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)

HYDROLOGY
TECHNICAL REPORT

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Description

- Hydrology Study Plan

3.4 Hydrology Study Plan

3.4.1 Pertinent Issue Questions

The Hydrology Study Plan addresses Aquatic/Water issue Questions:

17. How has the Project affected the timing and natural hydrology in all Project reaches and tributaries? What are the effects on habitat and geomorphology?
43. What are the unimpaired (pre-Project) and regulated flows in the Project area? What is the range of variability of those flows?

Note that this study plan only addresses hydrology. Any environmental affects related to hydrology are addressed in other study plans such as the Channel Morphology Study Plan.

3.4.2 Background

Streamflow hydrology is essential when evaluating the management of water resources. This information is used by SMUD on the Upper American River Project (UARP) and by Pacific Gas and Electric Company on the Chili Bar Project for both operations and planning. The regulated flow, diversion and storage data of the UARP and Chili Bar Project are measured by a network of gages maintained by SMUD and Pacific Gas and Electric Company and summarized in the annual California Water Supply Papers that are prepared by the USGS. The USGS certified record for various stream gages in the area of the projects includes some sites that are designed to gage low flows only. SMUD's 2001 Initial Information Package (IIP) describes the available hydrological record on the UARP.

In addition to the gages within the boundaries of the projects, there are additional gages on the South Fork of the American River above and below the confluence of the regulated flows from the UARP that will be included in this Study Plan.

3.4.3 Study Objectives

The objective of this Study Plan is to develop hydrologic information to evaluate the impact of the UARP and Chili Bar Project (Combined Project) on the unregulated flow characteristics. Results from this study will be used as input to other study Plans including the Riparian, Channel Morphology, Water Balance Model, Instream Flow and a variety of recreational study plans.

The following terms will be used for the purpose of this Study Plan:

- "natural flow:" unregulated streamflow computation adjusted for regulation and diversions from upstream projects including Project 184 and the Combined Project
- "unregulated flow:" unregulated streamflow computation adjusted for regulation and diversions made by the Combined Project
- "regulated flow:" refers to the observed or measured flow (not adjusted for regulation and diversion upstream of station).

Study objectives are as follows:

Develop Streamflow Database

1. **Mean Daily Data:** Develop mean daily flow data at all Combined Project reservoir release points (summarized in Table 1) under unregulated conditions (without-Project or unimpaired flows) and with-Project conditions (regulated or observed flows) for the period October 1, 1975 through September 30, 2001 (WY 1976-2001). Regulated flow data for the period of investigation may be limited at some locations.
2. **Hourly Flow Data:** Evaluate diurnal fluctuations in unregulated flow for South Fork Silver Creek downstream of Ice House Reservoir and the South Fork American River below Slab Creek Reservoir using hourly flow data from representative unregulated watersheds nearby the UARP. Hourly data are available for the period WY 1990 through WY 2001.

3. **Annual Peak Flow Data:** Summarize annual peak flow data at all gage locations in the Project area with long-term regulated and unregulated peak flow information (summarized in Table 2). All available peak flow data will be used in this analysis (i.e., as early as WY 1925 through WY 2001).
4. **Monthly Accretion Flow estimates in the Project Bypass Reaches:** Synthesize monthly accretion flow data at the bottom of all project bypass reaches, including contributions from significant tributaries (summarized in Table 3). These data will be synthesized for the investigation period, WY 1976 through 2001.

Assess Project Effects on the Unregulated Flow Characteristics

- **Flow Statistics.** An analysis will be performed on Mean Daily Data . The analysis will be limited at some locations due to insufficient data.
- **Flood Peak Frequency Analysis:** Flood peak frequency curves (annual-event curves) will be developed from the Annual Peak Flow Data at all locations identified in Table 2, with separate curves developed for regulated and unregulated periods.
- **Diurnal Flow Analysis:** Investigate the relationship between mean daily flow and minimum or maximum daily flow during the spring snowmelt. Hourly streamflow data are readily available from the USGS after 1990. The purpose of this study is to better understand the diurnal fluctuation of the unregulated snowmelt. Hourly unregulated flow data are not available from the Project, therefore unimpaired stream gage data will be collected from nearby watersheds and analyzed. The analysis will be performed on data provided in Table 4. The results from this study may be highly variable.

3.4.4 Study Area and Sampling Sites

The study area includes all Combined Project affected stream reaches, tributaries and Combined Project reservoirs as identified by the Aquatic TWG. Table 5 summarizes available USGS gage data (existing and discontinued gages) for the Combined Project area. Stream gage locations are depicted in Figure 1. Table 6 summarizes the location sites for the Low-flow Monitoring Program (monthly manual measurements during low flow season).

3.4.5 Information Needed From Other Studies

No information is required from other relicensing studies to complete this study. The information developed from this study will be used in other relicensing study plans, including the Riparian, Geomorphology, Instream Flow, Spill Assessment and Recreational study plans. Data will be obtained from El Dorado Irrigation District's FERC Project 184 hydrological analysis. For the purpose of the UARP relicensing, the EID will be considered inflow only: that is, SMUD will not verify or alter EID's data.

3.4.6 Study Methods and Schedule

The tasks of the Study Plan are:

- Define the regulated flow conditions for points described in Table 1
- Define the unregulated flow conditions for points described in Table 1
- Define the natural flow conditions for the South Fork American River below Slab Creek Dam and the South Fork American River near Placerville
- Summarize additional data (hourly streamflow data and annual peak flow data)
- Develop monthly accretion flows in the Project bypass reaches and evaluate background inflow to project reservoirs (Table 3)
- Assess Project effects on the unregulated flows using various tools such as:
    - Indicators of Hydrologic Alteration (IHA)
    - Flood Peak Frequency Analysis
    - Diurnal Flow Analysis

Each of the phases described above will be discussed below. Work is scheduled to be completed sometime in late 2002.

3.4.6.1 Regulated Flows

Regulated flows will be reviewed and missing data estimated using UARP records (e.g., reservoir storage and spill, powerhouse draft and precipitation data) and/or streamflow records from nearby watersheds with similar characteristics (e.g., watershed elevation, basin geology). When missing data cannot be reconstructed from the UARP records, or when synthesized data result in negative numbers, best professional judgment will be applied to estimate the missing data. Adjustment techniques and data modifications will be presented to the Aquatic TWG. Data preparation includes 1) data review; and 2) estimation of missing record. Some of the regulated flow data for the Project was provided to the Aquatic TWG in CD format (dated January???, 2002).

3.4.6.2 Unregulated Flows

Unregulated flows will be computed using the records available from the USGS and the Combined Project records via a mass balance or other synthesis techniques. Unregulated flows will be adjusted for net evaporation at all reservoirs. Missing data will be estimated using streamflow records from nearby watersheds with similar characteristics (e.g., watershed elevation, basin geology). Data to be used in the analysis includes all streamflow gage data in Table 5 (all available record) and the stations summarized in Table 4. Similar techniques will be applied to extend the hydrologic record, if necessary, to develop a record for the entire investigation period. Data preparation includes 1) computation of unregulated flow; 2) estimation of missing record; 3) evaluation of data homogeneity (data consistency).

At locations where historical data are available, an analysis will be performed to compare annual flow characteristics of the investigation period, WY 1976 through WY 2001, to the long-term record, mid-1920's through WY 2001.

3.4.6.3 Natural Flows

"Natural flows" will be computed for the South Fork American River below Slab Creek Dam and the South Fork American River near Placerville using the unregulated flows from this Study Plan and the South Fork American unregulated inflow to Slab Creek Reservoir as computed by El Dorado Irrigation District.

3.4.6.4 Summarize Additional Streamflow Data

Additional analysis of hydrological data is required for other Study Plans. This section describes the data requirements for the additional studies.

Frequency curves generated from the peak flow data will be used in the Geomorphology and Riparian study plans. The USGS has collected and archived annual peak flows at all streamflow gaging sites described in Table 2. Data will be collected, reviewed and summarized in tables.

SMUD has been requested to investigate the relationship of mean daily flow to the minimum and maximum daily flow during the spring snowmelt at the site below Ice House Reservoir. The purpose of the investigation is to develop a better understanding of the unregulated diurnal flow pattern downstream of Ice House Reservoir and Slab Creek Reservoir. There was a gaging site at this location prior to the construction of the reservoir at Ice House, but only mean daily flows are available. Nevertheless, the USGS has, since 1990, recorded and stored 15-minute observations, which are available upon request. Data will be collected from nearby streamflow gages (Table 4). The analysis to be performed is described in the following section.

SMUD has also been requested to evaluate accretion flow downstream of Project facilities in Project bypass reaches as well as background flows in major tributaries feeding Project reservoirs. Using existing gage records from locations identified in Table 5, SMUD will synthesize monthly flow statistics for each of the stations identified in Table 3. In addition, SMUD will institute a program to measure, on a monthly basis, low flows at locations identified in Table 6. These data will be used to validate some of the synthesized monthly flow estimates. It is anticipated that the program will be on-line by summer of 2002.

3.4.6.5 Assess Project Effects on Unregulated Flows

The following studies will be performed on the data collected in Section 3.4.6.1 through 3.4.6.3.

3.4.6.5.1 IHA Analysis

To assess combined Project effects on the unregulated flow characteristics, flow characteristics will be computed and comparison tables prepared for the regulated and unregulated flow condition. The IHA methodology, as described by Richter et al. (1996), will be applied. Richter suggests that the hydrologic attributes of a stream can be described by five fundamental groups of "statistics". The five groups are:

- Group #1: Magnitude of monthly water conditions
- Group #2: Magnitude and duration of annual extreme water conditions
- Group #3: Timing of annual extreme water conditions
- Group #4: Frequency and duration of high and low pulses
- Group #5: Rate and frequency of change in water conditions

Statistics will be computed for the five IHA Groups using software developed by Smythe Scientific Software. The IHA methodology will be applied at most locations summarized in Table 1 (due to data limitations, it may not be possible to perform the analysis at all sites).

3.4.6.5.2 Flood Peak Frequency Analysis

A flood peak frequency analysis will be performed at locations described in Table 2. This analysis will be performed on instantaneous annual peak flow data (rather than mean daily values) collected by the USGS.

3.4.6.5.3 Diurnal Flow Analysis

As discussed in Section 1.1.6.4, SMUD has been requested to investigate the relationship of mean daily flow to the minimum and maximum daily flow during the spring snowmelt at the site below Ice House Reservoir. An hourly time-step has been selected for the analysis. Historical unimpaired hourly flow data are not available at this site so unimpaired stream gage data from nearby watersheds will be analyzed. The relationships will be explored at sites listed in Table 4. The anticipated results of this study are unclear. Results could be extremely variable since the relationship may be influenced by various basin characteristics (e.g., aspect, shape of basin, travel time, geology of basin). If reasonable results are obtained, they will be included in the Recreational Flow Study Plan.

3.4.6.5.4 Water Year Types

Water year types will be discussed/developed after the Hydrology Study Plan is completed.

3.4.7 <u>Study Output</u>

A hydrology presentation will be made to the Aquatics TWG and the Plenary Group in late 2002. A report will be prepared documenting basic data used in analysis, record estimation, adjustments and extension techniques, data used in analysis and study results. The report will be prepared in a format to be incorporated into the Licensee's draft environmental assessment report that will be submitted to FERC with the Licensee's application for a new license in the form of a CD.

3.4.8 <u>Preliminary Estimated Study Cost</u>

An estimated cost for this study will be prepared after approval by the Plenary Group.

3.4.9 TWG and Plenary Endorsement

The Aquatics TWG gave tentative approval to this plan at the June 24, 2002 TWG meeting; the document was circulated for a final electronic review, with no comments received. The Aquatics TWG gave final approval of this plan, as amended, on August 5, 2002. The participants at the meeting who said they could "live with" this study plan were Camp Lotus, California Sportfishing Protection Alliance, US Forest Service, Pacific Gas and Electric, National Marine Fisheries Service, State Water Resources Control Board and SMUD. None of the participants at the meeting said they could not "live with" this study plan. The Plenary Group gave approval of this plan at the August 7, 2002 Plenary Group meeting. The participants at the meeting who said they could "live with" this study plan were Taxpayers of El Dorado County, USFS, El Dorado County Water Agency, State Water Resources Control Board, El Dorado County Citizens for Water, National Park Service, US Bureau of Land Management, Placer County Water Agency, City of Sacramento, PG&E and SMUD. None of the participants at the meeting said they could not "live with" the study plan.

3.4.10 Literature Cited

Sacramento Municipal Utility District. 2001. Initial Information Package for Relicensing of the Upper American River Project (FERC Project No. 2101). Sacramento, CA.

Sacramento Municipal Utility District, 2002. UARP Regulated Hydrology (Pre-Project & With Project), Version 2, January 2002. . Sacramento, CA.

AQUATIC TWG NOTE

1. *The Aquatic TWG recognizes that there may be additional flow data that may need to be collected or synthesized for the Water Quality studies.*

Table 1. Combined Project Reservoir Release Points	
Rubicon River below Rubicon Dam	Silver Creek below Junction Dam
Little Rubicon River below Buck Island Dam	Silver Creek below Camino Dam
Gerle Creek below Loon Lake	Brush Creek below Brush Creek Dam
South Fork Rubicon River below Robbs Peak Dam	South Fork American River below Slab Creek Dam
Gerle Creek below Gerle Creek Dam	South Fork American River near Placerville
South Fork Silver Creek below Ice House Dam [1/]	

[1/] Only regulated flows subsequent to the completion of Jones Fork PH will be developed at this site.

Table 2. USGS Instantaneous Peak Flow Data to be used in Flood Frequency Analysis

USGS Number	USGS Description	Period of Record
Location of regulated and unregulated comparison		
11441500	South Fork Silver Creek near Ice House, CA	10/1/24 to 12/31/57 (unregulated) 1/58 to present (regulated by Project)
11442000 [1/] 11441900	Silver Creek near Placerville, CA Silver Creek below Camino Diversion Dam, CA	5/1/22-9/30/61 (unregulated) 10/1960 to present (regulated)
11443500	South Fork American River near Camino, CA	10/1922 to 12/31/57 (no regulation by SMUD) 1/1/58 to present (regulated by Project)
11444500	South Fork American River near Placerville, CA	10/1/1911 to 12/31/57 (no regulation by SMUD) 1/1/58 to present (regulated by Project)
Location of regulated or unregulated analysis only		
11429500	Gerle Creek below Loon Lake Dam near Meeks Bay, CA	9/1962 to present
11430000	South Fork Rubicon River below Gerle Creek near Georgetown, CA	8/1961 to present
11441000	Silver Creek at Union Valley, CA	10/1/24-12/31/27 10/1/28-1/31/50 7/27/50-2/28/51 8/31/51-9/30/60
11445500	South Fork American River near Lotus	1951 to 1995

[1/] The gage at Silver Creek below Camino Diversion Dam is upstream of the original gage. One site will be adjusted for precipitation and drainage area.

