Bar Reservoir bathymetric map in 2 ft contour intervals. This three-dimensional (length, width and depth) model of Chili Bar Reservoir is shown in Figure 3.1-2 (Appendix B).

In addition, since the survey occurred when the reservoir was between 2.6 and 4.7 ft below full pool, the full pool reservoir shoreline could not be surveyed. To compensate, the shoreline was digitized from a, high-resolution aerial photograph of Chili Bar Reservoir. The shoreline was then assigned the elevation of the water surface (as provide by Pacific Gas and Electric Company) the day and time the photo was taken. This shoreline map and point data were incorporated into the Field Survey software package to develop the Chili Bar Reservoir bathymetric map. The aerial contour was merged with the bathymetric data to create one set of contours. Where bathymetric and shoreline data existed for the same elevation, the shoreline data was used and bathymetric data discarded. This is because the resolution of the aerial data is much better than the bathymetry, especially near the shore where poor GPS satellite reception and depth transducer feedback is common. Reservoir surface area was calculated from this corrected Field Survey map.

To calculate reservoir volume, the Chili Bar Reservoir bathymetric map created by the Field Survey software was imported into AutoDesk's "Land Development Desktop" (LDD) software to create an additional three-dimensional Triangulated Irregular Network (TIN). LDD then used this three dimensional model to cut two-dimensional bands to obtain volumes and surface acres in two-foot contours.

These methods resulted in good coverage for the majority of the Chili Bar Reservoir. However, the survey could not be performed: 1) between the log boom and Chili Bar Dam (boats not allowed in this area due to safety concerns); and 2) in the shallow margins of the reservoir, especially at the most upstream area where the surveys were restricted to the wetted channel. Based on these limitations, DTA believes that the resulting Chili Bar Reservoir volume and surface area estimates are accurate within about 90-95 percent. This accuracy could be improved by surveying the area near the Chili Bar Dam from a boat, and ground surveying the upstream end of the reservoir outside the wetted channel.

3.2 Phase 1 – UARP Water Balance Model

As described in the study plan, the Licensees used the UARP/Chili Bar CHEOPS™ Water Balance Model as a means to evaluate various effects and implications of incremental increases in the storage capacity of Chili Bar Reservoir. The intent of the modeling exercise was to evaluate a variety of different operational or structural changes to the UARP and Chili Bar Project: 1) enhanced operational coordination between the Licensees; 2) increase in spillway crest height to provide additional storage; and 3) potential recovery of lost storage capacity in Chili Bar Reservoir via sediment removal.

The first step in the evaluation process was to modify the CHEOPS™ Model Base Case configuration in accordance with the operational or structural changes. Of particular importance was ensuring the model accurately reflected: 1) different levels of operational coordination between the UARP and Chili Bar Project; 2) the differences in storage associated with the original and the new bathymetry. Furthermore, in relation to spillway crest increases, it was important that the Model accurately reflected a new storage-elevation relationship; and 3) the spillway elevation-discharge relationship. The specific modifications made to the base case configuration are presented in the following subsections, beginning with a general discussion of the base case configuration as it relates to the lower developments of the UARP and to Chili Bar Project.

3.2.1 Description of CHEOPS™ Base Case

The CHEOPS™ Model was originally designed to evaluate how the operation of the UARP and Chili Bar Project might change under various scenarios proposed by members of the UARP ALP. The basic model includes separate modules for all UARP reservoirs and powerhouses as well as Chili Bar Reservoir and powerhouse. Hydrologic input to the model consists of a series of daily stream flows from calendar years 1975 through 2000.

The Licensees, in cooperation with participants to the Water Balance Model Subcommittee (WBMS), developed a B*ase Case* scenario that consists of a series of input variables and assumptions that dictate a regime of reservoir and powerhouse operations, minimum flow releases, and whitewater boating releases into the Reach Downstream of Chili Bar. Many of these operating assumptions and input variables were configured in the Model as target values and/or thresholds, and were based on a combination of historical operations and current-day intent. In general, the modeling paradigm for the Base Case reflects the notion that if the present license conditions are unchanged, and the same 26-year sequence of hydrologic conditions recurs, the Model output represents the expected approximate performance of both the UARP and Chili Bar Project.

The Base Case CHEOPS™ Model run has been designated *R01-BaseCase.* It was presented to the WBMS on September 27, 2004, and incorporates amendments and corrections made to the Model after the previous base case results presentation of June 28, 2004. The original Model run is described in detail in the document entitled *Operation Modeling Assumptions – Base Case* dated June 28, 2004.

Key relevant features of the Base Case run configuration include:

- The UARP and Chili Bar Project are not operated in a coordinated fashion (this is described in the next section).
- A whitewater boating flow is scheduled most days between May and September. The schedule varies from year to year and by day of the week, depending on water-year type, but the pattern is the same each week in a given year (Table 3.2-1).
- The module for the proposed Iowa Hill Development is turned off.

Table 3.2-1. Whitewater boating release schedule (flow in cfs / duration in hours) incorporated in CHEOPS™ model base case, by day of the week, under four water year type scenarios.

	Total Yearly Inflow to Folsom Lake, as Predicted on April 1			
Day	**< 1,000 TAF**	**1,000–1,500 TAF**	**1,500–2,000 TAF**	**> 2,000 TAF**
Sunday	1200 / 3	1500 / 6	1750 / 8	1750 / 8
Monday	—	1200 / 3	1200 / 6	1500 / 6
Tuesday	—	1200 / 3	1200 / 6	1500 / 6
Wednesday	1200 / 3	1200 / 3	1200 / 6	1500 / 6
Thursday	—	1200 / 3	1200 / 6	1500 / 6
Friday	1200 / 3	1200 / 3	1200 / 6	1500 / 6
Saturday	1200 / 3	1500 / 6	1750 / 8	1750 / 8

Table 3.2-1. Whitewater boating release schedule (flow in cfs / duration in hours) incorporated in CHEOPS™ model base case, by day of the week, under four water year type scenarios.

	Total Yearly Inflow to Folsom Lake, as Predicted on April 1			
Day	**< 1,000 TAF**	**1,000–1,500 TAF**	**1,500–2,000 TAF**	**> 2,000 TAF**
Start Date	26 May	26 May	26 May	1 Mar
End Date	15 Sep	15 Sep	15 Sep	31 Oct

It is important to understand that in these Model runs the water year type changes on April 1 and then remains fixed until the following April 1, and this is a slight simplification of the timing of water year classification that is described above in Section 2.2. The simplification occasionally causes counter-intuitive results due to unusual sequences of water year types. For example, flows during March 1976 are based on the water year type that was established 11 months earlier by the April 1, 1975 forecast. As defined below, 1975 is a ">2,000 TAF" year and 1976 is a "<1,000 TAF" year. Therefore, the model simulates whitewater boating from March 1, 1976, through March 30, 1976, but it discontinues them from April 1, 1976, to May 26, 1976, due to the change to a "<1,000 TAF" water year type. Similar situations may occur in the future due to routine, springtime changes in water year classification, so the 1975 and 1976 case was not considered to be a problem.

3.2.2 Coordinated Operational Mode

As described in the previous section, the Base Case configuration does not reflect coordinated operations between the UARP and Chili Bar Project. Under the Base Case, the UARP is not operated to meet the constraints of base flows and rafting flows in the Reach Downstream of Chili Bar. For this analysis, an option in the Model that allows for an evaluation of the effects of coordinated operation was implemented. Coordination essentially means that CHEOPS™ Models the two projects conjunctively. Since the UARP is upstream of the Chili Bar Project, this generally means that the UARP will support Chili Bar Project operating requirements, and Chili Bar Project operation includes some knowledge of UARP operations.

The CHEOPS™ Model can be configured to implement coordination between the UARP and the Chili Bar Project in several ways. The two ways applied to this analysis are: 1) support by the UARP of minimum streamflow constraints; and 2) support by the UARP of whitewater boating constraints. Table 3.2-2 describes these operational modes used in this evaluation and the base case scenario.

Table 3.2-2. Attributes of CHEOPS™ operational modes with and without coordination relative to minimum flow constraints and whitewater rafting flow targets.

Operational Mode	Minimum Flow Constraint	Whitewater Rafting Constraint
No Coordination, or Lack of Support from UARP (the configuration reflected in base case)	Releases from the UARP (via White Rock Powerhouse) are made without considering impacts on the Chili Bar Project. Chili Bar Powerhouse is operated with no knowledge of future UARP water delivery. Thus, Chili Bar generation may be curtailed so that water is conserved for minimum streamflow releases on future days.	White Rock Powerhouse will not provide additional water for whitewater rafting flow targets. Thus, at the start of each day's water balance computation for Chili Bar Reservoir on whitewater boating days, the model determines if adequate reservoir storage and estimated inflow exists. If so, whitewater boating flow will be provided. Otherwise, it will be canceled.
Coordination, or Support from UARP	The model operates the two projects so that most constraints at Chili Bar Dam are always met. These include minimum streamflow releases and minimum reservoir elevation. Additional generation will be scheduled through White Rock Powerhouse and upstream, if necessary. This does not include avoidance of spill at Chili Bar Dam.	The model will schedule additional generation through White Rock Powerhouse, if needed, so that sufficient water will be available in storage at Chili Bar Reservoir to provide whitewater boating flows the next day.

3.2.3 Storage-Elevation and Spillway Discharge Relationships

Under the CHEOPS™ Model Base Case configuration, the storage-elevation curve for Chili Bar Reservoir reflects the original bathymetry of the reservoir. As described in Section 3.1, the Licensees conducted a detailed bathymetric survey of the reservoir in 2004 to evaluate the amount of storage that has been lost due to sedimentation in Chili Bar Reservoir. An alternate storage-elevation curve was developed from the results of this survey for use in this analysis and is compared with the original-bathymetry curve, as shown in Figure 3.2-1. The difference between the historic and the 2004 bathymetry represents the storage volume that has been lost to operations as a result of natural sediment transport into Chili Bar Reservoir. The survey data suggest a loss of about 250 ac-ft of storage between 984 ft and 995 ft, the normal operating range of the reservoir. To evaluate the benefit to Chili Bar Project operations associated with recovery of the lost storage capacity, the model was run with the "as constructed" bathymetry storage-elevation curve (essentially the base case model run) and with the 2004 bathymetry storage-elevation curve.