Table 3. Locations throughout the Project area where monthly flow statistics will be synthesized to evaluate accretion flow in project bypass reaches and inflow from major tributaries to Project reservoirs
Rubicon River inflow to Rubicon Reservoir
Highland Creek inflow to Rockbound Reservoir
Little Rubicon River outflow from Rockbound Lake
Jerrett Creek upstream of confluence with Gerle Creek
Barts/Dellar Creek upstream of confluence with Gerle Creek
Rocky Basin Creek upstream of confluence with Gerle Creek
S.F. Rubicon River upstream of confluence with Gerle Creek
Gerle Creek inflow to Gerle Creek Reservoir
S.F. Rubicon River upstream of Rubicon River
Tells Creek inflow to Union Valley Reservoir
Big Silver Creek inflow to Union Valley Reservoir
Jones Fork Silver Creek inflow to Union Valley Reservoir
S.F. Silver Creek 3-4 miles downstream of Ice House Reservoir
S.F. Silver Creek upstream of Big Hill Canyon
Little Silver Creek inflow to Junction Reservoir
Silver Creek immediately upstream of S.F. American River
S.F. American River upstream of confluence with Silver Creek
S.F. American River upstream of Camino Powerhouse
S.F. American River downstream of Camino Powerhouse
Slab Creek. inflow to Slab Creek Reservoir
S.F. American River outflow from Slab Creek Reservoir (upstream of Iowa-Brushy Canyon Creek Confluence)
S.F. American River between Slab Creek Reservoir and Rock Creek
Rock Creek upstream of confluence with S.F. American River

Table 4. Preliminary List of Adjacent or Nearby Streamflow Sites to be Used in Hydrology Study Plan

USGS Number	USGS Description	Nature Of Data	Gage Elevation (feet)[1]	Drainage Area (sq-mi)	Period Of Record
10336660	Blackwood Creek near Tahoe City, CA	Hourly and mean daily flow	6240	11.2	10/1/1960 to present
10336676	Ward Creek at Hwy 89 near Tahoe Pines, CA	Hourly and mean daily flow	6230	9.7	10/1/1972 to present
10336780	Trout Creek near Tahoe Valley, CA	Hourly and mean daily flow	6250	36.7	10/1/1960 to present
11427700	Duncan Creek near French Meadows, CA	Hourly and mean daily flow	5270	9.9	10/1/1960 to present
11431800	Pilot Creek above Stumpy Meadows, CA	Mean daily flow	4280	11.7	10/1/1960 to present
11264500	Merced River at Happy Isle Bridge, near Yosemite, CA	Hourly flow	4017	181	10/1/1989 to present
11266500	Merced River at Pohono Bridge, near Yosemite, CA	Hourly flow	3862	321	10/1/1989 to present
11427000	North Fork American River at North Fork Dam	Hourly flow	715	342	10/1/1989 to present

Table 5. Existing and discontinued United States Geological Survey gage records in the Combined Project Area

USGS Number	USGS Description	Nature Of Data	Gage Elevation (feet)[1]	Drainage Area (sq-mi)	Period Of Record[4/]
Stream/River Flow Gages					
11427960	Rubicon River below Rubicon Dam near Meeks Bay, CA	Low flow only (<10 cfs) does not record dam spill	6,520	29.8	Unpublished: 1964 to 1991 Published: 10/91 to present
11428000[3] (formally gage 391)	Rubicon River at Rubicon Springs, CA	Entire record prior to UARP. Gage was located downstream of present Rubicon Dam, 0.75 mile upstream of Miller Creek		31.6	2/1/10-12/31/13 10/1/56 –9/30/62
11428400	Little Rubicon River below Buck Island Dam near Meeks Bay, CA	Low flow only (<2 cfs) does not record dam spill	6,420	6.0	Unpublished: 1964 to 1990 Published: 10/1990 to present
11429500	Gerle Creek below Loon Lake Dam near Meeks Bay, CA	Records Loon Lake spill and release	6,250	8.0	9/1962 to present
11430000	South Fork Rubicon River below Gerle Creek near Georgetown, CA	Records release and spill from Gerle and Robbs Peak Reservoirs	4,970	47.6	8/1961 to present
11441000[3] (formally gage 414)	Silver Creek at Union Valley, CA	Entire record prior to UARP. Gage was located near present Union Valley Dam, 0.6 mile downstream of confluence of Big Silver and Jones Fork creeks.		82.7	10/1/24-12/31/27 10/1/28-1/31/50 7/27/50-2/28/51 8/31/51-9/30/60
11441500[3] (formally gage 415)	South Fork Silver Creek near Ice House, CA	Entire record prior to UARP. Gage was located near the present Ice House Dam, 0.3 mile downstream of Peavine Creek	5,290	27.2	10/1/24-12/31/57
11441500	South Fork Silver Creek near Ice House, CA	Records Ice House Dam spill and release	5,290	27.5	1/58 to present
11441800	Silver Creek below Junction Dam near Pollock Pines, CA	Low flow only (<30 cfs) does not record dam spill	4,280	147	Unpublished: 1965 to 1987 Published: 10/1987 to present
11441900	Silver Creek below Camino Diversion Dam, CA	Records Camino Dam spill and release plus Round Tent Canyon	2,754	171	10/1960 to present
11442000[3] (formally gage 417)	Silver Creek near Placerville, CA	Entire record prior to UARP. Gage was located 0.2 mile upstream of confluence with SFAR.		177	5/1/22-9/30/61

Table 5. Existing and discontinued United States Geological Survey gage records in the Combined Project Area

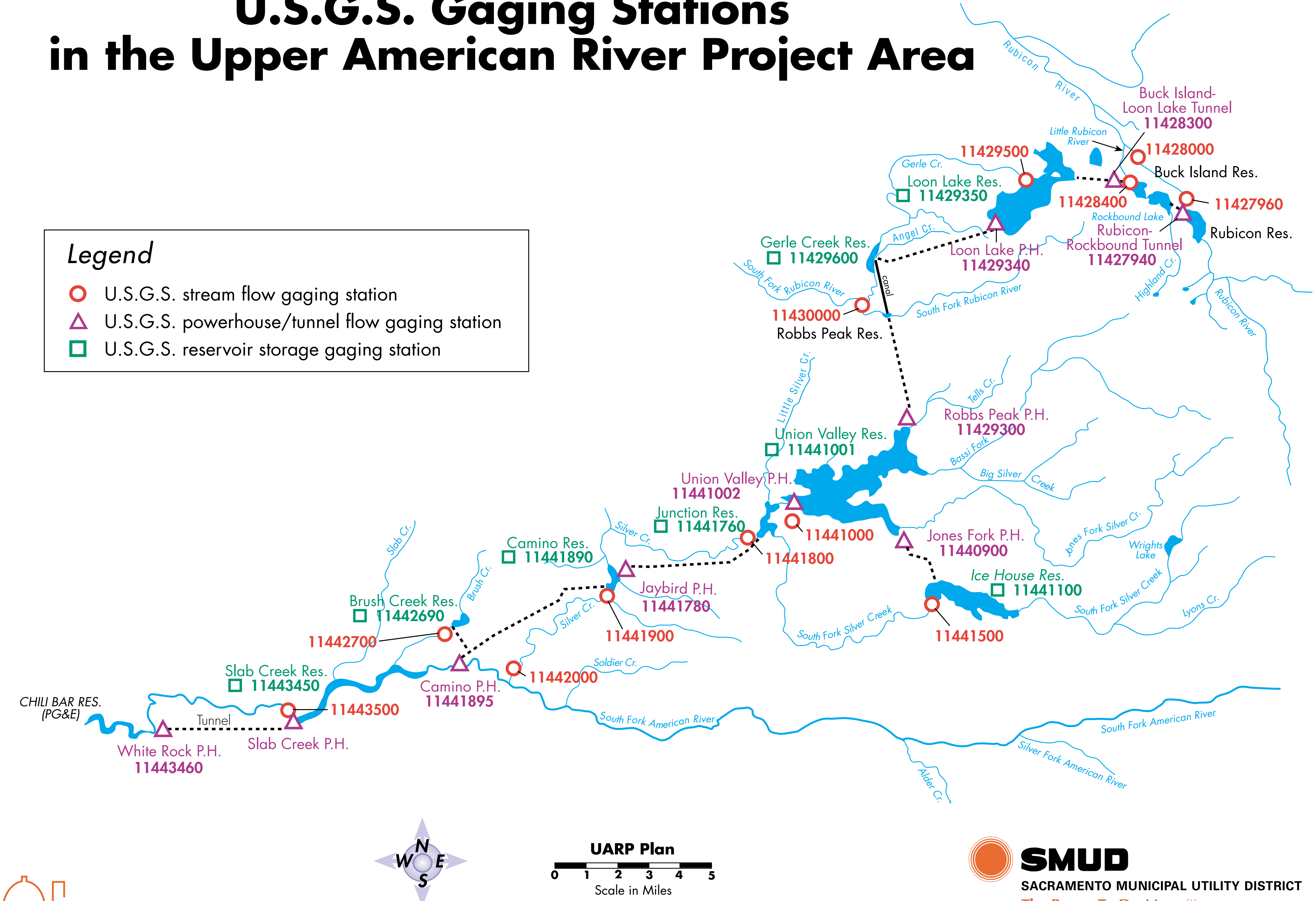
USGS Number	USGS Description	Nature Of Data	Gage Elevation (feet)[1]	Drainage Area (sq-mi)	Period Of Record[4/]
11442700	Brush Creek below Brush Creek Dam near Pollock Pines, CA	Flow released from Brush Creek Dam, spill not recorded	2,700	8.0	Unpublished: 1971 to 1987 Published: 10/1987 to present
11443500	South Fork American River near Camino, CA	Records Slab Creek Dam spill and release	1,625	493	10/1922 to present
1144500	South Fork American River near Placerville	Records Chili Bar Reservoir spill and release	920	598	1911-1920 1964 to present
11445500	South Fork American River near Lotus	Records flow below Lotus	673	635	1951 to 1995
Powerhouse and Tunnel Flow					
11427940	Rubicon-Rockbound Tunnel near Meeks Bay, CA	Flow that is diverted to Buck Island Reservoir	6,533	N/A³	10/1963 to present
11428300	Buck-Loon Tunnel near Meeks Bay, CA	Flow that is diverted from Buck Island to Loon Lake	6,425	N/A	10/1963 to present
11429300	Robbs Peak Powerplant	Flow through powerhouse	4,827	N/A	10/1962 to present
11429340	Loon Lake Powerplant	Flow through powerhouse	5,270	N/A	10/1974 to present
11440900	Jones Fork Powerplant	Flow through powerhouse	4,870	N/A	10/1984 to present
11441002	Union Valley Powerplant	Flow through powerhouse	4,435	N/A	10/1972 to present
11441780	Jaybird Powerplant	Flow through powerhouse	2,920	N/A	10/1991 to present
11441895	Camino Powerplant	Flow through powerhouse	1,848	N/A	10/1973 to present
11443460	White Rock Powerhouse	Flow through powerhouse	990	N/A	3/1972 to present
Reservoir Elevation					
11429350	Loon Lake near Meeks Bay, CA	Daily Observation at midnight	N/A	8.0	12/1963 to present
11429600	Gerle Reservoir near Meeks Bay, CA	Daily Observation at midnight	N/A	28.7	10/1990 to present
11441001	Union Valley Reservoir near Riverton, CA	Daily Observation at midnight	N/A	83.7	11/1962 to present
11441100	Ice House Reservoir near Kyburz, CA	Daily Observation at midnight	N/A	27.2	10/1959 to present
11441760	Junction Reservoir near Pollock Pines, CA	Daily Observation at midnight	N/A	147	Unpublished: 1980 to 1991 Publish ed: 10/1991 to present
11441890	Camino Reservoir near Pollock Pines, CA	Daily Observation at midnight	N/A	160	Unpublished: 1980 to 1991 Published: 10/1991 to present
11442690	Brush Creek Reservoir near Pollock Pines, CA	Daily Observation at midnight	N/A	8.0	Unpublished: 1980 to 1991 Published: 10/1991 to present
11443450	Slab Creek Reservoir near Camino, CA	Daily Observation at midnight	N/A	493	Unpublished: 1969 to 1986 Published: 5/1987 to present

[1/] Powerplant elevation is based on centerline of turbines.
[2/] N/A means not applicable.
[3/] Gage discontinued.
[4/] The quality or time-step of the unpublished USGS record is uncertain.

Table 6. Locations throughout UARP area where monthly flow low flow measurements will be taken to supplement synthesized monthly flow estimates.
Rubicon River inflow to Rubicon Reservoir
Highland Creek inflow to Rockbound Reservoir
Little Rubicon River outflow from Rockbound Lake
Jerrett Creek Upstream of confluence with Gerle Creek
Barts/Dellar Creek upstream of confluence with Gerle Creek
Rocky Basin Creek upstream of confluence with Gerle Creek
S.F. Rubicon River upstream of confluence with Gerle Creek
Gerle Creek inflow to Gerle Creek Reservoir
S.F. Rubicon River inflow to Robbs Peak Reservoir
Tells Creek inflow to Union Valley Reservoir
Big Silver Creek Inflow to Union Valley Reservoir
Jones Fork Silver Creek inflow to Union Valley Reservoir
S.F. Silver Creek inflow to Ice House Reservoir
S.F. Silver Creek 3-4 miles downstream of Ice House Reservoir (one time)
S.F. Silver Creek upstream of Big Hill Canyon (one time)
Little Silver Creek inflow to Junction Reservoir
Silver Creek inflow to Camino Reservoir
Silver Creek upstream confluence with S. F. American River
Slab Creek inflow to Slab Creek Reservoir (one time)
S.F. American River between Slab Creek Reservoir and Rock Creek
Rock Creek, upstream of confluence with S.F. American River
S.F. American River upstream of White Rock Powerhouse

Figure B1.2-1

U.S.G.S. Gaging Stations in the Upper American River Project Area



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0522-01 6/21/01

HYDROLOGY TECHNICAL REPORT

SUMMARY

This report includes the following analyses:

- Computation of mean daily data: Development of mean daily flow data at all reservoir release points for both unregulated and regulated conditions for water years 1975 through 2001.
  - o Introduction - Summary of available data including and discussion of points where unregulated data and regulated data are provided.
  - o Methods - Summary of methods used to compute calculated unregulated mean daily flow and synthesized unregulated mean daily flow.
  - o Results - Summary of unregulated mean daily flow data (box-whisker diagrams and average annual flow).
- Computation of monthly accretions (Note that this has been revised to a computation of daily accretions for all points described above Chili Bar Reservoir): Development of mean daily accretions for locations described by the Water Balance Subcommittee (8 October 2003) for water years 1975 through 2001.
  - o Introduction - Summary of locations where flow is computed.
  - o Methods - Summary of methods used to compute accretions.
  - o Results – Summary of unregulated mean daily accretions data.
- Computation of flow statistics: Development of mean daily flow statistics for selected locations using data for water years 1975 through 2001.
  - o Introduction - Summary of available data where statistics are computed.
  - o Analysis – Assess project effects of the unregulated flow characteristics. IHA methodology is applied.
- Hourly Flow Data: Evaluate diurnal fluctuations in unregulated flow data for the South Fork Silver Creek downstream of Ice House Dam and the South Fork American River downstream of Slab Creek Dam using hourly flow data from representative unregulated watersheds nearby the UARP for water years 1990 through 2001.
  - o Introduction - Summary of available data including and discussion of points where analysis will be performed.
  - o Methods - Summary of methods used to evaluate daily diurnal fluctuations.
  - o Results - Graphical presentation of relationship between mean daily flow and maximum daily flow during the spring snowmelt.
- Annual Peak Flow Data: Summarize annual peak flow data at all gage locations in the UARP and Chili Bar Project area with long-term regulated and unregulated peak flow information. All available peak flow data is used in this analysis.
  - o Introduction - Summary of available data including and discussion of points where analysis is performed.
  - o Methods - Application of U.S. Army Corps of Engineers statistical methodology.
  - o Results - Graphical presentation of flood-peak frequency analysis.

1.0 INTRODUCTION

This technical report is one in a series of reports prepared by Devine Tarbell and Associates, Inc., and Margaret Hannaford 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 addresses unregulated and regulated flows in the basins.

- **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.
- **DESCRIPTION OF ANALYSIS AND RESULTS BY SUBJECT AREA**
- **METHODS** – A description of the methods used in the study, including a listing of study sites.
- **RESULTS** – A description of the most important data results. Raw data, where copious, and detailed model results are provided by request in a separate compact disc (CD) for additional data analysis and review by interested parties.
- **ANALYSIS** – A brief analysis of the results, where appropriate.
- **LITERATURE CITED** – A listing of all literature cited in the report.

This technical report does not include a detailed description of the UARP Alternative Licensing Process (ALP) or the Project, 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).

Also, this technical report does not include a discussion regarding the effects of the UARP and Chili Bar Projects on hydrology or associated environmental resources, nor does the report include a discussion of appropriate protection, mitigation, and enhancement measures. An impacts discussion regarding the UARP is included in the applicant-prepared preliminary draft environmental assessment (PDEA) document, which is part of the Licensee's application for a new license. Development of resource measures will occur in settlement discussions, which will commence in early 2004, and will be reported in the PDEA.

2.0 BACKGROUND

2.1 Hydrology Study Plan

On August 7, 2002, the UARP Relicensing Plenary Group approved the Hydrology Study Plan that was developed and approved by the Aquatic Technical Working Group (TWG) on June 24, 2002. The study plan was designed to address, in part, the following questions developed by the Plenary Group:

Issue Question 17. How has the Project affected the timing and natural hydrology in all Project reaches and tributaries? What are the effects on habitat and geomorphology?

Issue Question 43. What are the unregulated (pre-Project) and regulated flows in the Project area? What is the range of variability of those flows?

This technical report addresses these issue questions with the exception of effects on habitat and geomorphology, which are addressed in separate technical reports (i.e., *Stream Habitat, Reservoir Habitat and Amphibians Test Flow Technical Reports*).

For the purpose of the study, “natural flow” was defined as the unregulated streamflow computation adjusted for regulation and diversions from upstream projects including Project 184 and the UARP and Chili Bar Project;”unregulated flow” was defined as the unregulated streamflow computation adjusted for regulation and diversions made by the UARP and Chili Bar Project; and “regulated flow” referred to the observed or measured flow (not adjusted for regulation and diversion upstream of station).

The study objectives were two fold. First, to develop a stream flow database composed of:

- Mean Daily Data: Develop mean daily flow data at all reservoir release points for both unregulated and regulated conditions for period of record from Water Year 1976 through 2001.

- Hourly Flow Data: Evaluate diurnal fluctuations in unregulated flow data for the South Fork Silver Creek downstream of Ice House Dam and the South Fork American River downstream of Slab Creek Dam using hourly flow data from representative unregulated watersheds nearby the UARP for the period from Water Year 1990 through 2001.

- Annual Peak Flow Data: Summarize annual peak flow data at all gage locations in the Project area with long-term regulated and unregulated peak flow information. All available peak flow data will be used in this analysis (i.e., as early as WY 1925 through WY 2001).

- Monthly Accretion Flow Estimates in Project Reaches: Synthesize monthly accretion flow data at the bottom of all Project Reaches, including contributions from significant tributaries for the period from Water Year 1976 through 2001.

The second objective was to assess Project effects on the unregulated flow characteristics including:

- Flow Statistics: Where data are not limiting the analysis, analyze mean daily flow data.

- Flood Peak Frequency Analysis: Develop flood peak frequency curves (annual-event curves), with separate curves developed for regulated and unregulated conditions.

- Diurnal Flow Analysis: Investigate the relationship between mean daily flow and minimum or maximum daily flow during the spring snowmelt.

The study plan specifically listed that an Indicators of Hydrologic Alteration (IHA) analysis, a flood peak frequency analysis, and a diurnal flow analysis would be performed. The study area encompassed all stream reaches affected by the UARP and Chili Bar Project, including the Reach Downstream of Chili Bar.

2.2 Water Year Type

The information in this subsection is provided for informational purposes, as requested by agencies. The derivation of water year types is described in the *Water Quality Technical Report*. Note that the types in Table 2.2-1 below are those that would result from the application of the water types proposed by the UARP Relicensing Water Year Type Subgroup to the period of record, and not those water year types that actually were applied in conformance with the existing UARP or Chili Bar licenses. Table 2.2-1 presents water year types for the period that is pertinent to this *Hydrology Technical Report*.

Table 2.2-1. Water year types applied to individual months for Water Years 1975 through 2003.
(CD=Critically Dry; D=Dry; BN=Below Normal; AN=Above Normal; W=Wet)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1974	---	---	---	---	---	---	---	---	---	W	W	W
1975	W	D	BN	BN	AN	AN	AN	AN	AN	AN	AN	AN
1976	AN	D	D	CD	CD	CD	CD	CD	CD	CD	CD	CD
1977	CD	CD	CD	CD	CD	CD	CD	CD	CD	CD	CD	CD
1978	CD	AN	AN	AN	W	W	W	W	W	AN	AN	AN
1979	AN	D	BN	BN	BN	BN	BN	BN	BN	BN	BN	BN
1980	BN	AN	W	W	W	W	W	W	W	W	W	W
1981	W	D	D	D	D	D	D	D	D	D	D	D
1982	D	W	W	W	W	W	W	W	W	W	W	W
1983	W	W	W	W	W	W	W	W	W	W	W	W
1984	W	W	W	W	W	W	W	W	W	W	W	W
1985	W	BN	BN	BN	D	D	D	D	D	D	D	D
1986	D	BN	W	W	W	W	W	W	W	W	W	W
1987	W	D	D	D	CD	CD	CD	CD	CD	CD	CD	CD
1988	CD	BN	D	CD	CD	CD	CD	CD	CD	CD	CD	CD
1989	CD	D	D	BN	BN	BN	BN	BN	BN	BN	BN	BN
1990	BN	D	D	D	D	D	D	D	D	D	D	D
1991	D	CD	CD	D	D	D	D	D	D	D	D	D
1992	D	D	D	D	D	D	D	D	D	D	D	D
1993	D	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN
1994	AN	D	D	D	CD	CD	CD	CD	CD	CD	CD	CD
1995	CD	W	AN	W	W	W	W	W	W	W	W	W
1996	W	BN	AN	AN	AN	AN	AN	AN	AN	W	W	W
1997	W	W	W	W	W	W	W	W	W	W	W	W
1998	W	AN	W	W	W	W	W	W	W	W	W	W
1999	W	AN	W	AN	AN	AN	AN	AN	AN	AN	AN	AN
2000	AN	BN	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN
2001	AN	D	D	D	D	D	D	D	D	D	D	D
2002	D	BN	BN	BN	BN	BN	BN	BN	BN	BN	BN	BN
2003	BN	BN	BN	D	BN	BN	BN	BN	BN	---	---	---

2.3 Agency Requested Information

In a letter dated December 17, 2003 to the Licensee regarding content of technical reports, the agencies requested that the *Hydrology Technical Report* include (besides the information listed in the Hydrology Study Plan):

- Updated, corrected report
- Flood frequency analysis

In a May 13, 2004 letter, the agencies stated in regards to the *Hydrology Technical Report* (February 2004) the following:

- We would like to compliment Margaret Hannaford on the commendable work she did on this report. We have several comments but believe they are generally minor in nature.

    1. The accretion estimates for Dutch Creek, Greenwood Creek, and Weber Creek are provided as monthly averages. Since this is a reach of the SFAR in which many collaborative participants are interested in short-term modeling, discussion needs to occur as to whether these monthly estimates should be disaggregated into daily estimates consistent with the rest of the hydrology data set.

    2. Provide a short description of what a Box-Whisker diagram represents.

    3. On page 90, the average annual runoff reported for Silver Creek at Camino appears to have been switched with the value of the average annual runoff for Silver Creek at Junction.

    4. In Appendix A, coefficients were applied only to the flow above the estimated base flow for Trout Creek and Pilot Creek. The description in this appendix should be expanded to explain why this procedure was used.

    5. The Indicators of Hydrologic Alteration results for the SFAR below Chili Bar look suspicious. The pre- and post-project comparisons appear too similar considering the amount of regulation upstream. This Indicators of Hydrologic Alternation comparison should be re-evaluated.

    6. In Appendix D, the charts have no labels for axis.

    7. In Appendix F, the plots are difficult to read. It would be helpful if different symbols had different colors.

    8. In the Raw Data Folder for Unimpaired Daily Data, please label and describe the differences between the SFAR at Slab Creek Reservoir Unimpaired and Regulated columns (with and without the El Dorado Project, FERC No. 184).

3.0 COMPUTATION OF MEAN DAILY DATA

The Licensee's methods conformed to the methods in the study plan, with the exception that the Licensee's study period began in Water Year 1975 rather than Water Year 1976.

This document summarizes the results of the Hydrology Study Plan Mean Daily Flow Analysis prepared for SMUD's Upper American River Project (UARP) and PG&E's Chili Bar Project. Daily data for this analysis are provided in an electronic format on the accompanying CD. Included in this document is a description of the computation of unregulated mean daily flow for the drainage areas at the following reservoir release points:

Table 3.0-1. UARP and Chili Bar Project Reservoir Release Points

Rubicon River at Rubicon Reservoir	South Fork Silver Creek at Ice House Reservoir
Little Rubicon River at Buck Island Reservoir	Silver Creek at Junction Reservoir
Gerle Creek at Loon Lake	Silver Creek at Camino Reservoir
South Fork Rubicon River at Robbs Peak Reservoir	Brush Creek at Brush Creek Reservoir
Gerle Creek at Gerle Creek Reservoir	South Fork American River at Slab Creek Reservoir
Silver Creek at Union Valley Reservoir	South Fork American River at Chili Bar Reservoir

The period of record analyzed was October 1, 1974 through September 30, 2001 (water years 1975 through 2001). Figure 3.0-1 delineates several of the drainage areas described in Table 3.0-1.

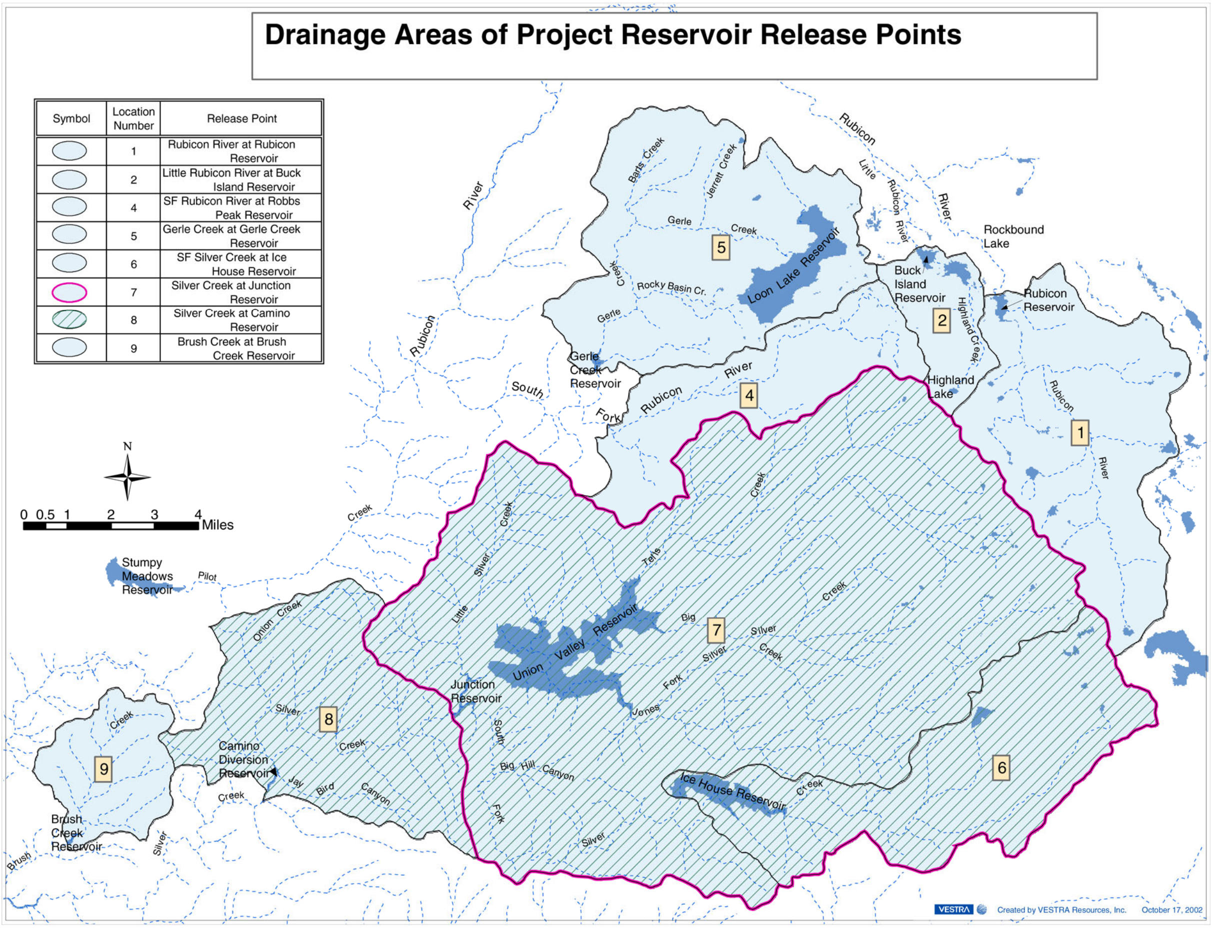


Figure 3.0-1. Drainage Area of UARP and Chili Bar Project Reservoir Release Points

3.1 Available Data

The United States Geological Survey (USGS) and SMUD have monitored reservoir storage, powerhouse draft, releases at reservoirs and tunnel diversions for many points within the drainage basin. Available data are summarized in Table 3.1-1.