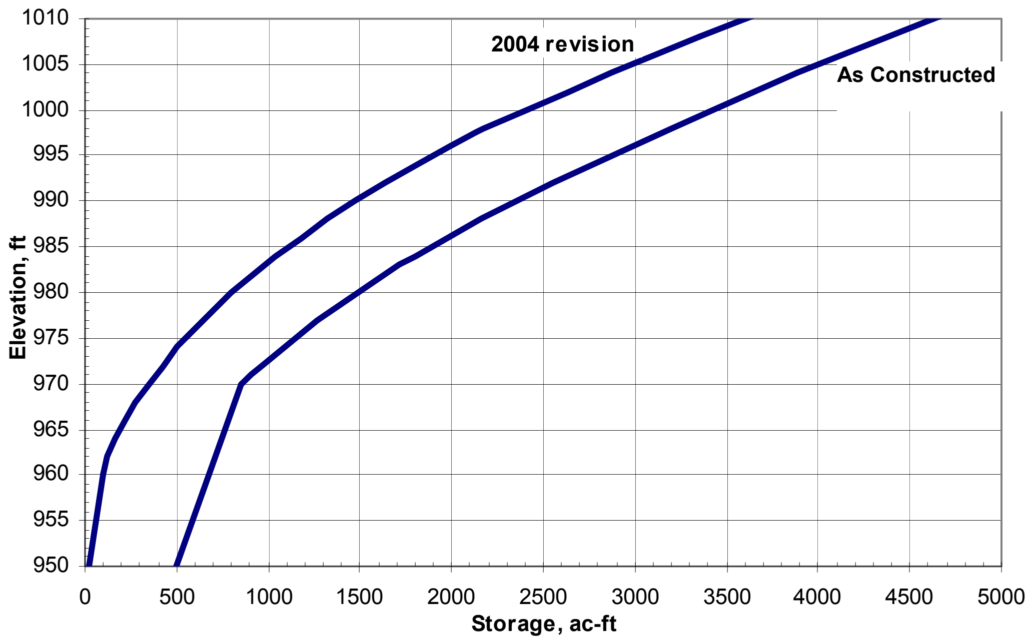


Figure 3.2-1. Chili Bar Reservoir storage-elevation relationship

The other means of increasing storage capacity that was evaluated in this study involves simulating the effect of increasing the elevation of the spillway crest at Chili Bar Dam. To do this, the spillway discharge curve was simply offset upwards by four increments, designated A through D, such that zero discharge occurs until the reservoir level reaches the higher water-surface elevation.

The crest elevations used for this study are listed in Table 3.2-3. Figure 3.2-2 shows plots of the adjusted discharge curves.

Table3.2-3. Chili Bar Dam spillway crest designations evaluate in CHEOPS model.

Designation	Chili Bar Dam Crest Elevation (ft)
Base Case	997.5
A	1,000
B	1,002
C	1,004
D	1,006

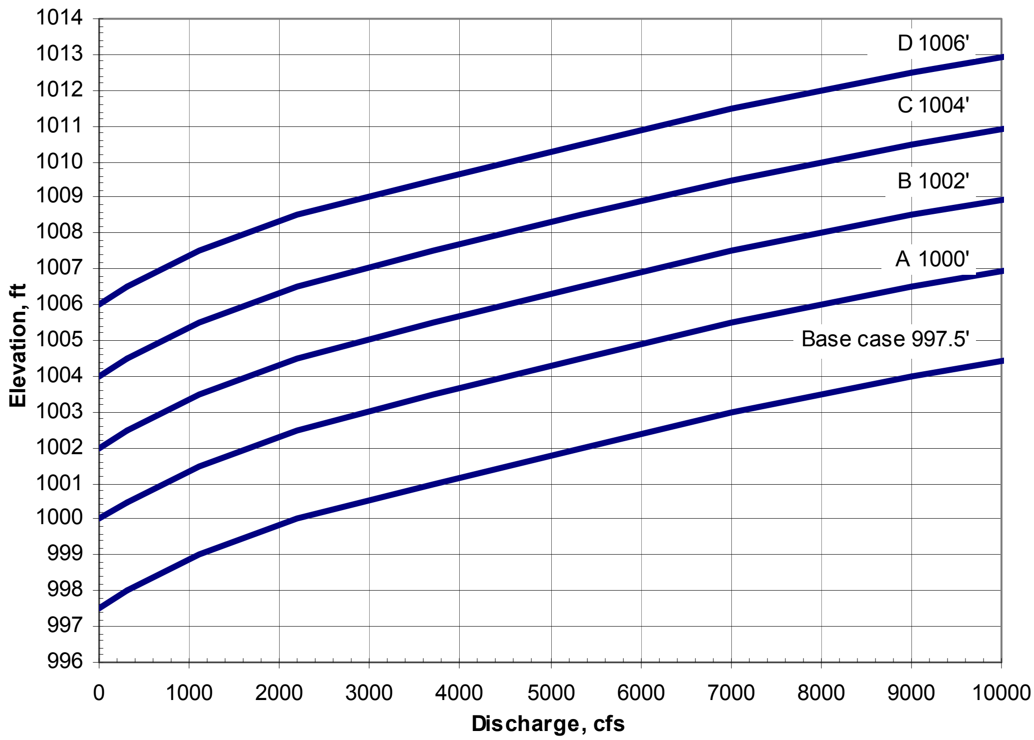


Figure3.2-3. Chili Bar Dam spillway-discharge relationship.

3.2.4 Iowa Hill Pumped Storage Development

Operation of the proposed Iowa Hill Development is not expected to impact the daily schedule of White Rock Powerhouse operations, and the Iowa Hill module was turned off during the runs in this study. With the Iowa Hill Development operating, generation at White Rock Powerhouse would be slightly affected over the Base Case due to changes in Slab Creek Reservoir elevations—the hourly head on the powerhouse turbine would differ from the Base Case scenario. However, the CHEOPS™ Model will generally allocate the same amount of water each day to be run through White Rock Powerhouse with or without Iowa Hill operating.

3.2.5 Description of CHEOPS™ Model Runs

A total of 12 CHEOPS™ Model runs were performed for this study (Table 3.2-4). Each of these Model runs evaluates different aspects of coordination, lost storage capacity, and spillway elevation increases. A summary table of each Model run is provided below. Each Model run is identified with a letter prefix, a two-digit number, and an abbreviated name.

Table 3.2-4. Summary of CHEOPS™ Model runs performed.

Model Run Identification	Operational Model (see Table 3.2-1)	Storage-elevation curve (Figure 3.2-2)	Spillway Crest Elevation (ft)	Usable Storage (ac-ft)[1]
R01-BaseCase	No Coordination	As Constructed	997.5	1,339

Table 3.2-4. Summary of CHEOPS™ Model runs performed.

Model Run Identification	Operational Model (see Table 3.2-1)	Storage-elevation curve (Figure 3.2-2)	Spillway Crest Elevation (ft)	Usable Storage (ac-ft)[1]
C22-BaseRevUn	No Coordination	Revised 2004	997.5	1,088
C23-RevStorAUn	No Coordination	Revised 2004	1,000	1,359
C24-RevStorBUn	No Coordination	Revised 2004	1,002	1,590
C25-RevStorCUn	No Coordination	Revised 2004	1,004	1,826
C26-RevStorDUn	No Coordination	Revised 2004	1,006	2,068
C01-BaseHist	With coordination	As Constructed	997.5	1,339
C02-BaseRev	With coordination	Revised 2004	997.5	1,088
C03-RevStorA	With coordination	Revised 2004	1,000	1,359
C04-RevStorB	With coordination	Revised 2004	1,002	1,590
C05-RevStorC	With coordination	Revised 2004	1,004	1,826
C06-RevStorD	With coordination	Revised 2004	1,006	2,068

[1]Usable storage is the volume between the spillway crest and elevation 984'

Comparisons of different model runs provide an understanding of the effects of various operational/structural changes. For example, a comparison of model runs R01 and C22 reveals the differences associated with the lost storage in Chili Bar Reservoir, as the R01 represents the "as constructed" bathymetry while C22 represents the revised 2004 bathymetry. Both these Model runs represent no operational coordination between the Licensees. A similar comparison of as constructed vs. 2004 bathymetry can be evaluated under a coordinated operations scenario by reviewing Model runs C01 and C02. The effects of incremental increases in spillway elevation can be evaluated with and without UARP and Chili Bar Project coordination by comparing the A, B, C, and D storage levels to their respective unaltered storage runs, C22 and C02 respectively.

3.2.6 Chili Bar Reservoir Impact on White Rock Powerhouse

One of the options considered in this analysis is raising the spillway at Chili Bar Dam. A higher spillway crest could cause the water surface elevation of Chili Bar Reservoir to stay longer at a higher elevation than it does now.

SMUD's White Rock Powerhouse is situated at the upstream end of Chili Bar Reservoir. The powerhouse tailrace invert is near 992 ft elevation. Whenever Chili Bar Reservoir's elevation is above this level, the White Rock Powerhouse turbine discharge elevation is the same as the elevation of Chili Bar Reservoir. The head across the turbines influences the power output of the turbines and hence the generators' output.

Therefore, raising the spillway crest at Chili Bar Dam will impact the power generation at White Rock Powerhouse to some extent. This is evaluated by examining the performance of the turbines at White Rock Powerhouse and comparing Chili Bar Reservoir elevation with the on-peak schedule at White Rock Powerhouse.

3.3 Phase 2 – Feasibility Analysis

In Phase 2, Feasibility Analysis, the Licensees would focus on alternatives to increase usable storage in Chili Bar Reservoir to a level that the Phase One analysis indicated provided reasonable benefits. Options would include adding a seasonally-operated crest-gate to the Chili Bar Dam Spillway and sediment removal in Chili Bar Reservoir. The analysis would include dam safety, financial feasibility and environmental considerations (i.e. permitting, impacts, effects on privately owned lands and impacts due to inundation of additional riverine habitat upstream of Chili Bar Reservoir); jurisdictional implications (i.e. effect on BLM and private land, and impacts on the UARP facilities); effects on electrical generation at the White Rock and Chili Bar powerhouses; and approximate costs of the various alternatives. The feasibility analysis could use results from the *Chili Bar Reservoir Sediment Deposition Technical Report* and other engineering investigations to better assess potential impacts caused by the inundation of the White Rock Powerhouse tailrace, and could also include operational coordination approaches. The analysis would consist of a comparison of the frequency and magnitude of spills and volume of available water between each model run and the current operating assumptions, and an evaluation of the approximate cost to achieve the alternative presumed by each model run. The evaluation would also compare the cost of providing similar water management benefits in the Reach Downstream of Chili Bar through coordinated operations between White Rock Powerhouse and Chili Bar Powerhouse with the cost of achieving those benefits through modifications to Chili Bar Dam or removal of sediment from Chili Bar Reservoir.

4.0 RESULTS

Results for Phase 1 (evaluation of effects and alternatives through the use of the UARP/Chili Bar Project water balance mode) are presented in Sections 4.1 through 4.3. As per the study plan, Phase 2 results (a feasibility study on costs, permitting, and engineering issues of implementation of an identified alternative) will be developed if the Phase 1 results and conclusions reached in consultation with the Aquatic TWG, indicate that further feasibility analysis should be performed.

4.1 Reservoir Bathymetry

Based on the Chili Bar Reservoir bathymetry, DTA calculated reservoir volume in two-foot-contours from the bottom of the reservoir to normal full pool elevation and compared these data to similar data from 1965 Chili Bar Reservoir data, as constructed (Table 4.1-1). Based on these data and the fact that Pacific Gas and Electric Company has never dredged Chili Bar Reservoir and assuming that the 1965 data are accurate, one could conclude that since Chili Bar Reservoir was impounded in 1963, total storage has been reduced by 1,011 ac-ft (from 3,139 ac-ft to 2,128 ac-ft), and usable storage (between el. 997.5 ft and 984 ft) has been reduced by 252 ac-ft (from 1,340 ac-ft to 1,088 ac-ft) - about 407,000 cubic yards.

Table 4.1-1. Chili Bar Reservoir volume comparison between 1965 data as constructed and 2004 bathymetry survey.

Elevation	Volume (ac-ft)		
	1965 As-Built Drawings	2004 Bathymetry Survey	Difference
997.5[a]	3,139	2,128	1,011
996	2,976	1,990	986
994	2,763	1,812	951
992	2,555	1,640	915
990	2,353	1,475	878
988	2,159	1,320	839
986	1,974	1,175	799
984[b]	1,800	1,040	760
982	1,635	915	729
980	1,480	800	680
978	1,335	694	641
976	1,200	596	604
974	1,074	506	568
972	958	423	535
970	853	346	507
968	754	275	479
966	660	216	444
964	571	166	405
962	486	125	361
960	406	93	313
958	332	68	264
956	266	49	217
954	207	35	172
952[c]	156	25	131
950	112	17	95
948	76	12	64
946	47	7	40
944	26	4	22
942	13	2	11
940	7	1	6
938	5	0	5
924.4[d]	0	0	0

[a] Normal full pool elevation at top of spillway.
[b] Pacific Gas and Electric Company's minimum routine operating elevation.
[c] Invert elevation of Chili Bar Powerhouse intake.
[d] Invert elevation of low level outlet.

4.2 Incremental Storage Analysis CHEOPS™ Modeling

The Aquatic TWG phrased the objectives of the study in terms of improvements in water management that might result from increased storage. Two of the desired improvements were more reliable provision of whitewater boating releases during the summer months and reductions in spill at Chili Bar Dam during the summer boating season. Spill reduction could both allow more water to be devoted to whitewater boating releases as well as possible improving aquatic ecosystem conditions. To this end, the results of the 12 CHEOPS™ Model runs were evaluated relative to their effect on these two key variables in the model output, plus another variable of keen interest to the Licensees:

1. The number of whitewater boating days provided in the Reach Downstream of Chili Bar.
2. The volume of spill from Chili Bar Reservoir and the number of days it occurred.
3. Changes in relative amount of off-peak generation at White Rock and Chili Bar powerhouses.

The results were evaluated for the entire modeling period of 1975–2000, and by water year type. The current license conditions for water-year type were used in this analysis. The water year types for each year in the period of record are defined in Table 4.2-1

Table 4.2-1. Water Year Types and Associated Years, 1975–2000

Runoff Range (TAF)	Associated Water Years
< 1,000	1976, 1977, 1988, 1994
1,000–1,500	1981, 1987, 1990, 1991, 1992
1,500–2,000	1979, 1985
> 2,000	1975, 1978, 1980, 1982, 1983, 1984, 1986, 1989, 1993, 1995, 1996, 1997, 1998, 1999, 2000

It is important to emphasize that the water year type used for each year in this analysis is determined from the April 1 runoff forecast, and that in this study, that water year classification remains current until the April 1 runoff forecast of the following year.

The modeling results are summarized in Table 4.2-2. In this table, results are grouped by water year type. Column 1 identifies the CHEOPS™ model run, as defined in Table 3.2-4. Columns 2 and 3 describe the whitewater boating days scheduled and actually provided, respectively. Columns 4 and 5 list the volume and the number of days of Type II spill that occur during scheduled boating days. These data are totals for all of the years that fall in the water year type listed: they are not averages. Columns 6 and 7 show power generation at White Rock and Chili Bar powerhouses expressed as percentage occurring off-peak during the months of June through September.

4.2.1 Whitewater Boating Days

The WBMS approved a schedule of whitewater boating flows and durations on September 27, 2004. All Model runs use this schedule (see Table 3.2-1).

When the Model is run in the coordination mode with support of whitewater boating, the whitewater boating flows are always provided as scheduled as long as sufficient volume is available in Slab Creek Reservoir. The volume to be delivered from Slab Creek Reservoir to Chili Bar Reservoir keeps the water surface elevation of Chili Bar Reservoir above its minimum target level of 984 ft. Operation of Camino Powerhouse and other upstream facilities is not modified by the model to provide whitewater boating volume.

When the model is run without whitewater boating support, the whitewater boating flows are provided only when certain criteria are met at Chili Bar Reservoir for the upcoming day. These criteria include an estimated mean daily inflow of at least 200 cfs and a midnight elevation of at least 992 ft. These thresholds were chosen so that storage is likely to be adequate to make several subsequent days of minimum streamflow release in the event that White Rock Powerhouse does not operate. If both criteria are met, whitewater boating flows are provided as scheduled.

Columns 2 and 3 of Table 4.2-2 summarize the boating flow statistics for each of the model runs. Examination of the 1975-2000 total record shows modest changes in the number of boating days provided associated with increasing storage in the uncoordinated operation of the reservoir. The results show a drop for 82% to 76% when the decreased usable storage is accounted for in the revised storage curve based on the new bathymetry. The results also show that with coordinated operations, 100% of the scheduled boating days are provided. A similar pattern is displayed when the total record is disaggregated into the current four water year types.

4.2.2 Chili Bar Reservoir Spill

Another important Model result is the change in frequency and volume of spill at Chili Bar Reservoir between the different Model runs. Within the CHEOPS™ Model, Chili Bar Reservoir spills water for two reasons, referred to in this report as Type I and Type II.

Type I — Total inflow during the day exceeds the capability of the Chili Bar Reservoir to regulate the inflow, even with the powerhouse operating at full flow capacity. This occurs primarily during the spring snowmelt season, but it also occurs during winter storm events of sufficient magnitude.

Type II — The hourly timing of inflow during the day does not coincide with the scheduled generation at Chili Bar Powerhouse. This occurs when White Rock Powerhouse provides a large on-peak inflow, Chili Bar Reservoir is nearly full, and the model either schedules Chili Bar Powerhouse generation at a level below its maximum flow or the inflow from White Rock Powerhouse exceeds Chili Bar Powerhouse capacity.

Spilled water represents an economic loss to Pacific Gas and Electric Company and potentially to SMUD as well. The following method was used to classify each daily spill event as either Type I or Type II:

- A day's spill was classified as Type I if the total outflow volume exceeded the capacity of Chili Bar Powerhouse, or approximately 4,000 ac-ft. In other words, at least some of the volume would have spilled even with the powerhouse running at full capacity all day.

- A day's spill was classified as Type II if the total outflow volume was less than the capacity of Chili Bar Powerhouse. In this case, the CHEOPS™ model allocated flow through the powerhouse below its capacity for part of or all of the day, and as a result, some of the inflow spilled.

A review of the modeling results (not included here) reveals that raising the spillway crest does not alleviate Type I spill. This type of spill occurs during periods of high runoff, typically in winter and spring, and is not affected by the relatively small amount of storage in Chili Bar Reservoir. For example, raising the spillway to 1,006 ft adds about 1,000 ac-ft of active storage. Type I spill occurring in a typical multi-week snowmelt spill event exceeds 1,000 ac-ft per day; so this extra storage would alleviate only one day's spill. Because the purpose of this report is to assess the effect on the provision of whitewater boating between June and September associated with changes in storage in Chili Bar Reservoir, this report focuses on Type II spill.

Type II spill events occur for three principal reasons:

1. When White Rock and Chili Bar powerhouses are not being operated in a coordinated fashion, Chili Bar Reservoir must be operated conservatively and maintain a large storage reserve at the end of each day's inflow. (If Chili Bar Reservoir were to not have a storage reserve and not have inflow from White Rock Powerhouse for several days, Chili Bar Reservoir might be unable to fulfill its minimum streamflow release requirement on subsequent days.) When large or unscheduled inflows occur, spills result.

2. Chili Bar Powerhouse is operating with coordination and thus with the expectation of inflow from White Rock Powerhouse, but discharge from White Rock exceeds Chili Bar Powerhouse's flow capacity. In order to avert spill at Chili Bar Dam under this condition, the model would have to curtail White Rock Powerhouse generation. The model is not configured to curtail White Rock Powerhouse generation in these runs.

3. With coordinated operation, the Licensees would schedule water on a daily basis, and CHEOPS™ also does a similar scheduling process. The Model decides on the volume of water to be released from Chili Bar Powerhouse on a midnight-to-midnight basis. Furthermore, Chili Bar Powerhouse has a ramping rate restriction of approximately 550 cfs per hour. When it computes the 15-minute release hydrograph, the model fails to begin increasing Chili Bar Powerhouse release sufficiently far in advance so that it arrives at full flow capacity in time to route the spill volume through the powerhouse.

The results in Columns 4 and 5 of Table 4.2-2 show that the water year type significantly affects spill volumes and days. In the three dryer water year types (i.e., years of <2,000 TAF inflow to Folsom Reservoir), the volume and number of days of spill are very low. For example, the five years that represent the 1,000-1,500 TAF class are predicted to experience a cumulative total of only 4 days of Type 1 spill under the coordinated operation and 2004 bathymetry condition (C02-BaseRev). This equates to 1 day of spill a year on average, although a close scrutiny of the model output reveals that three of the five years experienced no spills and the remaining two had all four days of spill. The corresponding 5-year cumulative volume of water spilled was 2,300 ac-ft, which is also a very small volume. There is little difference between uncoordinated and coordinated operation results in the dryer water year types due to incremental storage increases. Coordinated operations yield a reduction in spill volume and days when comparing the change in bathymetry curves during the three dryer water year types (comparing C22-BaseRevUn with C02-BaseRev).

The low frequency of spill during the drier water years is the result of low daily water volume that is released from the UARP reservoirs during summer of these years. The low daily water volume is a direct result of limited runoff, which often leads to the three UARP storage reservoirs not attaining the full pool of the target storage curves. Under this circumstance the model implements conservative water management practices in an attempt to regain the target storage levels and ensure carryover storage for the next year. This results in the scheduling of low daily water volumes through the UARP system, which are in turn passed through Chili Bar Reservoir without creating a spill.

Most of the Type II spill occurs during the wettest water year class, which is during the 15 years in which Folsom inflow exceeds 2,000 TAF. This increased incidence of spill in these years is predominantly due to the large runoff volumes from snowmelt that often continue into June. In these years, the runoff is sufficient to meet the UARP reservoir target elevations and even exceed them. More water is available to schedule on a daily basis, and when the target storage elevations have been exceeded, an even larger volume of water is scheduled in order to regain the target levels. This increased scheduling is at its peak during the end of the runoff period, generally which is typically during the month of June.

With the current Chili Bar Reservoir storage volume and without coordinated operation, the model predicts 371 days of spill events that comprise a cumulative volume of 122,500 ac-ft of water (C22-BaseRevUn). With coordinated operation and 2004 bathymetry (C02-BaseRev), the model predicts a cumulative total of 218 spill days and 110,300 ac-ft of water for the 15 water years that comprise the wet water year types. This equates to an average of 14 days a year. Representative C02-BaseRev hourly times series plots of Chili Bar Powerhouse releases volumes and spill flows are provided in Appendix A for three typical wet years (1984, 1993, and 1997). These plots, which span the period of June 1 through September 30, show the relatively infrequent character of the Type II spill events. In general the majority of the spill events occur in the month of June, with far fewer events occurring in the other summer months. Dredging Chili Bar Reservoir (C01-BaseHist) results in an 8 percent reduction in the cumulative spill events and a 13 percent reduction in cumulative spill volume. Similarly, incremental increases in storage volume result in gradual decreases in cumulative spill days and volume, but do not eliminate spill altogether.

4.2.3 Off-peak generation

The CHEOPS™ Model first allocates a volume of water to be diverted through each powerhouse each day. It starts with the upper reservoirs in the UARP and finishes with Chili Bar Powerhouse.

Next, within each day, the CHEOPS™ Model schedules power generation during the peak hours of the day. This accommodates all or part of the scheduled water for the day. Generally, with increased demands for minimum flow and whitewater boating in the Reach Downstream of Chili Bar, Chili Bar and White Rock powerhouses must divert increased water to the off-peak period. Shifting of water from on-peak to off-peak generation represents an economic loss to the Licensees—but a less severe loss than spill.