Table 3.1-1. Existing and Discontinued USGS Gage Records for the UARP and Chili Bar Project.

USGS Number	USGS Description	Notes	Gage Elevation (feet)	Drainage Area (sq-mi)	Period of Record
Stream/River Flow Gages					
Rubicon River					
11427960	Rubicon River below Rubicon Dam near Meeks Bay, CA	The gage only measures low flows less than 10 cfs; however, SMUD has provided estimates of daily spill for the period 1993 to present and for some years prior to this period.	6,520	29.8	Published: 10/91 to present. The USGS records indicate that there is unpublished record for the period 1964-91; however, they were unable to locate the record. SMUD also has some sporadic measurements for the Rubicon River above the reservoir for the period 1975-91.
11428000 (formally gage 391)	Rubicon River at Rubicon Springs, CA	Gage located downstream of present Rubicon Dam, 0.75 mile upstream of Miller Creek		31.6	2/1/10-12/31/13 10/1/56 –9/30/86
Little Rubicon River					
11428400	Little Rubicon River below Buck Island Dam near Meeks Bay, CA	The gage only measures low flows less than 2 cfs; however, SMUD has provided estimates of daily spill for the period 1993 to present and for some years prior to this period.	6,420	6.0	Published: 10/1990 to present The USGS records indicate that there is unpublished record for the period 1964-91; however, they were unable to locate the record.
Gerle Creek					
11429500	Gerle Creek below Loon Lake Dam near Meeks Bay, CA	Records Loon Lake spill and release	6,250	8.0	9/1962 to present
South Fork Silver Creek					
11441500 (formally gage 415)	South Fork Silver Creek near Ice House, CA	Gage was located near the present Ice House Dam, 0.3 mile downstream of Peavine Creek	5,290	27.2	10/1/24-12/31/57
11441500	South Fork Silver Creek near Ice House, CA	Records Ice House Reservoir spill and release	5,290	27.5	1/58 to present

Table 3.1-1. Existing and Discontinued USGS Gage Records for the UARP and Chili Bar Project.

USGS Number	USGS Description	Notes	Gage Elevation (feet)	Drainage Area (sq-mi)	Period of Record
Silver Creek					
11441800	Silver Creek at Junction Dam near Pollock Pines, CA	Gage monitors low flows only (<30 cfs); however SMUD has estimated daily spills for the period 1993 to present.	4,280	147	Published: 10/1987 to present. The USGS records indicate that there is unpublished record for the period 1965-87; however, they were unable to locate the record.
11441900	Silver Creek below Camino Diversion Dam, CA	Records Camino Dam spill and release plus Round Tent Canyon	2,754	171	10/1960 to present
11442000 (formally gage 417)	Silver Creek near Placerville, CA	Gage was located 0.2 mile upstream of confluence with SFAR.		177	5/1/22-9/30/61
Brush Creek					
11442700	Brush Creek below Brush Creek Dam near Pollock Pines, CA	Flow released from Brush Creek Dam. SMUD has estimated daily spills for the period 1993-present.	2,700	8.0	Published: 10/1987 to present. The USGS records indicate that there is unpublished record for the period 1971-87; however, they were unable to locate the record.
South Fork American River					
11443500	South Fork American River near Camino, CA	Records Slab Creek Dam spill and release	1,625	493	10/1922 to present
11444500	South Fork American near Placerville	Records Chili Bar spill, release and flow through Chili Bar Powerhouse	931	598	10/1/1964 to present
11445500	South Fork American near Lotus	Flow	635	673	10/1/1951 to 9/30/1995
Rock Creek					
11444201	Rock Creek near Placerville	Records flow over broad-crested weir and sharp-crested weir. Water diverted immediately upstream to Rock Creek Powerplant (11444280)	1,305	73	10/1/1986 to present

Table 3.1-1.	**Existing and Discontinued USGS Gage Records for the UARP and Chili Bar Project.**				
USGS Number	**USGS Description**	**Notes**	**Gage Elevation (feet)**	**Drainage Area (sq-mi)**	**Period of Record**
Weber Creek					
11446000	Weber Creek near Salmon Falls	Flow	610	97.6	4/1/1943 to 9/30/59
Powerhouse and Tunnel Flow					
11427940	Rubicon-Rockbound Tunnel near Meeks Bay, CA	Flow that is diverted to Buck Island Reservoir	6,533	N/A	10/1963 to present
11428300	Buck-Loon Tunnel near Meeks Bay, CA	Flow that is diverted from Buck Island to Loon Lake	6,425	N/A	10/1963 to present
11429300	Robbs Peak Powerplant	Flow through powerhouse	4,827	N/A	10/1962 to present
11429340	Loon Lake Powerplant	Flow through powerhouse	5,270	N/A	10/1974 to present
11440900	Jones Fork Powerplant	Flow through powerhouse	4,870	N/A	10/1984 to present
11441002	Union Valley Powerplant	Flow through powerhouse	4,435	N/A	10/1972 to present
11441780	Jaybird Powerplant	Flow through powerhouse	2,920	N/A	10/1991 to present
11441895	Camino Powerplant	Flow through powerhouse	1,848	N/A	10/1973 to present
11443460	White Rock Powerhouse	Flow through powerhouse	990	N/A	3/1972 to present
11444280	Rock Creek Powerhouse	Flow through powerhouse	N/A	73	10/1/1986 to present
Reservoir Elevation					
SMUD	Rubicon Reservoir	Daily Observation	N/A	N/A	1993 to present (some earlier record, sporadic)
SMUD	Buck Island Reservoir	Daily Observation	N/A	N/A	1993 to present (some earlier record, sporadic)
11429350	Loon Lake near Meeks Bay, CA	Daily Observation at midnight	N/A	N/A	12/1963 to present
11429600	Gerle Reservoir near Meeks Bay, CA	Daily Observation at midnight	N/A	N/A	10/1990 to present
11441001	Union Valley Reservoir near Riverton, CA	Daily Observation at midnight	N/A	N/A	11/1962 to present
11441100	Ice House Reservoir near Kyburz, CA	Daily Observation at midnight	N/A	N/A	10/1959 to present
11441760	Junction Reservoir near Pollock Pines, CA	Daily Observation at midnight	N/A	N/A	SMUD operation record 1980-91 (sporadic) Published: 10/1991 to present

Table 3.1-1. Existing and Discontinued USGS Gage Records for the UARP and Chili Bar Project.

USGS Number	USGS Description	Notes	Gage Elevation (feet)	Drainage Area (sq-mi)	Period of Record
11441890	Camino Reservoir near Pollock Pines, CA	Daily Observation at midnight	N/A	N/A	SMUD operation record 1980-91 (sporadic) Published: 10/1991 to present
11442690	Brush Creek Reservoir near Pollock Pines, CA	Daily Observation at midnight	N/A	N/A	SMUD operation record 1980-91 (sporadic) Published: 10/1991 to present
11443450	Slab Creek Reservoir near Camino, CA	Daily Observation at midnight	N/A	N/A	SMUD operation record 1975-86 (sporadic) Published: 5/1987 to present
PG&E	Chili Bar Reservoir	Daily Observation, various times	N/A	N/A	1/1/1993 to present

Precipitation data have also been collected for many points within and adjacent to the UARP. Isohyetal maps describing annual precipitation are available from the Oregon Climate Service. These data were obtained for the UARP and are illustrated in Figure 3.1-1. An area-weighted average precipitation was determined for each watershed and is summarized in Table 3.1-2.

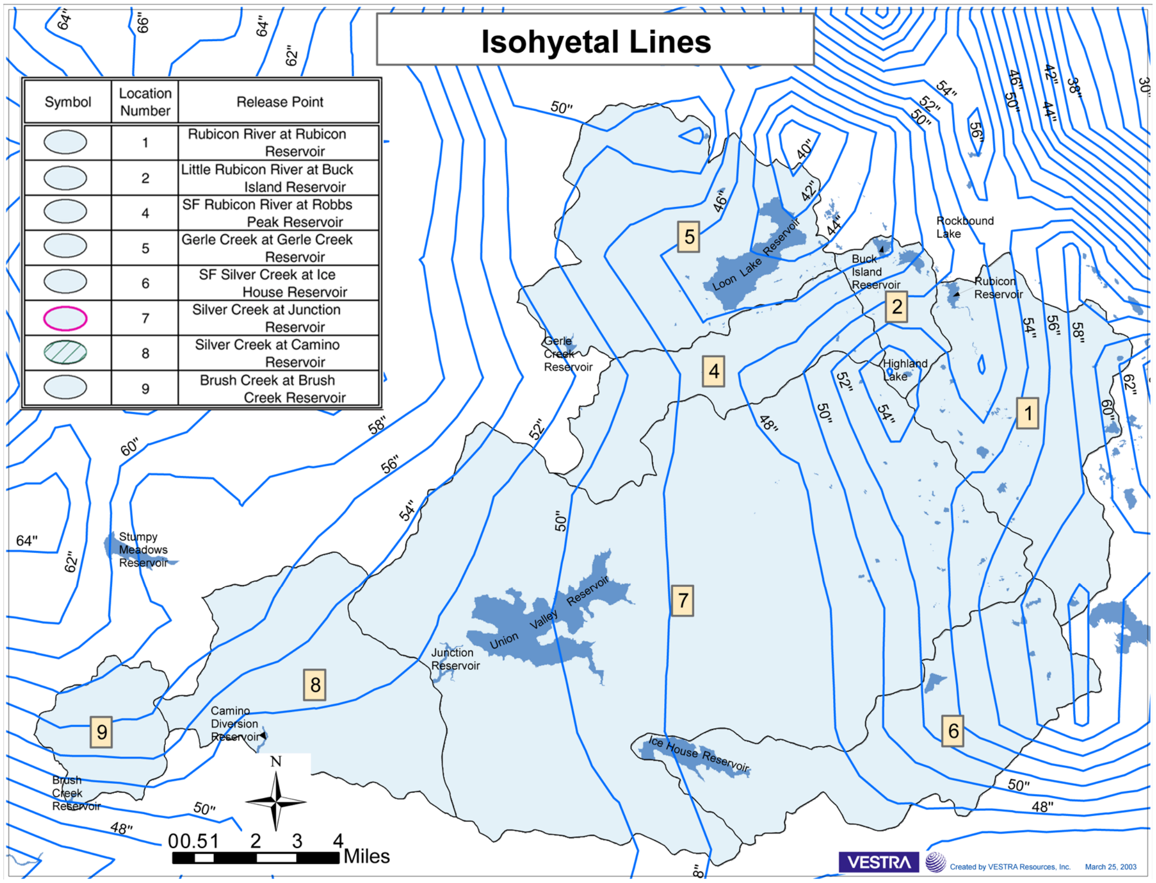


Figure 3.1-1. Isohyetal Lines

Table 3.1-2. Drainage Area and Average Annual Precipitation (as computed by Vestra)		
Drainage Area	**Area (sq mi)**	**Annual Precipitation (inches)**
Rubicon River at Rubicon Reservoir	26.5	55.3
Little Rubicon River at Buck Island Reservoir	6.0	50.1
Gerle Creek at Loon Lake	8.0	44.2
South Fork Rubicon River at Robbs Peak Reservoir	15.2	48.7
Gerle Creek at Gerle Creek Reservoir	30.7	47.5
Silver Creek at Union Valley Reservoir	83.9	49.5
South Fork Silver Creek at Ice House Reservoir	27.3	51.7
Silver Creek at Junction Reservoir	142.6	50.3
Silver Creek at Camino Reservoir	167.1	50.7
Brush Creek at Brush Creek Reservoir	8.0	55.1
South Fork American River at Slab Creek Reservoir	Not computed by Vestra	Not computed by Vestra
South Fork American River at Chili Bar Reservoir	Not computed by Vestra	Not computed by Vestra

A combination of storage and elevation data was provided by SMUD for the project reservoirs. Reservoir storage data for some project reservoirs is available from the USGS. However, the USGS data for many locations are rounded to the nearest 100 acre-feet, and the unregulated inflow to be computed during the summer months is less than 10 cfs. To develop a computation of the unregulated inflow with a meaningful level of precision, the analysis required the abandonment of the USGS-reported storage in the computation process. SMUD provided daily elevation data for Ice House Reservoir, Loon Lake Reservoir and Union Valley Reservoir. These elevation data were then converted to acre-feet (without rounding) based on storage-elevation curves provided by SMUD.