The results in Columns 6 and 7 show the changes in off-peak generation at White Rock and Chili Bar powerhouses associated with the changes in bathymetry and storage change increments for the total record and by water year type. As with the spill analysis, water year type has a strong effect on off-peak generation at both powerhouses, and much more off-peak generation occurs in the wettest water year type. In the two driest water year types, coordinated operations cause a slight increase in off-peak generation at White Rock Powerhouse and a slight decrease in off-peak generation at Chili Bar Powerhouse. For the 1,500 – 2,000 TAF water year type, there is a slight decrease in off-peak generation at both White Rock and Chili Bar powerhouses due to coordinated operation. In the most common (15 of 27 years), > 2,000 TAF water year type, coordination causes a slight decrease in off-peak generation, and incremental storage increases in both uncoordinated and coordinated cases provide no appreciable change in off-peak generation.

4.2.4 Summary

The value of coordinated operation between the UARP and Chili Bar Project is demonstrated in the results of the CHEOPS™ modeling. Coordinated operation provides a greater improvement in the provision of boating days than incremental increases in storage in all water year types. In both coordinated and uncoordinated operation, incremental storage increases do not provide increased boating days. The CHEOPS™-predicted benefits of coordinated operation in providing desired whitewater boating flows were demonstrated by actual events during the summer of 2004. Throughout the summer, SMUD provided PG&E operators with 24 hours projected discharge rates for White Rock discharge. These project rates were updated every hour of the day. This information allowed the Chili Bar Project operators to provide the desired whitewater boating flows throughout the summer and into the fall.

The model results also demonstrated the value of coordinated operations with respect to reducing the spill frequency and volume at Chili Bar Reservoir. Under the scenario of coordinated operation and 2004 bathymetry, the number of spill days was extremely small in dryer water year types and relatively infrequent in wet water year types. Incremental increases in the storage capacity in Chili Bar Reservoir gradually reduced the frequency and volume of spill events but did not eliminate them. Further improvements in coordination are possible beyond what was modeled (changes in the target elevation of Chili Bar Reservoir) and would further decrease summer spill occurrence and volume without the need to increase storage.

Water year type has a more significant effect on the amount of off-peak generation than incremental storage increases, and coordinated operations cause an overall increase in off-peak generation at White Rock Powerhouse but have the opposite effect at Chili Bar Powerhouse compared to uncoordinated operation.

Table 4.2-2. Results of 12 CHEOPS™ Model runs for boating days provided, volume and number of days of Chili Bar Project spill, and changes in off peak power generation at UARP and the Chili Bar Project.

Model run identifier	Boating days scheduled (2)	Boating days provided (3)	Chili Bar spill, Type II (not annualized)		Generation, off peak, June–September	
			Volume, taf (4)	Days (5)	White Rock PH (6)	Chili Bar PH (7)
All water year types (1975–2000)						
R01-BaseCase	4692	82%	81.8	159	3.2%	15.6%
C22-BaseRevUn	4692	76%	130.8	423	3.2%	15.6%
C23-RevStorAUn	4692	84%	81.3	195	3.2%	16.1%
C24-RevStorBUn	4692	85%	61.5	177	3.2%	16.3%
C25-RevStorCUn	4692	86%	39.1	135	3.2%	16.4%
C26-RevStorDUn	4692	86%	25.3	97	3.2%	16.4%
C01-BaseHist	4692	100%	101.1	210	3.4%	15.1%
C02-BaseRev	4692	100%	114.4	234	3.7%	15.3%
C03-RevStorA	4692	100%	85.	184	3.6%	15.4%
C04-RevStorB	4692	100%	74.3	153	3.6%	15.5%
C05-RevStorC	4692	100%	54.5	140	3.6%	15.5%
C06-RevStorD	4692	100%	32.7	81	3.6%	15.5%
Water year type < 1,000 TAF (4 in 1975–2000)						
R01-BaseCase	256	96%	0.5	1	0.0%	5.1%
C22-BaseRevUn	256	82%	1.3	12	0.0%	5.5%
C23-RevStorAUn	256	82%	0.3	1	0.0%	5.8%
C24-RevStorBUn	256	82%	0	0	0.0%	5.8%
C25-RevStorCUn	256	82%	0	0	0.0%	5.8%
C26-RevStorDUn	256	82%	0	0	0.0%	5.8%
C01-BaseHist	256	100%	.4	1	0.0%	5.6%
C02-BaseRev	256	100%	1.	8	0.1%	5.6%
C03-RevStorA	256	100%	0.2	1	0.2%	5.6%
C04-RevStorB	256	100%	0	0	0.2%	5.6%
C05-RevStorC	256	100%	0	0	0.2%	5.6%
C06-RevStorD	256	100%	0	0	0.2%	5.6%
Water year type 1,000–1,500 TAF (5 in 1975–2000)						
R01-BaseCase	565	86%	0.7	1	0.0%	6.5%
C22-BaseRevUn	565	70%	3.2	20	0.0%	7.4%
C23-RevStorAUn	565	72%	1.4	4	0.0%	7.7%
C24-RevStorBUn	565	72%	1.1	2	0.0%	7.8%
C25-RevStorCUn	565	73%	0	0	0.0%	7.8%
C26-RevStorDUn	565	72%	.7	2	0.0%	7.7%
C01-BaseHist	565	100%	2.9	6	0.9%	5.3%
C02-BaseRev	565	100%	2.3	4	1.5%	5.8%
C03-RevStorA	565	100%	1.	3	1.4%	5.8%
C04-RevStorB	565	100%	1.	3	1.4%	5.8%
C05-RevStorC	565	100%	.9	1	1.4%	5.8%
C06-RevStorD	565	100%	1.4	2	1.4%	5.8%
Water year type 1,500–2,000 TAF (2 in 1975–2000)						
R01-BaseCase	226	83%	2.5	6	0.4%	13.8%
C22-BaseRevUn	226	77%	3.8	20	0.4%	13.7%
C23-RevStorAUn	226	82%	1.5	4	0.4%	14.7%
C24-RevStorBUn	226	83%	0.9	3	0.4%	14.4%
C25-RevStorCUn	226	83%	1.0	4	0.4%	14.2%
C26-RevStorDUn	226	84%	0.8	3	0.4%	14.1%

Table 4.2-2. Results of 12 CHEOPS™ Model runs for boating days provided, volume and number of days of Chili Bar Project spill, and changes in off peak power generation at UARP and the Chili Bar Project.

Model run identifier	Boating days scheduled (2)	Boating days provided (3)	Chili Bar spill, Type II (not annualized)		Generation, off peak, June–September	
			Volume, taf (4)	Days (5)	White Rock PH (6)	Chili Bar PH (7)
Water year type 1,500–2,000 TAF (2 in 1975–2000)						
C01-BaseHist	226	100%	1.5	2	0.4%	12.7%
C02-BaseRev	226	100%	.9	4	1.0%	13.1%
C03-RevStorA	226	100%	1.1	2	0.3%	13.3%
C04-RevStorB	226	100%	1.3	3	0.3%	13.4%
C05-RevStorC	226	100%	.8	3	0.3%	13.2%
C06-RevStorD	226	100%	0	0	0.3%	13.3%
Water year type > 2,000 TAF (15 in 1975–2000)						
R01-BaseCase	3645	80%	78.	151	5.5%	21.6%
C22-BaseRevUn	3645	77%	122.5	371	5.5%	21.2%
C23-RevStorAUn	3645	87%	78.1	186	5.6%	21.7%
C24-RevStorBUn	3645	88%	59.4	172	5.6%	22.1%
C25-RevStorCUn	3645	89%	38.2	131	5.6%	22.2%
C26-RevStorDUn	3645	89%	23.9	92	5.6%	22.2%
C01-BaseHist	3645	100%	96.2	201	5.5%	21.1%
C02-BaseRev	3645	100%	110.3	218	5.8%	21.1%
C03-RevStorA	3645	100%	82.6	178	5.6%	21.3%
C04-RevStorB	3645	100%	71.9	147	5.7%	21.5%
C05-RevStorC	3645	100%	52.8	136	5.7%	21.4%
C06-RevStorD	3645	100%	31.3	79	5.7%	21.5%

This summary is based on the changes in the provision of recreation releases, spill volumes and days, and changes in relative off-peak generation, assuming the base case modeling provisions, the current water year types, and the Base Case summer whitewater release schedule. The report has not evaluated other potential benefits or costs that might result from enhanced storage, larger multi-day elevation variations, or changes in White Rock Powerhouse operation so that spill is avoided. When PM&E measures are developed in the relicensing, additional runs of the Model may be warranted. Results from re-runs of C22-BaseRevUn and C02-BaseRev that contain the proposed PM&E's could be evaluated to determine if coordinated operations continue to provide the documented improvements.

4.3 Chili Bar Reservoir Elevation Impact on White Rock Powerhouse

White Rock Powerhouse has two turbine-generator units. The turbine part of each unit provides power to the generator through a shaft. The amount of power is described using a performance or efficiency curve. The efficiency values are a function of head and discharge. Higher efficiency means a greater amount of power extracted per unit of discharge.

The CHEOPS program first allocates a daily total volume of water that must be passed through the White Rock Powerhouse. Then, the program attempts to schedule flow through the turbines at a rate near the peak efficiency of the turbine. This produces the greatest amount of electric power generation per unit of water. The scheduling is constrained by the head across the turbine and the amount of flow allocated that day.

The head across the turbine is considered to be the gross head across the powerhouse, that is, the elevation difference between Slab Creek Reservoir and Chili Bar Reservoir, less a flow-dependent loss. White Rock Powerhouse will therefore generate less energy per unit of water when Chili Bar Reservoir is higher.

4.4 Feasibility Analysis

As specified in the Study Plan, the Phase 2 Feasibility Analysis will be deferred until completion of Phase 1, discussion of the results by the Aquatic TWG, and coordination with the Recreation TWG.