Elevation data and storage-elevation curves using recent bathymetry data collected during 1999-2000 were provided by SMUD for the Loon Lake and Ice House Reservoir. Storage-elevation relationships used in the analysis are summarized in Table 3.1-3. Storage-elevation data for the combined Gerle Reservoir/Gerle Canal/Robbs Reservoir was also provided by SMUD (Table 3.1-3). Storage-elevation curves developed by SMUD were provided for Rubicon, Buck Island and Union Valley reservoirs and are summarized in Figure 3.1-2. Elevation-area curves were developed from storage-elevation-curves for Rubicon and Buck Island reservoir and are also provided in Figure 3.1-2. Elevation-area curves assumed for Union Valley Reservoir are summarized in Table 3.1.3. Storage data in acre-feet were provided for the remaining regulating reservoirs. Data availability varied by location. Some missing data were estimated by linearly interpolating between days with available data. This technique was only applied when the number of consecutive missing days was less than five except at Rubicon Reservoir where storage data were collected at two to four-week intervals prior to water year 1993.

Table 3.1-3. Elevation-Storage-Area Curves

Ice House Reservoir			Loon Lake Reservoir			Union Valley Reservoir		Robbs-Gerle Regulation Reservoirs and Gerle Canal	
Elevation	Storage	Area	Elevation	Storage	Area	Elevation	Area	Elevation	Storage
Feet	Acre-feet	Acres	Feet	Acre-feet	Acres	Feet	Acres	Feet	Acre-feet
5,320	3	2	6,305	-	-	4,650	150	5,196	157
5,325	41	10	6,330	2,359	140	4,660	200	5,197	171
5,330	78	18	6,331	2,499	140	4,670	255	5,198	185
5,340	471	65	6,332	2,646	147	4,680	315	5,199	201
5,350	1,407	126	6,333	2,799	153	4,690	380	5,200	217
5,360	3,053	200	6,334	2,957	158	4,700	450	5,201	235
5,370	5,420	271	6,335	3,080	123	4,710	500	5,202	253
5,380	8,439	330	6,336	3,203	123	4,720	580	5,203	273
5,390	12,000	379	6,337	3,582	379	4,730	675	5,204	293
5,400	16,026	426	6,338	3,977	395	4,740	780	5,205	315
5,410	20,537	475	6,339	4,385	408	4,750	890	5,206	338
5,420	25,551	526	6,340	4,809	424	4,760	1,025	5,207	362
5,430	31,038	571	6,341	5,246	437	4,770	1,160	5,208	387
5,440	36,984	618	6,342	5,699	453	4,780	1,300	5,209	413
5,450	43,504	675	6,343	6,165	466	4,790	1,445	5,210	441
5,460	50,024	732	6,344	6,647	482	4,800	1,605	5,211	470
			6,345	7,142	495	4,810	1,770	5,212	500
			6,346	7,652	510	4,820	1,955	5,213	532
			6,347	8,176	524	4,830	2,150	5,214	565

Table 3.1-3. Elevation-Storage-Area Curves									
Ice House Reservoir			**Loon Lake Reservoir**			**Union Valley Reservoir**		**Robbs-Gerle Regulation Reservoirs and Gerle Canal**	
Elevation	**Storage**	**Area**	**Elevation**	**Storage**	**Area**	**Elevation**	**Area**	**Elevation**	**Storage**
Feet	**Acre-feet**	**Acres**	**Feet**	**Acre-feet**	**Acres**	**Feet**	**Acres**	**Feet**	**Acre-feet**
			6,348	8,715	539	4,840	2,355	5,215	600
			6,349	9,268	553	4,850	2,565	5,216	636
			6,350	9,835	567	4,860	2,765	5,217	674
			6,351	10,417	582	4,870	2,955	5,218	713
			6,352	11,013	596			5,219	754
			6,353	11,623	610			5,220	796
			6,354	12,247	624			5,221	840
			6,355	12,886	639			5,222	886
			6,356	13,539	653			5,223	933
			6,357	14,205	666			5,224	983
			6,358	14,887	682			5,225	1,034
			6,359	15,582	695			5,226	1,086
			6,360	16,291	709			5,227	1,141
			6,361	17,014	723			5,228	1,197
			6,362	17,752	738			5,229	1,254
			6,363	18,503	751			5,230	1,316
			6,364	19,269	766			5,231	1,378
			6,365	20,048	779				
			6,366	20,842	794				
			6,367	21,649	807				
			6,368	22,471	822				
			6,369	23,306	835				
			6,370	24,156	850				
			6,371	25,019	863				
			6,372	25,896	877				
			6,373	26,787	891				
			6,374	27,691	904				
			6,375	28,610	919				
			6,376	29,542	932				
			6,377	30,488	946				
			6,378	31,448	960				
			6,379	32,421	973				
			6,380	33,409	988				
			6,381	34,409	1,000				
			6,382	35,424	1,015				
			6,383	36,452	1,028				
			6,384	37,494	1,042				
			6,385	38,549	1,055				
			6,386	39,618	1,069				
			6,387	40,701	1,083				
			6,388	41,797	1,096				

Table 3.1-3. Elevation-Storage-Area Curves									
Ice House Reservoir			**Loon Lake Reservoir**			**Union Valley Reservoir**		**Robbs-Gerle Regulation Reservoirs and Gerle Canal**	
Elevation	**Storage**	**Area**	**Elevation**	**Storage**	**Area**	**Elevation**	**Area**	**Elevation**	**Storage**
Feet	**Acre-feet**	**Acres**	**Feet**	**Acre-feet**	**Acres**	**Feet**	**Acres**	**Feet**	**Acre-feet**
			6,389	42,907	1,110				
			6,390	44,030	1,123				
			6,391	45,166	1,136				
			6,392	46,316	1,150				
			6,393	47,480	164				
			6,394	48,656	1,176				
			6,395	49,847	1,191				
			6,396	51,050	1,203				
			6,397	52,267	1,217				
			6,398	53,498	1,231				
			6,399	54,741	1,243				
			6,400	55,998	1,257				
			6,401	57,268	1,270				
			6,402	58,551	1,283				
			6,403	59,848	1,297				
			6,404	61,158	1,310				
			6,405	62,481	1,323				
			6,406	63,817	1,336				
			6,407	65,166	1,349				
			6,408	66,529	1,363				
			6,409	67,904	1,375				
			6,410	69,293	1,389				
			6,411	70,694	1,401				
			6,412	72,109	1,415				

Storage in Acre-feet

Rubicon Reservoir = $MElev*(-2.8946) + MElev^2 * (2.712422) + MElev^3 * (-0.013234) + 19$
where MElev = Measured Elevation at Rubicon in Feet – 6520

Buck Island Reservoir = $MElev*(1.821236) + MElev^2 * (.330139) + MElev^3 * (0.01243) + 3$
where MElev = Measured Elevation at Buck Island in Feet – 6400

Union Valley Reservoir = $MElev*(266.02471854) + MElev^2 * (-0.7059044574) + MElev^3 * (0.0255698466) + MElev^4 * (-0.000032551) + MElev^5 * (0.0000000419) + 6605.806$
where MElev = Measured Elevation at Union Valley in Feet – 4640

Area in Acres

Rubicon Reservoir = *Maximum (0, or Minimum (Elev*532605, or Elev*0.21466 - 1292.4))*
where Elev = Measured Elevation at Rubicon in Feet

Buck Island Reservoir = *Maximum (Elev*1.333-8534, or Elev*2.2-14095, or 3.143*Elev – 20155)*
where Elev = Measured Elevation at Buck Island in Feet

Figure 3.1-2. Storage in Acre-feet

An adjustment for net evaporation is made at some UARP and Chili Bar Project reservoir release points. Net evaporation rates were developed from pan data collected by SMUD at several locations within the UARP and Chili Bar Project area during the seventies. Average monthly "net evaporation" rates were computed based on the collected data. The same monthly adjustment is applied each year regardless of water year type. Monthly net evaporation rates are summarized in Table 3.1-4. Monthly net evaporation data are not available for Rubicon and Buck Island Reservoirs. The values for Loon Lake Reservoir were assumed at both of these locations. Net evaporation was applied at Rubicon, Buck Island, Loon Lake, Ice House and Union Valley reservoirs using the following equation:

Net Evaporation = Reservoir surface area for day (values from Table 3.1-3 or Figure 3.1-2) * Evaporation Rate for month (Table 3.1-4)

Table 3.1-4. Net Evaporation Rates at Various UARP Reservoirs

Month	Loon Lake (Ft/day)	Ice House (Ft/day)	Union Valley (Ft/day)
January	0.000000	0.000000	0.000000
February	0.000000	0.000000	0.000000
March	0.005387	0.001871	0.001871
April	0.007900	0.005067	0.005067
May	0.014097	0.009290	0.009290
June	0.016433	0.014833	0.014833
July	0.021548	0.017903	0.017903
August	0.020194	0.016258	0.016258
September	0.017300	0.011500	0.011500

Table 3.1-4.	**Net Evaporation Rates at Various UARP Reservoirs**		
Month	**Loon Lake (Ft/day)**	**Ice House (Ft/day)**	**Union Valley (Ft/day)**
October	0.008935	0.005419	0.005419
November	0.002433	0.001367	0.001367
December	0.000000	0.000000	0.000000

Maps describing the geological characteristics within the UARP watershed were provided by the United States Department of Agriculture, Forest Service (El Dorado National Forest). These maps are included as figures 3.1-3 through 3.1-5 of this report and describe the following features:

- Figure 3.1-3: Geologic Formations, Sequences and Complexes
- Figure 3.1-4: Sedimentary Rocks and Gravels
- Figure 3.1-5: Metamorphic and Igneous Rocks