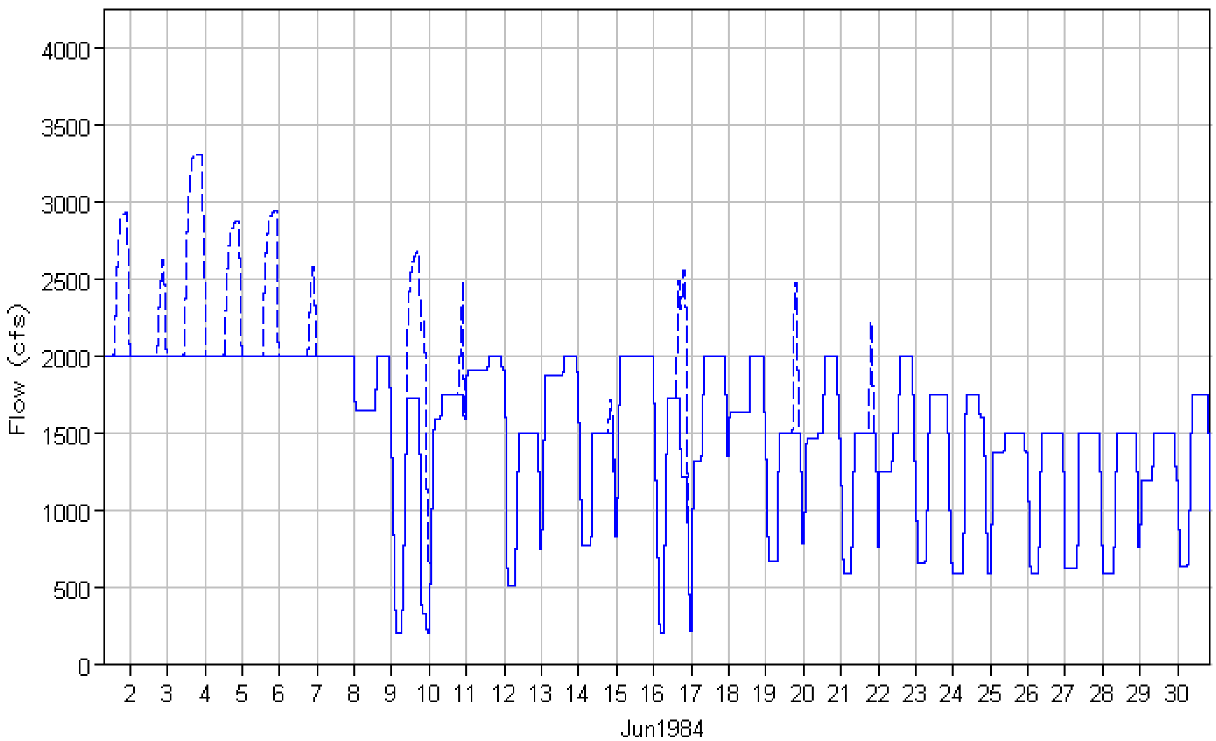
APPENDIX A

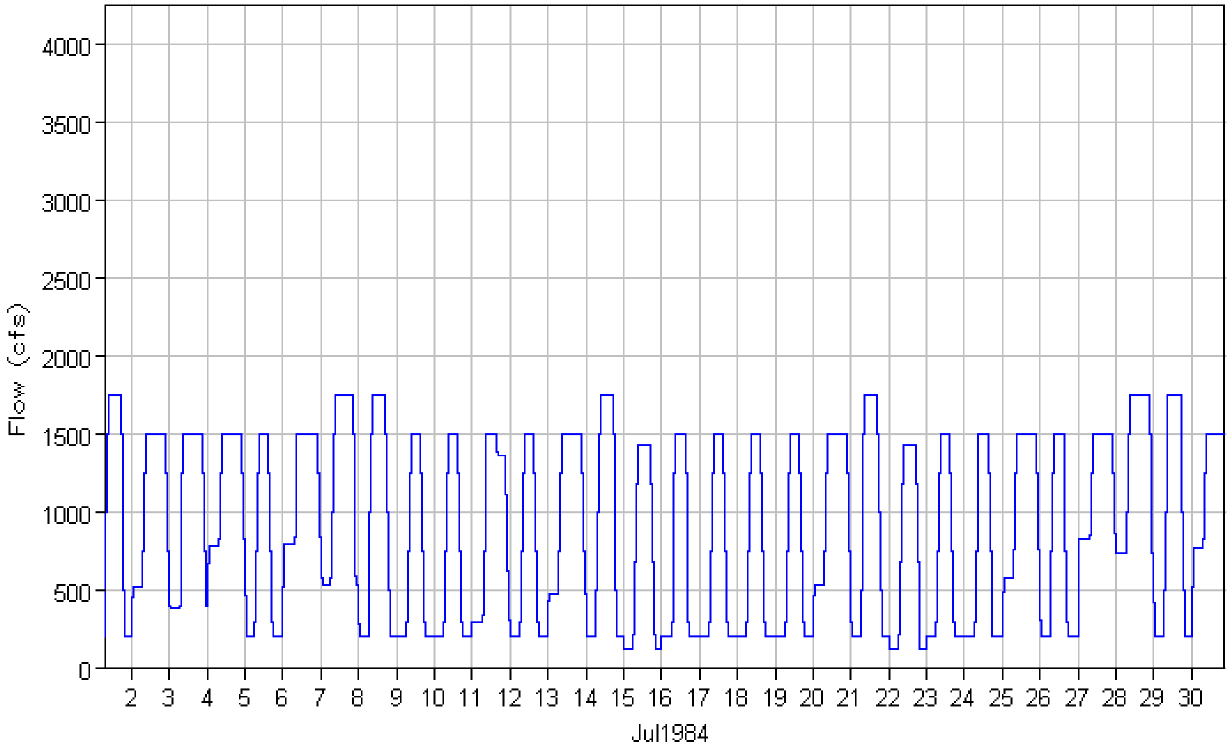
CHEOPS™ HOURLY TIME SERIES DATA PLOTS

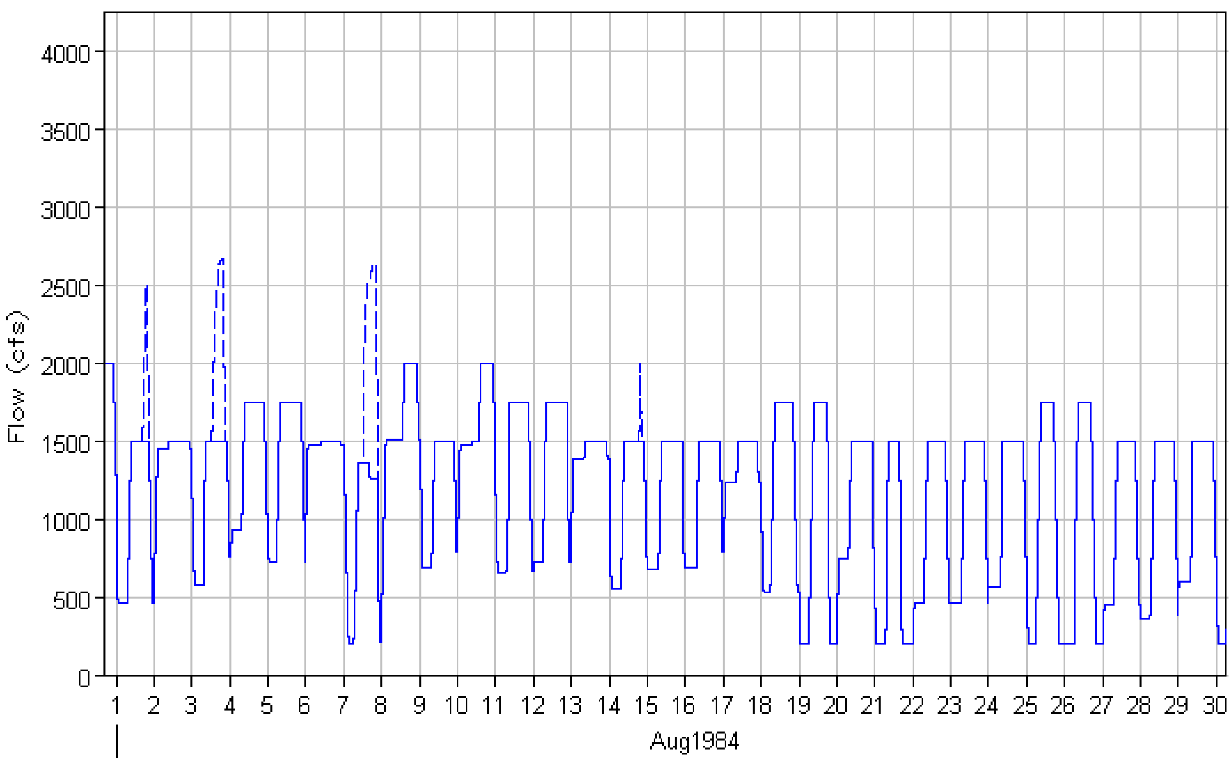
The following pages show plots of hourly time series data from CHEOPS™. They depict flow hydrographs from model run named C02-BaseRev, which used the 2004 capacity curve, coordinated operation, and no raising of the spillway.

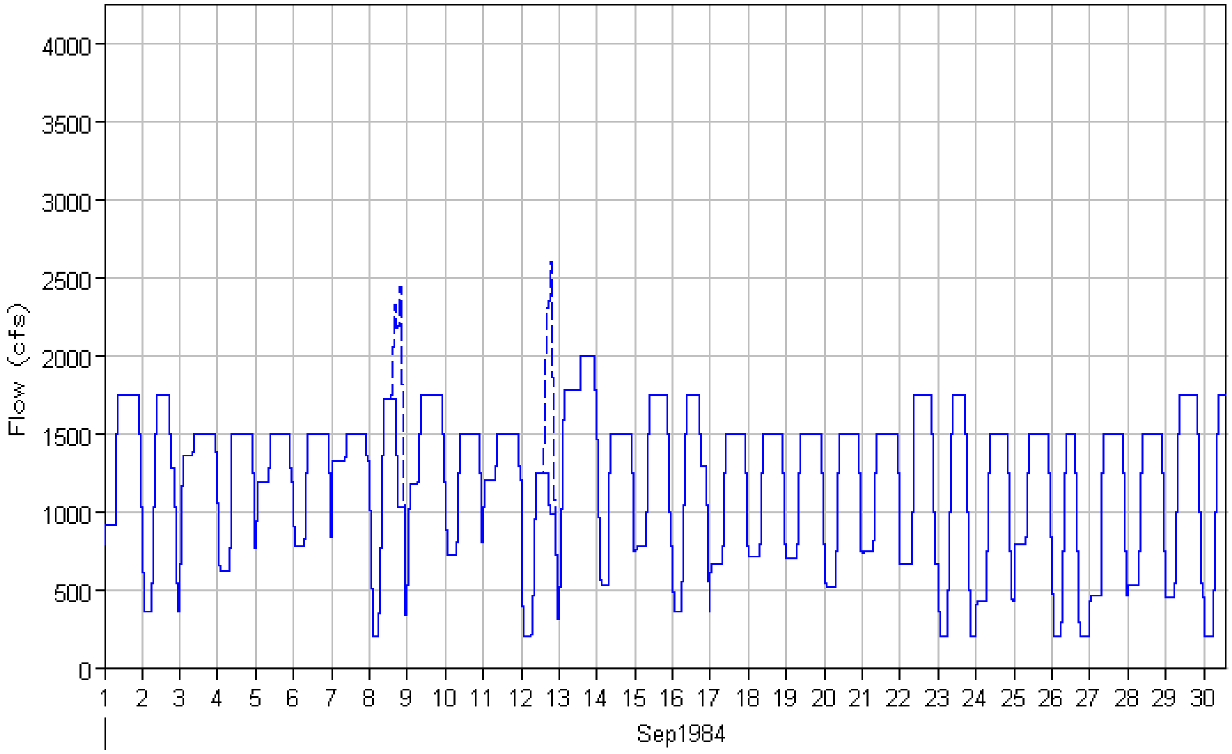
The plots include two traces: the flow through Chili Bar Powerhouse (solid) and the total flow downstream (dashed). The total flow downstream includes flow both the powerhouse and over the spillway. When the dam is not spilling, the total flow trace and the powerhouse flow trace coincide. When the dam is spilling, the total flow trace appears above the powerhouse flow trace.

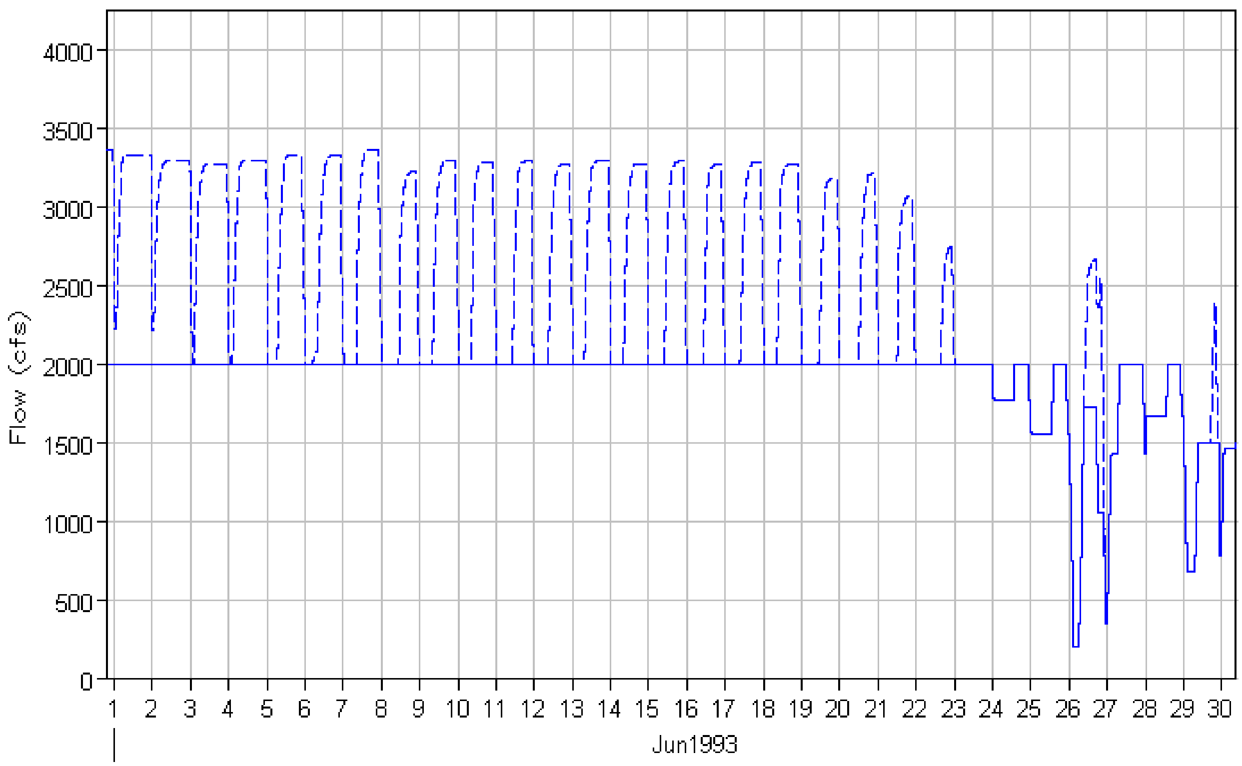
Data from months June through September are plotted, for years 1984, 1993, and 1997. These are all > 2,000 TAF –type years. Across the bottom of each plot is shown the month and year, and the horizontal scale is in days. The vertical scale is in cubic feet per second (cfs).

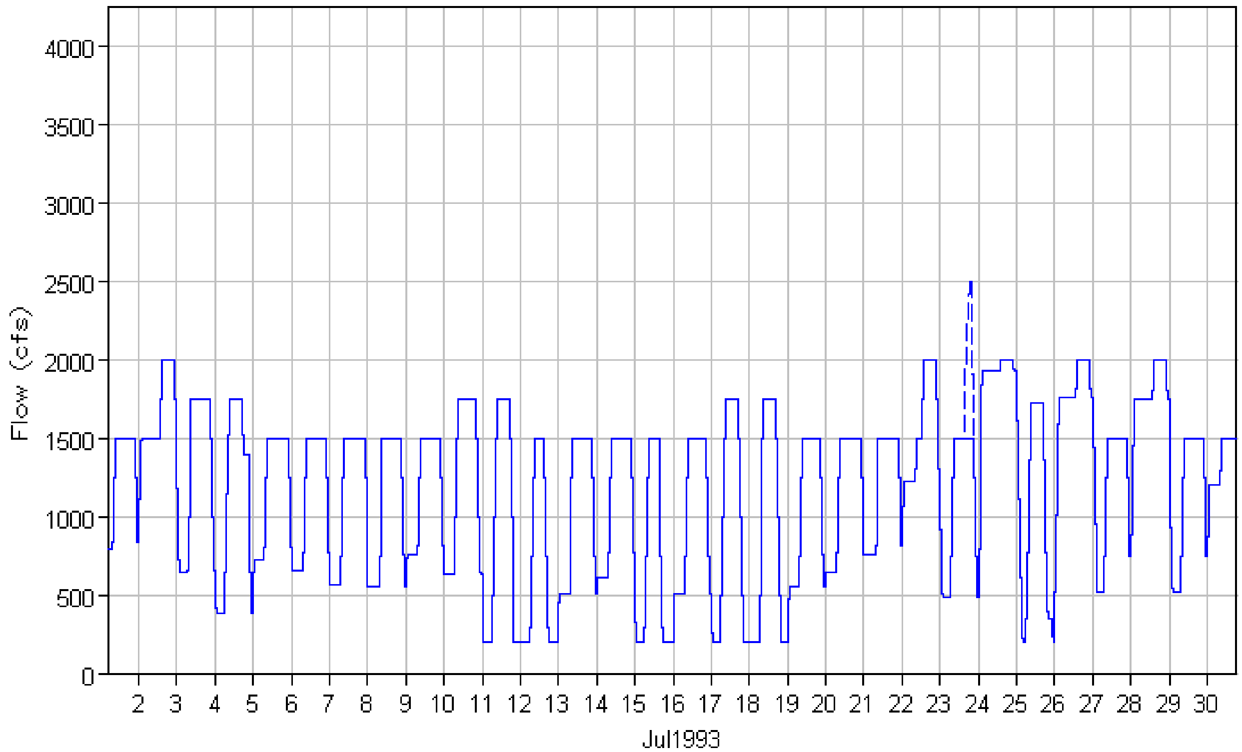


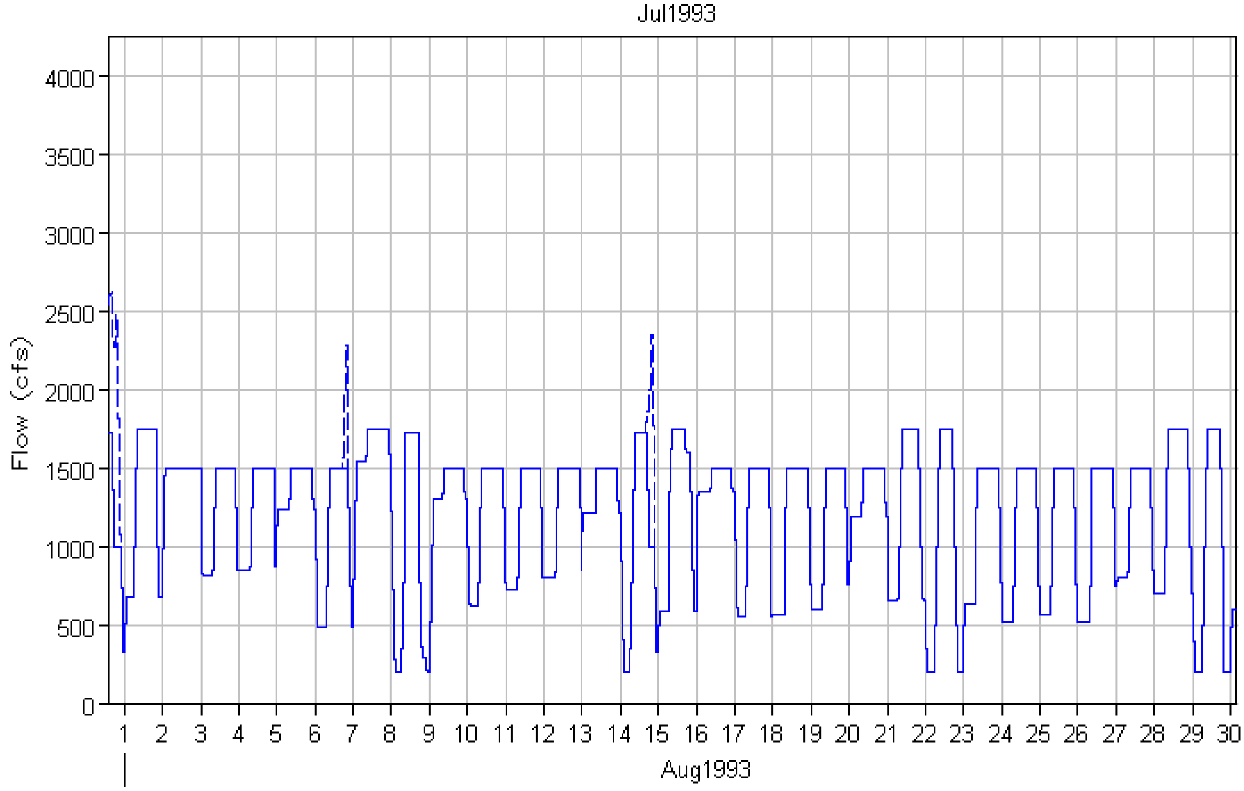

Flow (cfs)
0
500
1000
1500
2000
2500
3000
3500
4000
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Jul1984

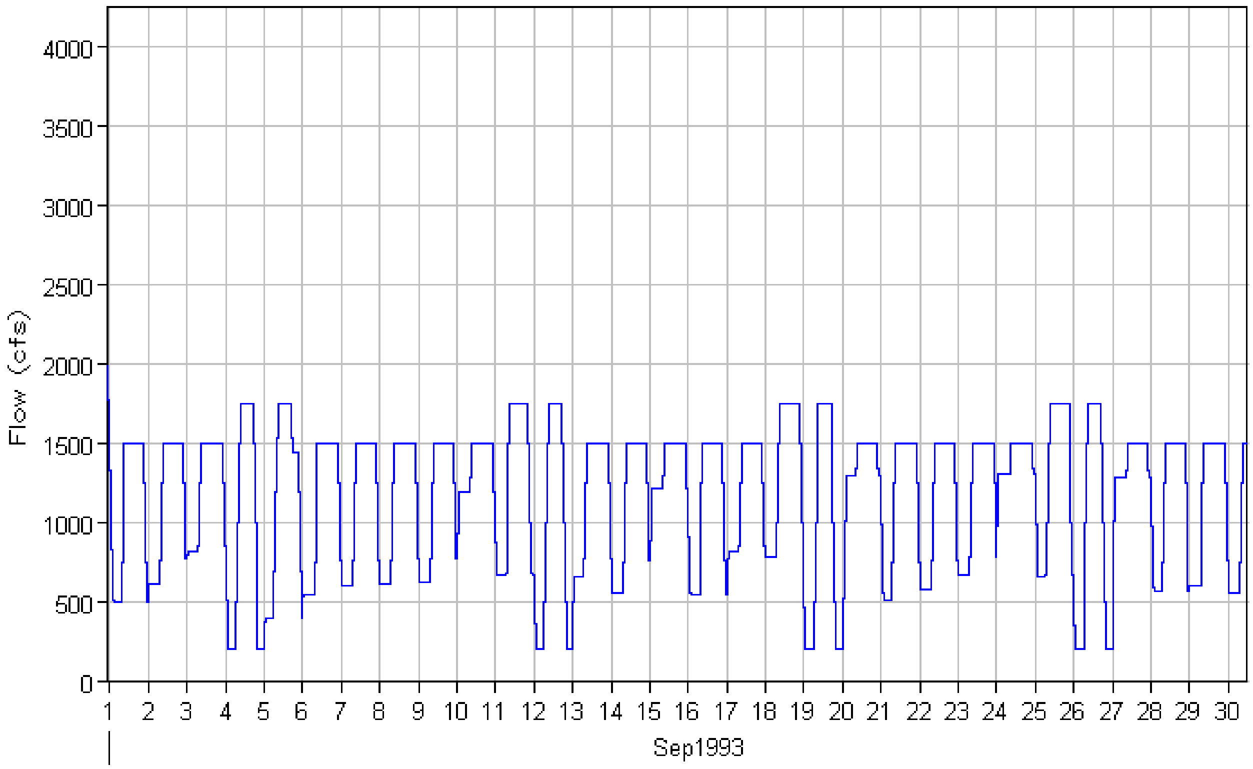

Flow (cfs)
0
500
1000
1500
2000
2500
3000
3500
4000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Aug1984