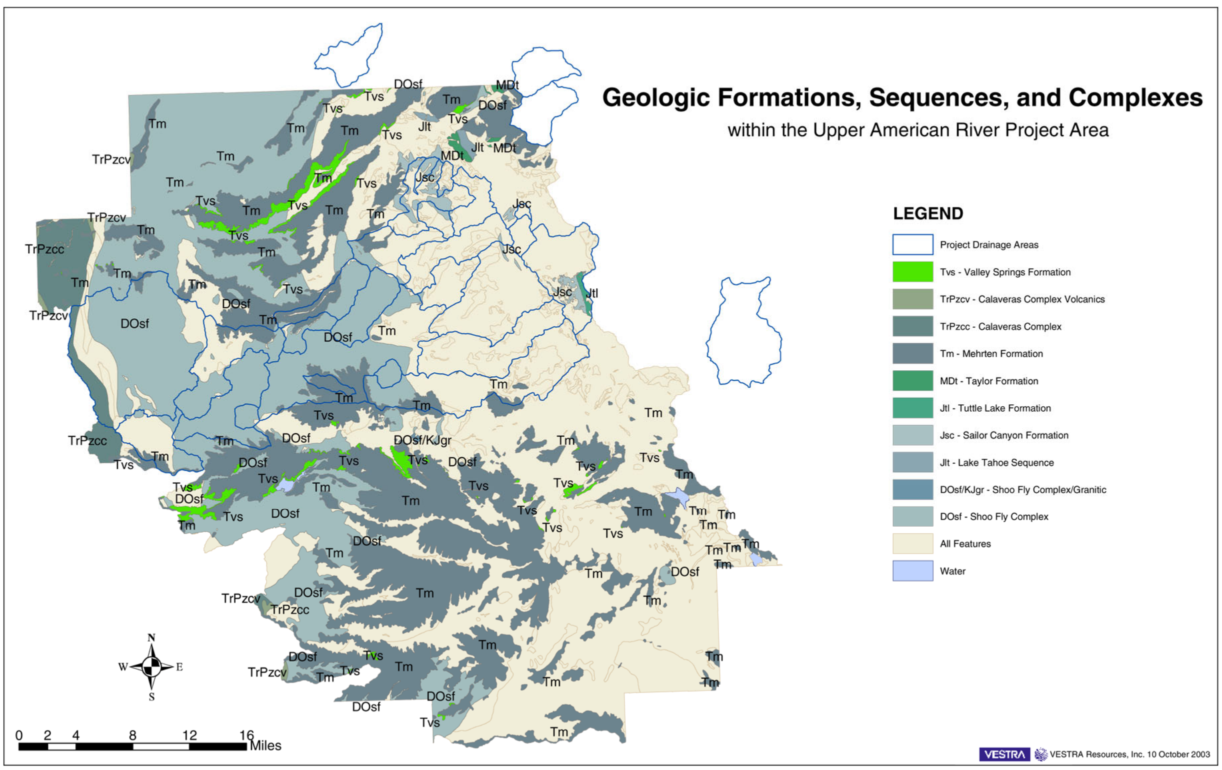


Figure 3.1-3. Geologic Formations, Sequences and Complexes

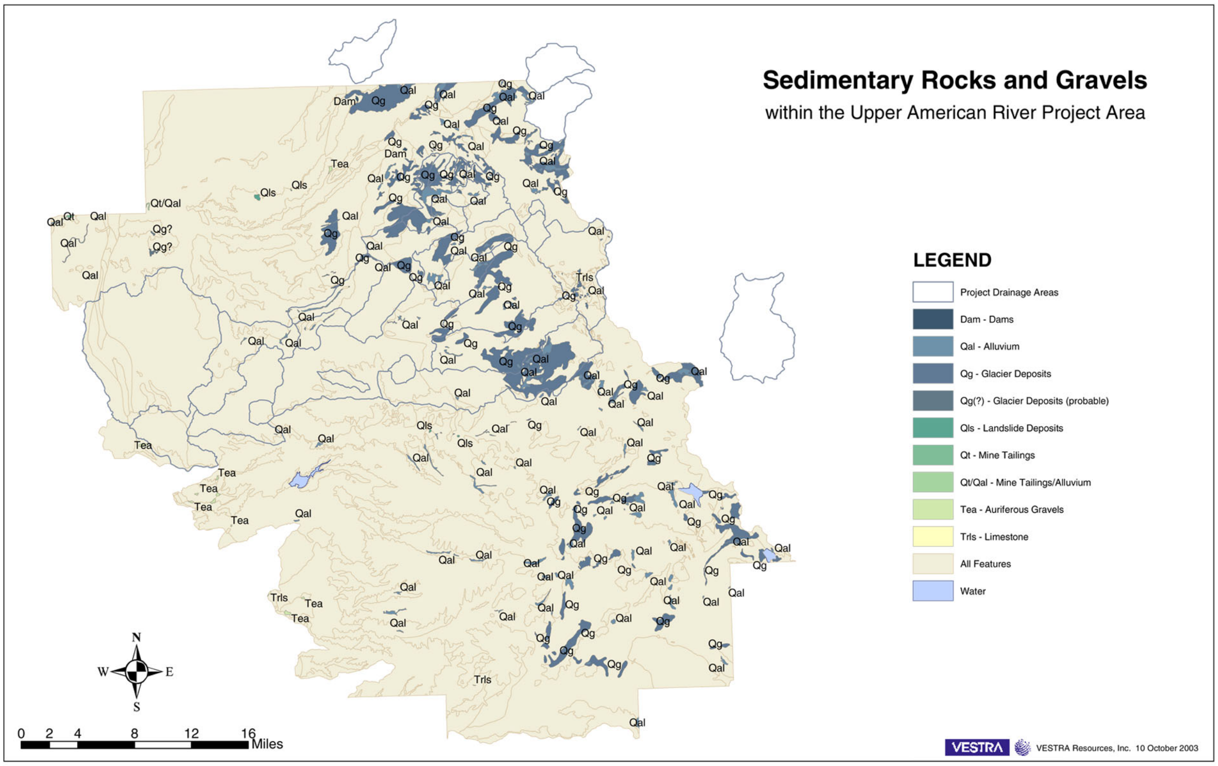


Figure 3.1-4. Sedimentary Rocks and Gravels

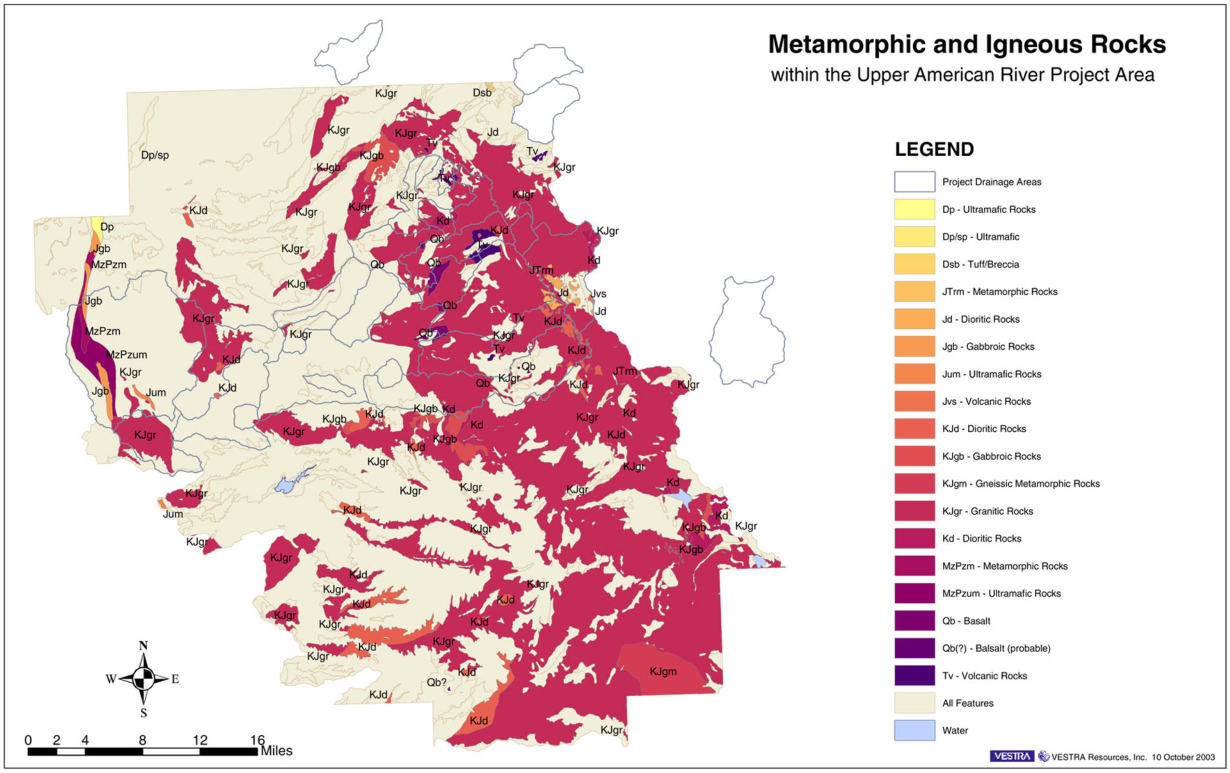


Figure 3.1-5. Metamorphic and Igneous Rocks

3.2 Methodology

In general, the unregulated inflow record was computed by mass balance when sufficient data were available. However, for periods during which a complete record of necessary hydrologic parameters was insufficient to apply a mass balance approach, the unregulated inflow record was synthesized using streamflow records from nearby watersheds with similar characteristics (e.g., watershed elevation and basin geology). Streamflow gage data from nearby stations used in the analysis are summarized in Table 3.2-1.

Table 3.2-1. Streamflow Gages Adjacent to or Nearby the UARP

USGS Number	USGS Description	Gage Elevation (feet)	Drainage Area (sq-mi)	Period of Record
10336660	Blackwood Creek near Tahoe City (Blackwood)	6,240	11.2	10/1/1960 to present
10336676	Ward Creek at Hwy 89 near Tahoe Pines (Ward)	6,230	9.7	10/1/1972 to present
10336780	Trout Creek near Tahoe Valley (Trout)	6,250	36.7	10/1/1960 to present
11427700	Duncan Creek near French Meadows (Duncan)	5,270	9.9	10/1/1960 to present
11431800	Pilot Creek above Stumpy Meadows (Pilot)	4,280	11.7	10/1/1960 to present
11444201	Rock Cr near Placerville, CA (adjusted to include powerhouse diversions) (Rock)	1,305	73.0	10/1/1986 to present

Depending upon the available data and quality of computed unregulated inflow data, different procedures were used to develop the final unregulated flow data. Because different techniques were sometimes applied, each site is discussed individually.

3.2.1 South Fork Silver Creek at Ice House Reservoir

Ice House Reservoir is located on South Fork Silver Creek. The drainage area above the reservoir is about 27.3 square miles and ranges in elevation from 5,290 to almost 10,000 feet. The watershed is a combination of granite at high elevations and timber area with more developed soils at the lower elevations. The USGS have collected streamflow data on the South Fork Silver Creek since October 1924. The original stream gage was located at the current dam site. After the reservoir was completed in October 1959, the gage was relocated 0.4 mi downstream of the reservoir. The increase in drainage area at the new gage site is about 1 percent.

Since October 1959, this measured flow of the South Fork Silver Creek near Ice House has been regulated by Ice House Reservoir. To compute the unregulated inflow to Ice House Reservoir, SMUD adjusts this measured flow to account for the change in storage at Ice House Reservoir and net evaporation. Net evaporation over the reservoir surface is based on the surface area at the beginning of the day times monthly evaporation rates (based on average pan evaporation data collected by SMUD during the seventies). The monthly evaporation rates are assumed to be constant for all years.

In 1985, the Jones Fork Powerhouse began operation. With the addition of Jones Fork Powerhouse, flow can bypass the stream gaging station, entering Silver Creek at Union Valley Reservoir. To compute the unregulated inflow to Ice House Reservoir after 1985, SMUD adjusts the measured flow downstream to account for the powerhouse draft, reservoir storage change and net evaporation. A schematic diagram showing storage, diversions and gaging locations is provided in Figure 3.2.1-1.

The Ice House Reservoir location was selected as the first site to compute unregulated flow data because of the long period of available daily record and the minimal regulation that occurs upstream of the site. Because of the robust nature of the available information at this location, a technique to synthesize the daily unregulated inflow record at this location based on streamflow data from nearby gaging stations was developed. The technique was then applied at the remaining basins where data are more limited. Though theoretically sound, and applicable for the Ice House drainage, the technique was not applicable at all UARP locations.

Using the historical record, the daily unregulated inflows to Ice House Reservoir were computed using a mass balance procedure with the information described in Figure 3.2.1-1. Examples of the "computed" unregulated inflow are provided in figures 3.2.1-2 through 3.2.1-4. The daily unregulated inflow for water year 1995 is displayed in Figure 3.2.1-2. The annual unregulated inflow during water year 1995 (wet year) was about 200% of the average annual inflow. Comparable data for water year 1975 are displayed in Figure 3.2.1-3. The annual unregulated inflow during water year 1975 (average year) was close to the average annual inflow. Water year 1994 is displayed in Figure 3.2.1-4. The annual unregulated inflow during water year 1994 (dry year) was about 40% of the average annual inflow. As seen in these figures, the calculation procedure occasionally resulted in computed negative inflows and some large fluctuations. These anomalies were probably due to questionable storage data (i.e., wind and erroneous gage readings). Further refinement was required to adjust these data to eliminate computed negative inflows and to provide some “data smoothing”.

As described before, the drainage basin lies above elevation 5,290 feet. Winter precipitation is in the form of snow and the majority of the annual runoff occurs during the spring months when the snow melts. To synthesize a daily inflow record at this site, recorded daily data from a nearby stream gage site in a basin of similar elevation characteristics is used. The elevation characteristics of the South Fork Silver Creek above the Ice House Reservoir (Ice House) drainage and the characteristics of drainages of nearby gaging stations are displayed in Figure 3.2.1-5.

As seen in Figure 3.2.1-5, none of the nearby drainage basins exactly replicate the elevation characteristics of the Ice House drainage. These nearby drainages are either higher in elevation (resulting in the drainage having snowmelt later into the spring season) or are lower in elevation (resulting in the drainage having an increased winter runoff and a reduced volume of runoff in the spring). A combination of these gages was used to develop a surrogate basin with similar characteristics to the Ice House drainage. First, the elevation data for each drainage basin was evaluated in size (square miles) and combined to create a basin with similar elevation/area characteristics to the Ice House drainage. A simplification of the methodology is provided in Table 3.2.1-1 using two hypothetical drainage basins. In the example provided in Table 3.2.1-1, a “synthetic” basin was created from drainage basins 1 and 2 that has similar elevation characteristics to drainage area A. A coefficient of 2 is applied to drainage basin 1 and 0.5 to drainage basin 2 in order to create a synthesized basin similar to basin A. Additional adjustments to the coefficients are made to compensate for large discrepancies in average annual precipitation characteristics.

Table 3.2.1-1. Evaluation of Drainage Area Elevation Characteristics, An Example

Drainage	**5,000-5,500 Feet**	**5,500-6,000 Feet**	**6,000-6,500 Feet**	**6,500-7,000 Feet**
A: To be Estimated	200	300	500	700
Nearby Gaging Stations				
1	105	160	0	0
2	0	0	950	1,500
Synthesized	210	320	475	750

This procedure was applied at the Ice House drainage using the sites identified in Figure 3.2.1-5 (Blackwood, Ward, Trout, Duncan and Pilot creek drainages). In a parallel procedure, a multiple regression analysis was performed relating the monthly inflow for Ice House and the flow for all the nearby drainage basins. The regression coefficients computed for the nearby gages by the procedure were very close to the coefficients that had been based upon the elevation/area characteristics.

The regression equation basically resembles the following equation:

Ice House Monthly Flow (AF) = Coefficient Area A * Area A monthly Flow (AF) plus
Coefficient Area B * Area B monthly Flow (AF) plus Constant

The following modification was made to convert the monthly relationship to a daily relationship in cubic feet per second (cfs):

Ice House Daily (cfs) = Coefficient Area A * Area A daily Flow (cfs) plus
Coefficient Area B * Area B daily Flow (cfs) plus Constant/60

The factor applied to the constant adjusts for the number of days in a month and a conversion from volume (AF) to cfs. The procedures and coefficients to compute the simulated inflow into Ice House Reservoir are provided in Appendix A.

The area-elevation characteristics of the synthesized basin which is based on the coefficients developed by the multiple regression procedure are displayed in Figure 3.2.1-6, and compares well to the characteristics of the Ice House Reservoir drainage. A comparison of synthesized daily flows for wet year 1995 to computed daily flows are plotted in Figure 3.2.1-7. The black line represents the computed daily inflow for Ice House based on a mass balance of gaged flows and computations. The red line represents the synthesized daily inflow based on the area/elevation and regression procedure. The results of the synthesis are considered to be very good in comparison to the gaged and computation values.

The "computed" monthly data for inflow to Ice House are of high quality, with the exception of some low flows that are discussed in the following section. To improve the synthesized record, the daily data were modified by proportionately adjusting the daily inflow values so that the total synthesized monthly inflow volume is equal to the monthly "computed" inflow volume to Ice House. This was accomplished by applying the following formula:

$$\text{Adjusted Synthesized Daily Inflow} = \text{Synthesized Daily Inflow} * \frac{\text{Computed Monthly Inflow to Ice House}}{\text{Synthesized Monthly Inflow to Ice House}}$$

There still remained a handful of computed negative monthly inflow volumes during low flow periods. The extensive pre-project USGS flow record was utilized to modify these values. The pre- and post-project data were evaluated to depict "carryover flow" conditions during the June through October period. Using both pre- and post-project data, plots (Figure 3.2.1-8) were made of:

- June versus July monthly flow
- July versus August monthly flow
- August versus September monthly flow
- September versus October monthly flow

Using these historical data for guidance, estimates of minimum monthly flows reasonably likely to occur were made. For example, the computed inflow to Ice House reservoir for July 1992, as compared to August 1992, appeared high for a dry year (Figure 3.2.1-8, light blue hatched circle). The simulated flows and computed flows were compared and the computed flow for August through October 1992 appeared too low and the computed flow for July 1992 appeared too high. The computed flow was redistributed between the four months based on the simulated monthly volumes. In most cases, an attempt was made to redistribute the computed volume over the modified period. In the specific case of calendar year 1992, the computed flow volume was reduced by 2.8%.

Comparisons of results for a wet, average and dry year are displayed in figures 3.2.1-9, 3.2.1-10, and 3.2.1-11, respectively. The black line represents the computed daily inflow for Ice House based on a mass balance of gaged flows and computations. The red line represents the synthesized daily inflow based on the area/elevation and regression procedure. The blue line represents the synthesized values which have been adjusted for the monthly computed values. This data set represents the final data values of the analysis.