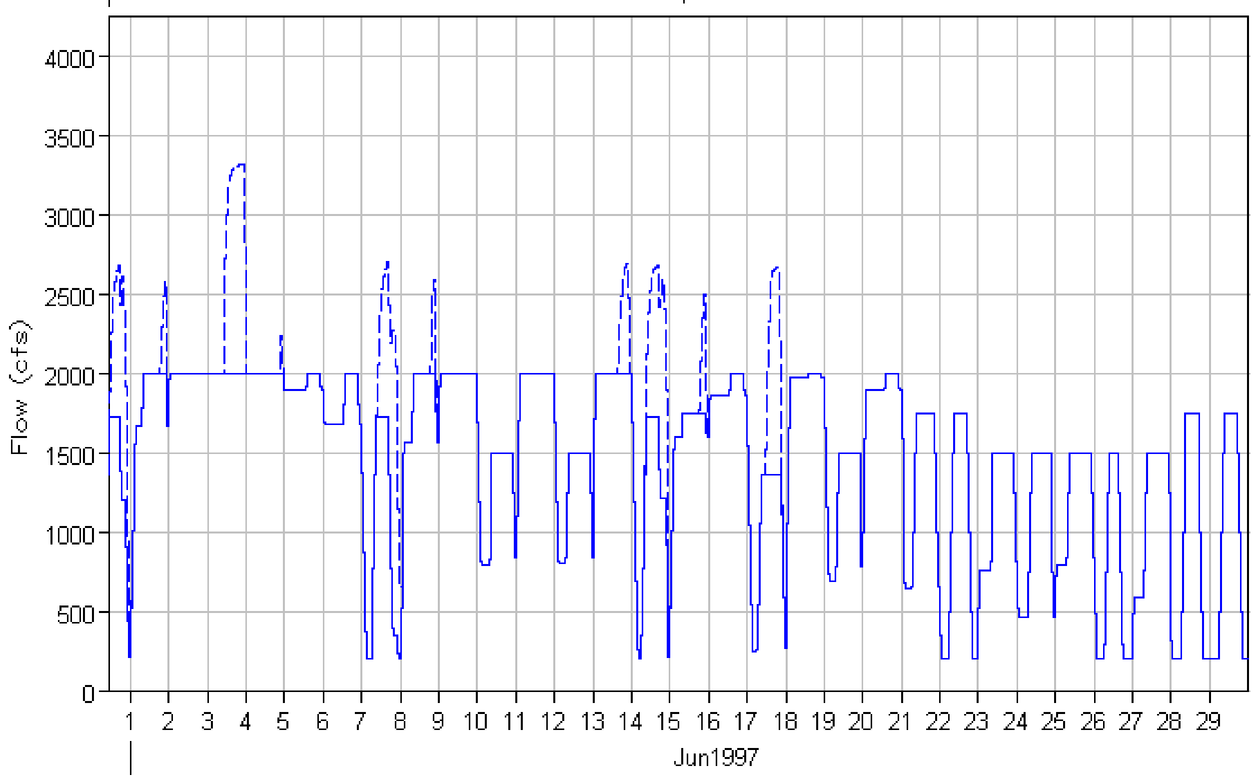

Flow (cfs)
0
500
1000
1500
2000
2500
3000
3500
4000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Sep1984

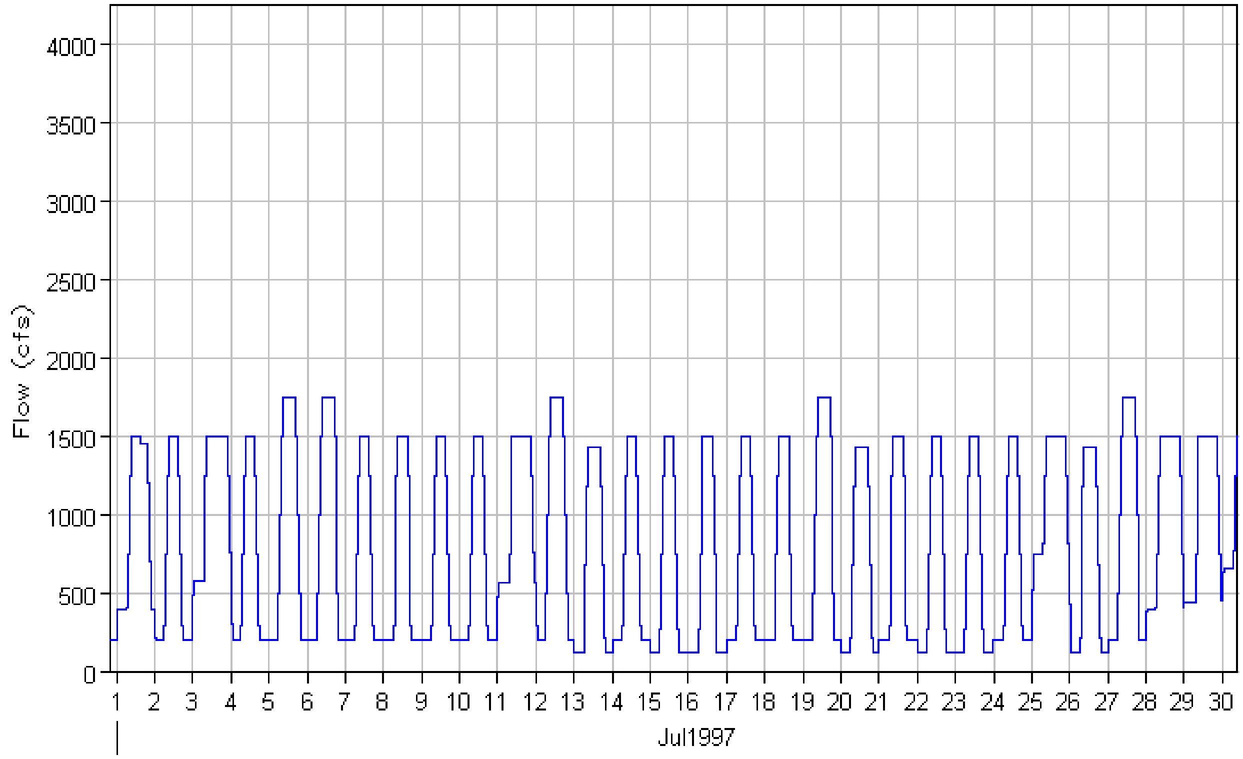

Flow (cfs)
0
500
1000
1500
2000
2500
3000
3500
4000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Jun1993

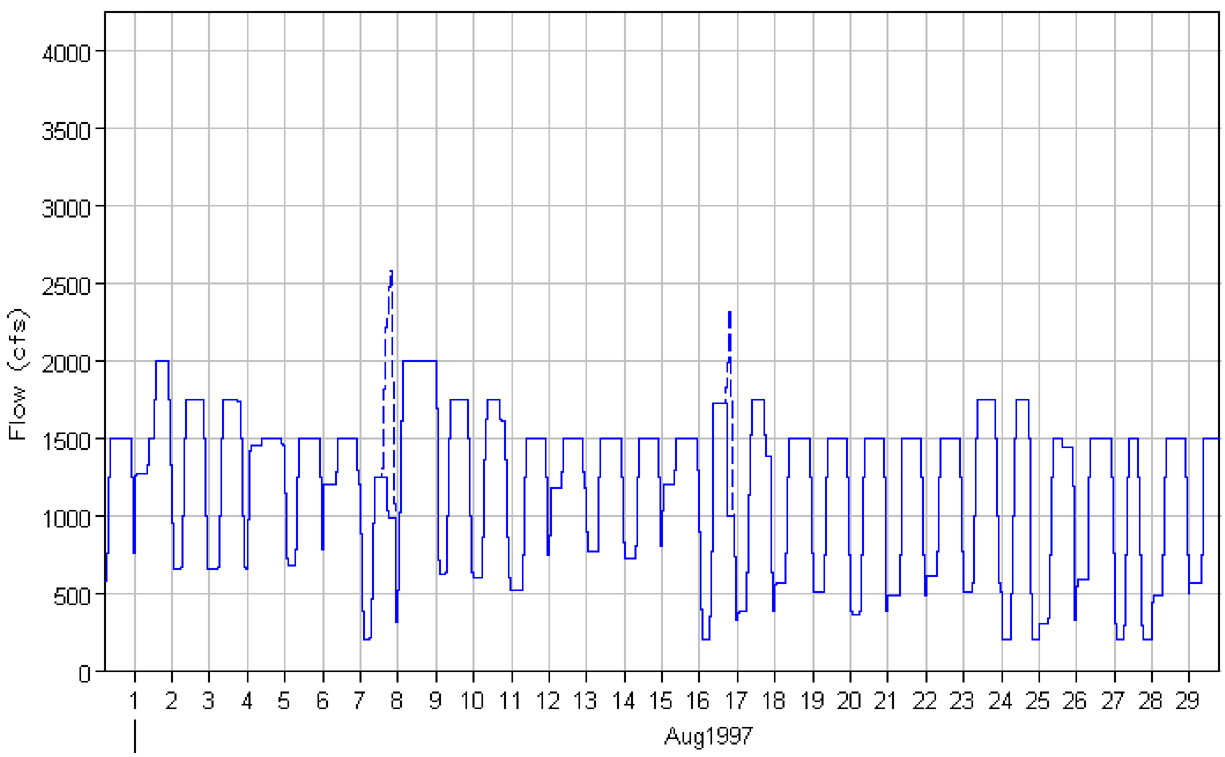

Flow (cfs)
0
500
1000
1500
2000
2500
3000
3500
4000
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Jul1993