Changes in gage location, instrumentation and observational procedures may cause a relative change in the computation of flow at a location. Sometimes these changes can be detected by plotting a scatter diagram of annual streamflow comparing two locations. However, these changes can be more easily detected by comparing the accumulated annual record of the two locations. A double-mass analysis evaluates the consistency of the data by comparing one site's accumulated annual runoff for the period of record with the accumulated annual runoff record from an adjacent location where the data have been already evaluated for consistency. As a final evaluation of the quality of the unregulated inflow data for the full investigation period (1975-2001), a consistency (or homogeneity) analysis was performed using a double mass procedure with the unregulated inflow for the American River at Fair Oaks site, as computed by the Department of Water Resources. Accumulated annual unregulated inflow to the American River at Fair Oaks plotted against inflow to Ice House Reservoir (double mass diagrams) is provided in Figure 3.2.1-12. The constant slope of the relationship without any significant shift illustrates that the synthesized data appear homogeneous.

A box-whisker plot describing the daily flow characteristics for each month is provided in Figures 3.2.1-13. A box-whisker plot is commonly used to show the minimum, maximum, median, and lower and upper quartile values for a data set. In this case, the box-whisker plot illustrates the characteristics of the daily flow data for a month. The box defines the range of values that is within the lower and upper quartiles of the data, and the line in the center of the box is the median value. The caps extending from the end of each box indicate the extreme values (minimum and maximum) of the data set. The median value represents the data point for which an equal number of values occur above and below. The lower quartile value represents the data point for which 25 percent of the sample will be less than (and 75 percent of the sample will exceed) and the upper quartile represents the data point for with 75 percent of the sample will be less than (and 25 percent of the sample will exceed).

The average annual runoff at Ice House Reservoir is 60,000 acre-feet. A table of monthly runoff at this site for the period 1975-2001 is included in Appendix B.

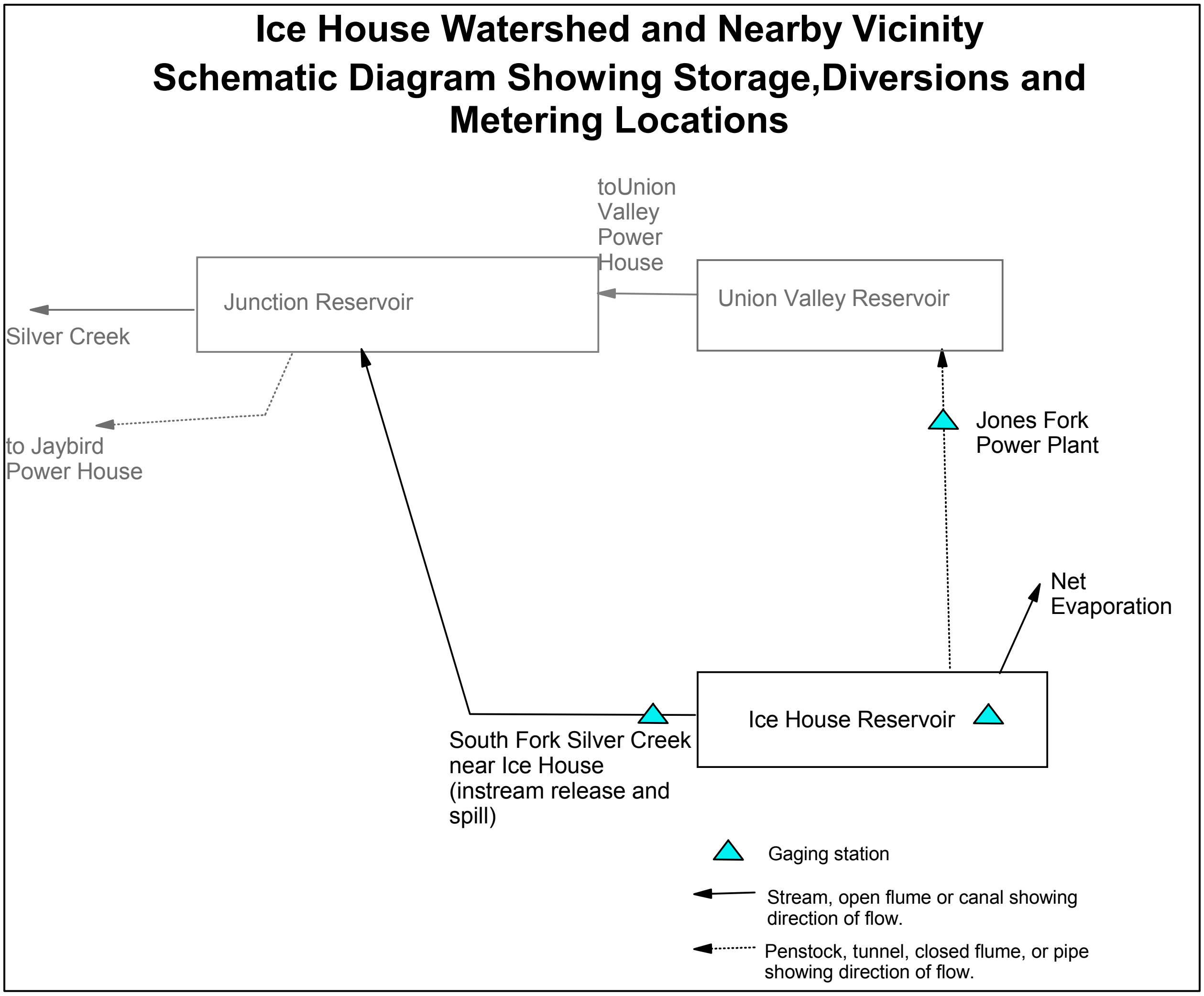


Figure 3.2.1-1. Ice House Watershed and Nearby Vicinity, Schematic Diagram Showing Storage, Diversions and Metering Locations