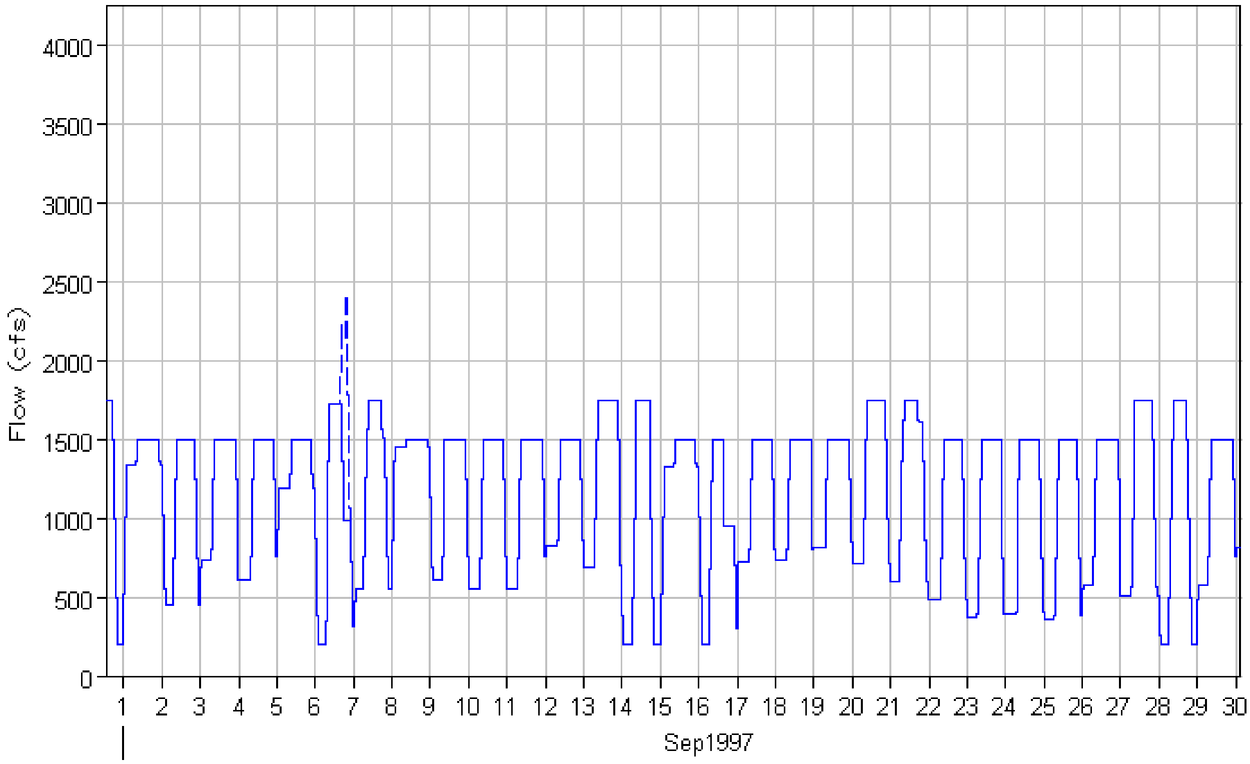

Flow (cfs)
0
500
1000
1500
2000
2500
3000
3500
4000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Aug1993


Flow (cfs)
0
500
1000
1500
2000
2500
3000
3500
4000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Sep1993


Flow (cfs)
0
500
1000
1500
2000
2500
3000
3500
4000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
Jun1997


Flow (cfs)
4000
3500
3000
2500
2000
1500
1000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Jul1997

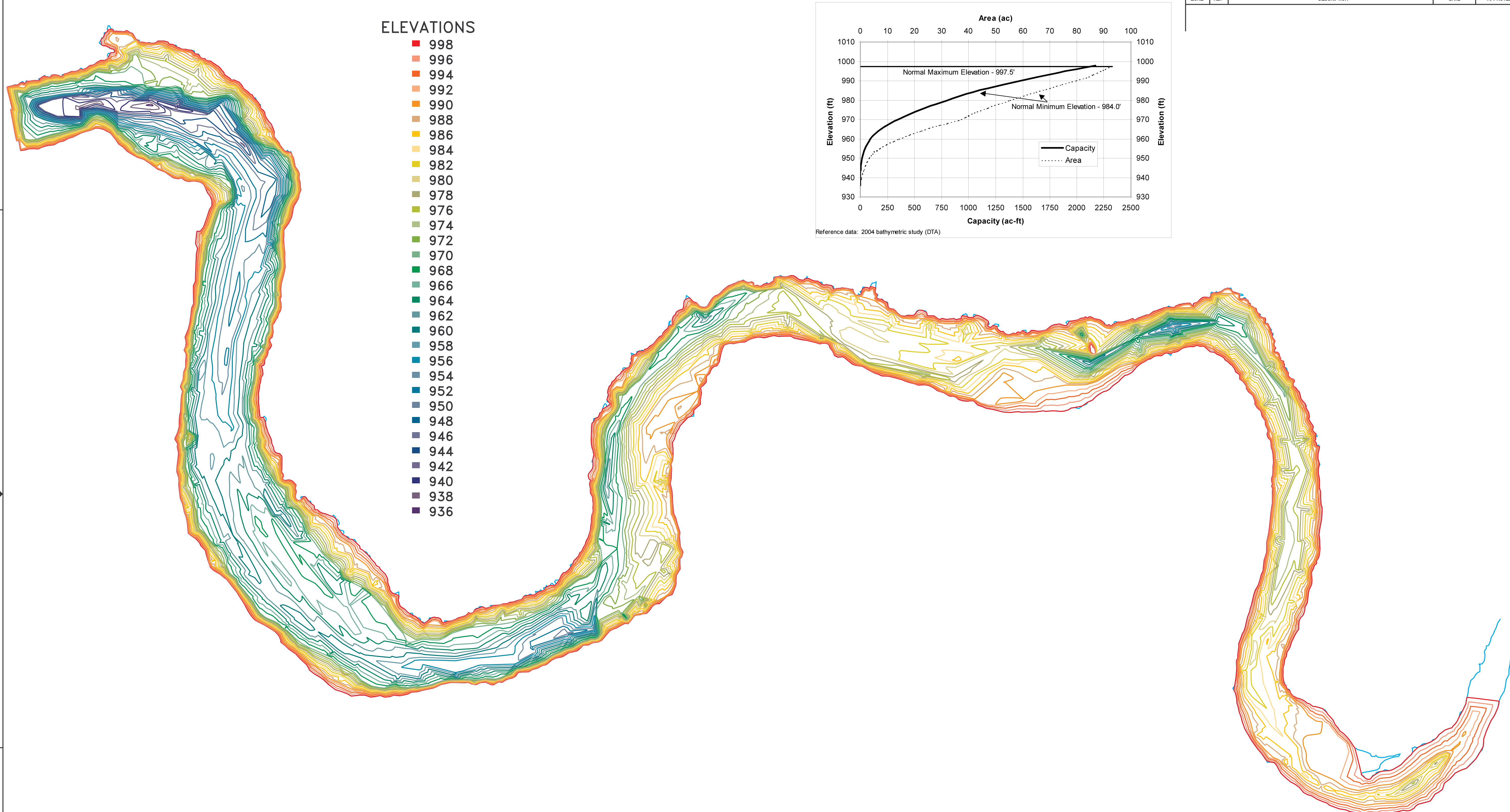

Flow (cfs)
4000
3500
3000
2500
2000
1500
1000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
Aug1997


Flow (cfs)
0
500
1000
1500
2000
2500
3000
3500
4000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Sep1997

APPENDIX B

CHILI BAR RESERVOIR VOLUME SURVEY MAPS

- Figure 3.2-1 – Bathymetric Map with Curve
- Figure 3.2-2 – Bathymetric Map with Survey Points



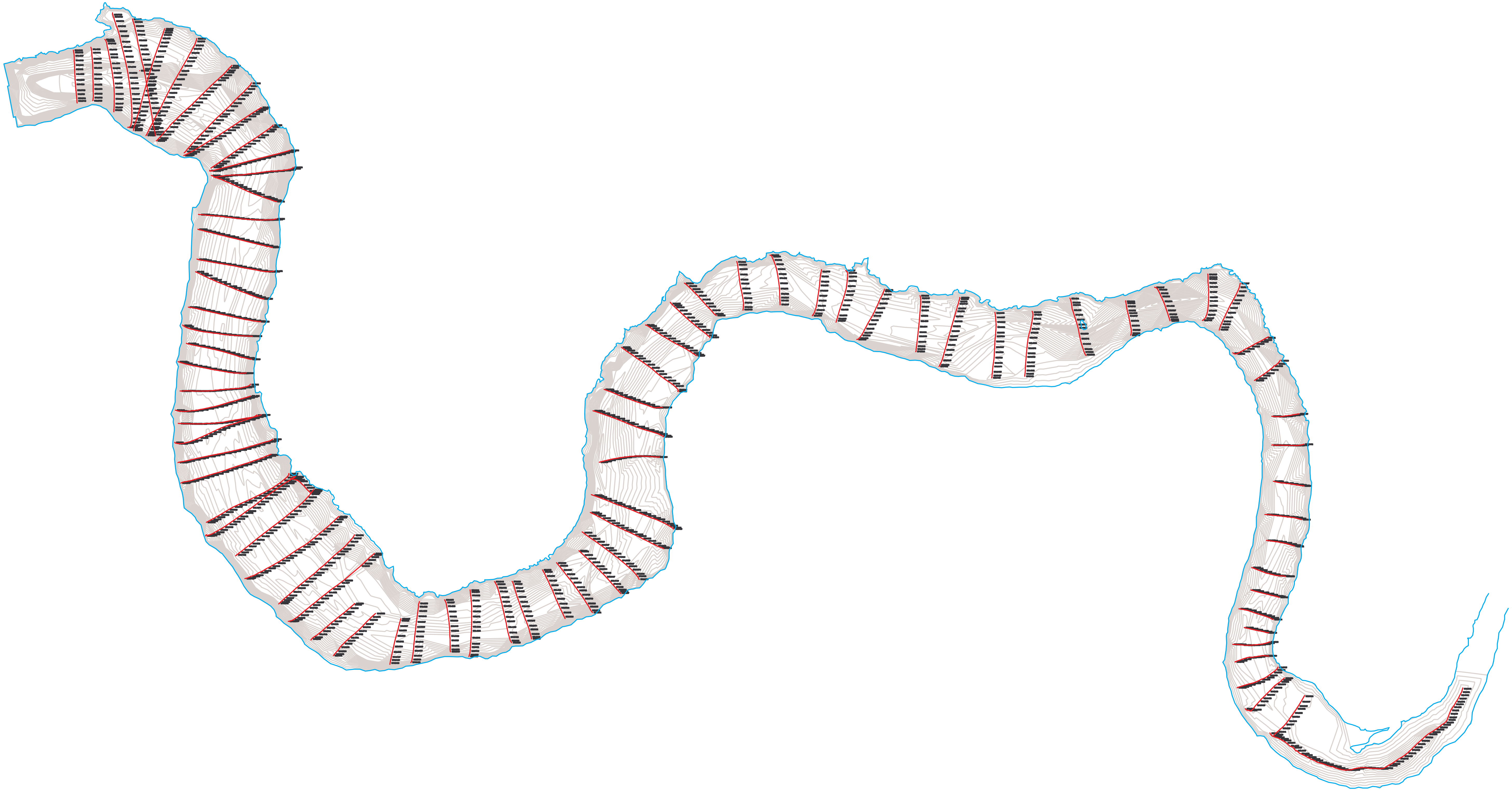
Reference data: 2004 bathymetric study (DTA)

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED

CHILIBAR RESERVOIR VOLUME SURVEY

SIZE	FSCM NO.	DWG NO.	REV
D		Figure 3.2–1	1

SCALE 1"=250' SHEET



REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED

CHILIBAR RESERVIOR
VOLUME SURVEY

SIZE | FSCM NO. | DWG NO. Figure 3.2–2 | REV

SCALE | SHEET