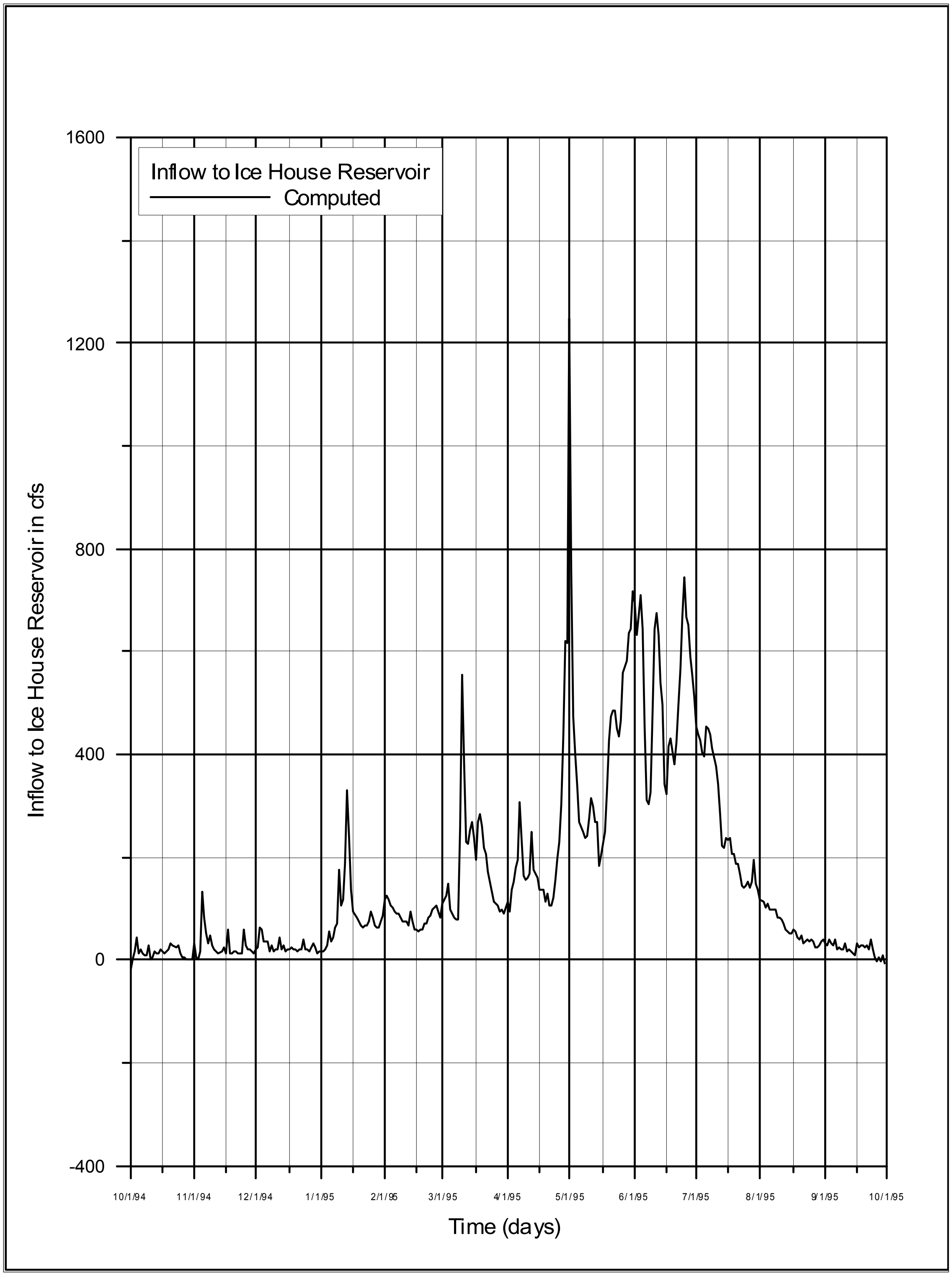


Figure 3.2.1-2. Unregulated Inflow to Ice House Reservoir, WY 1995

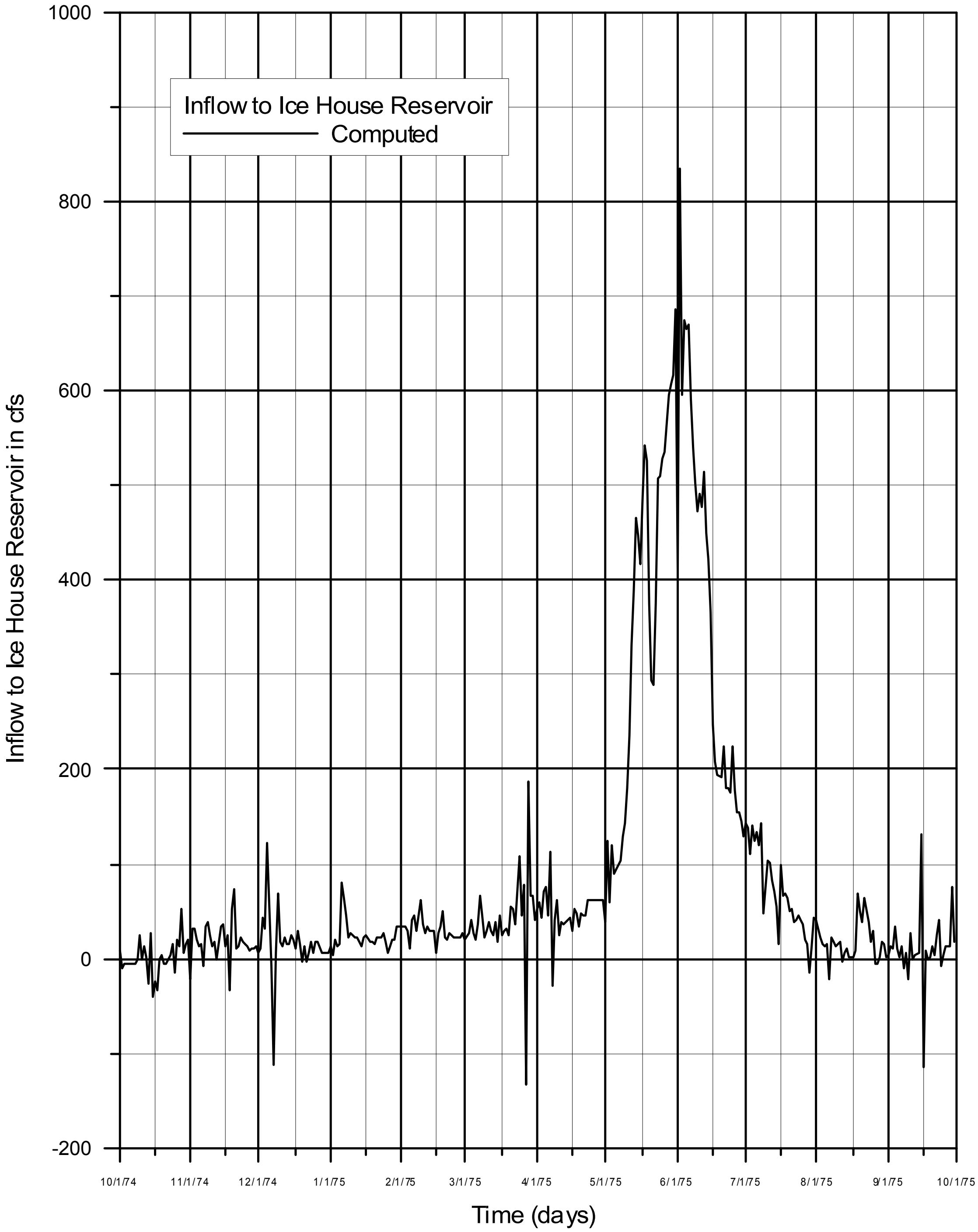


Figure 3.2.1-3. Unregulated Inflow to Ice House Reservoir, WY 1975

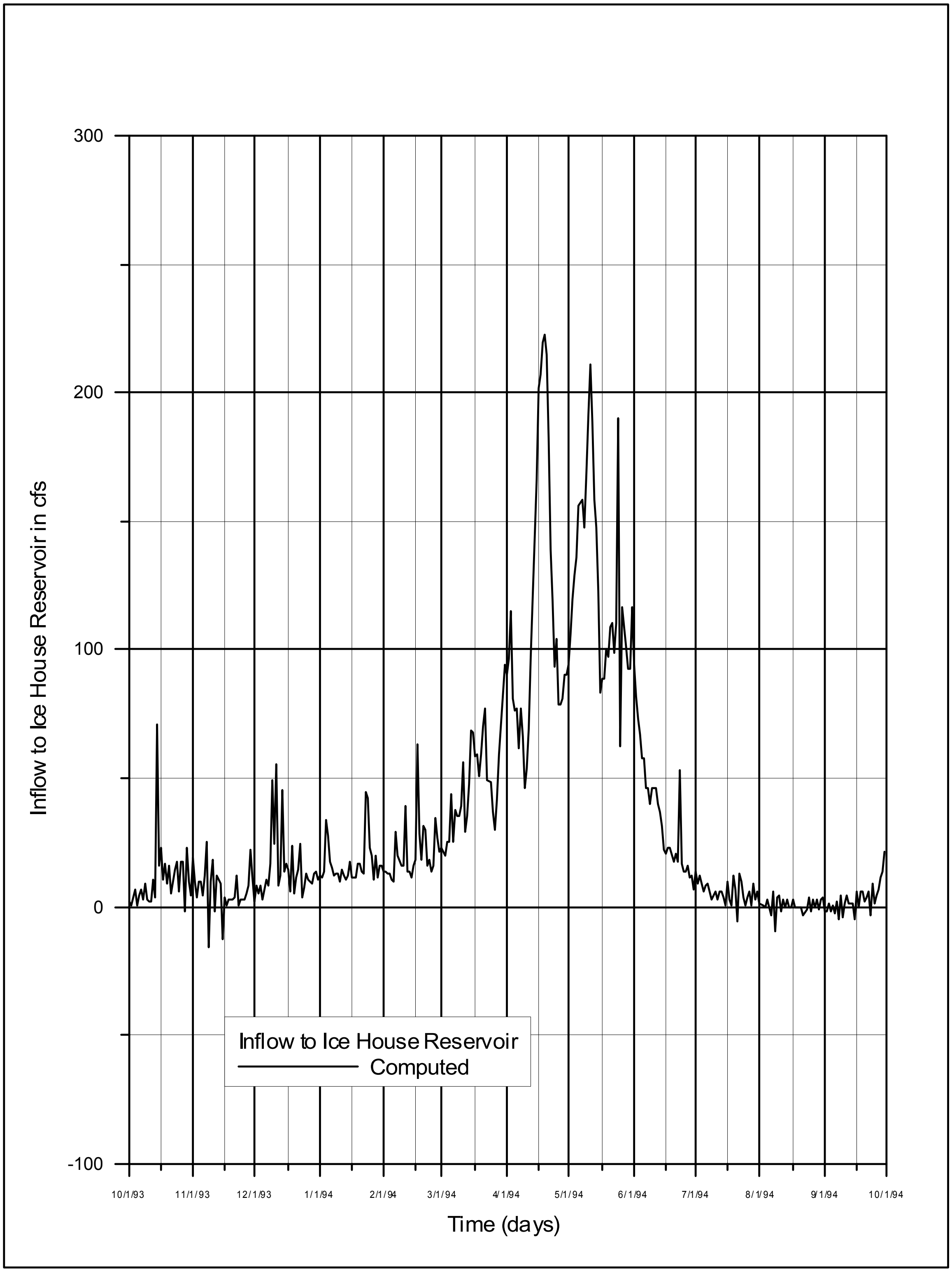


Figure 3.2.1-4. Unregulated Inflow to Ice House Reservoir, WY 1994

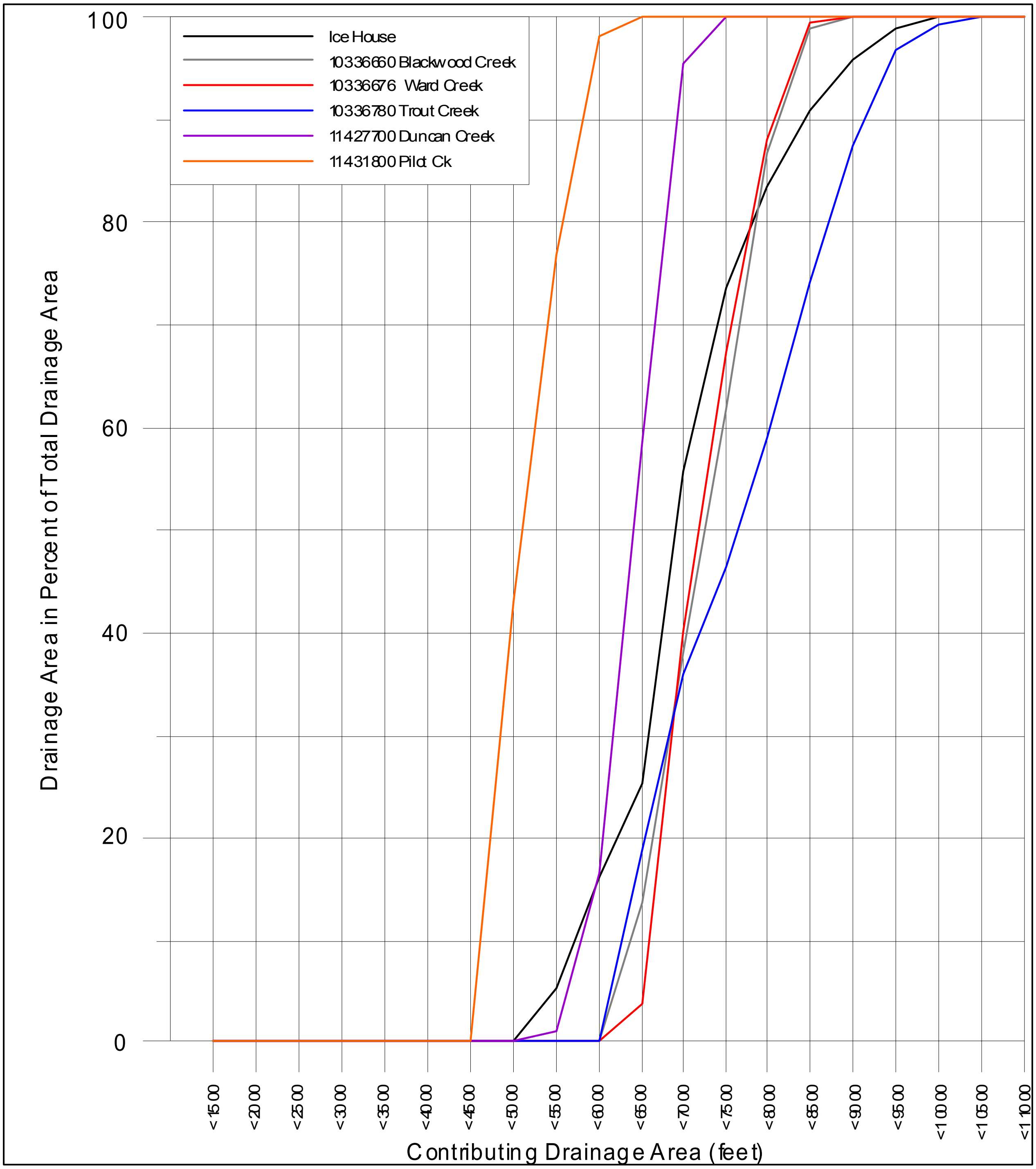


Figure 3.2.1-5. Ice House Reservoir Drainage Area Versus Elevation

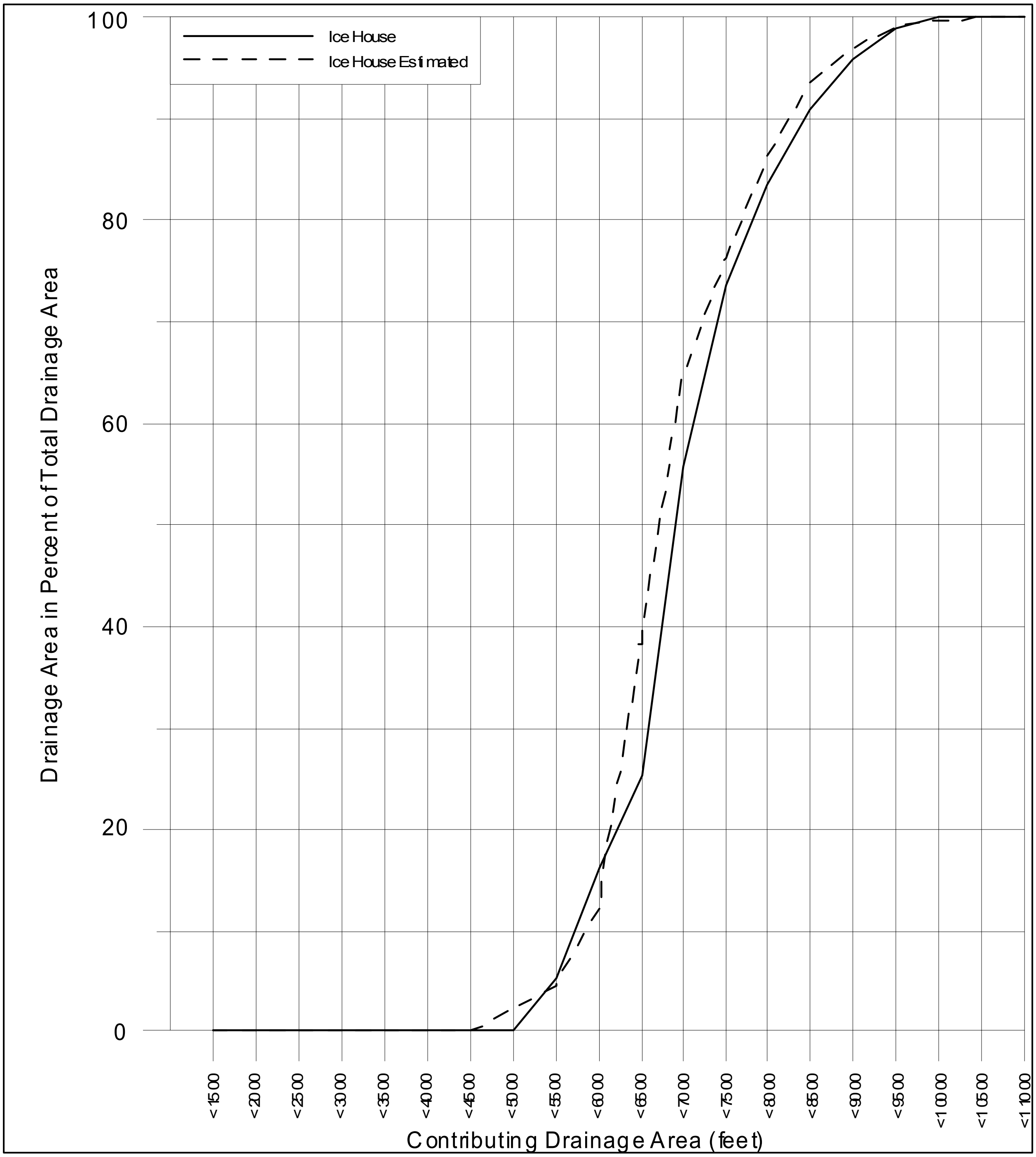


Figure 3.2.1-6. Ice House Reservoir Drainage Area Versus Elevation For Simulated Data

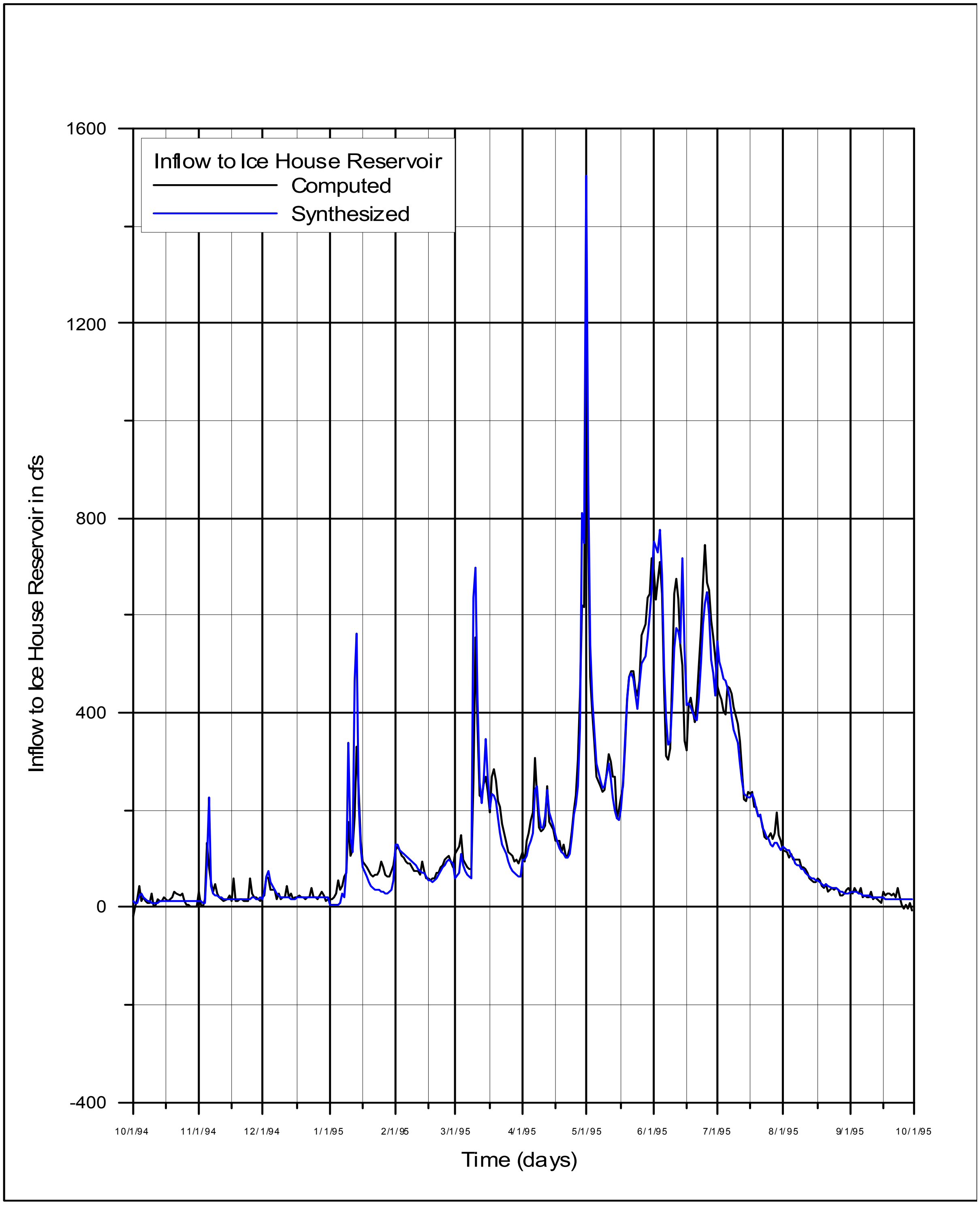


Figure 3.2.1-7. Unregulated Inflow to Ice House Reservoir, WY 1995

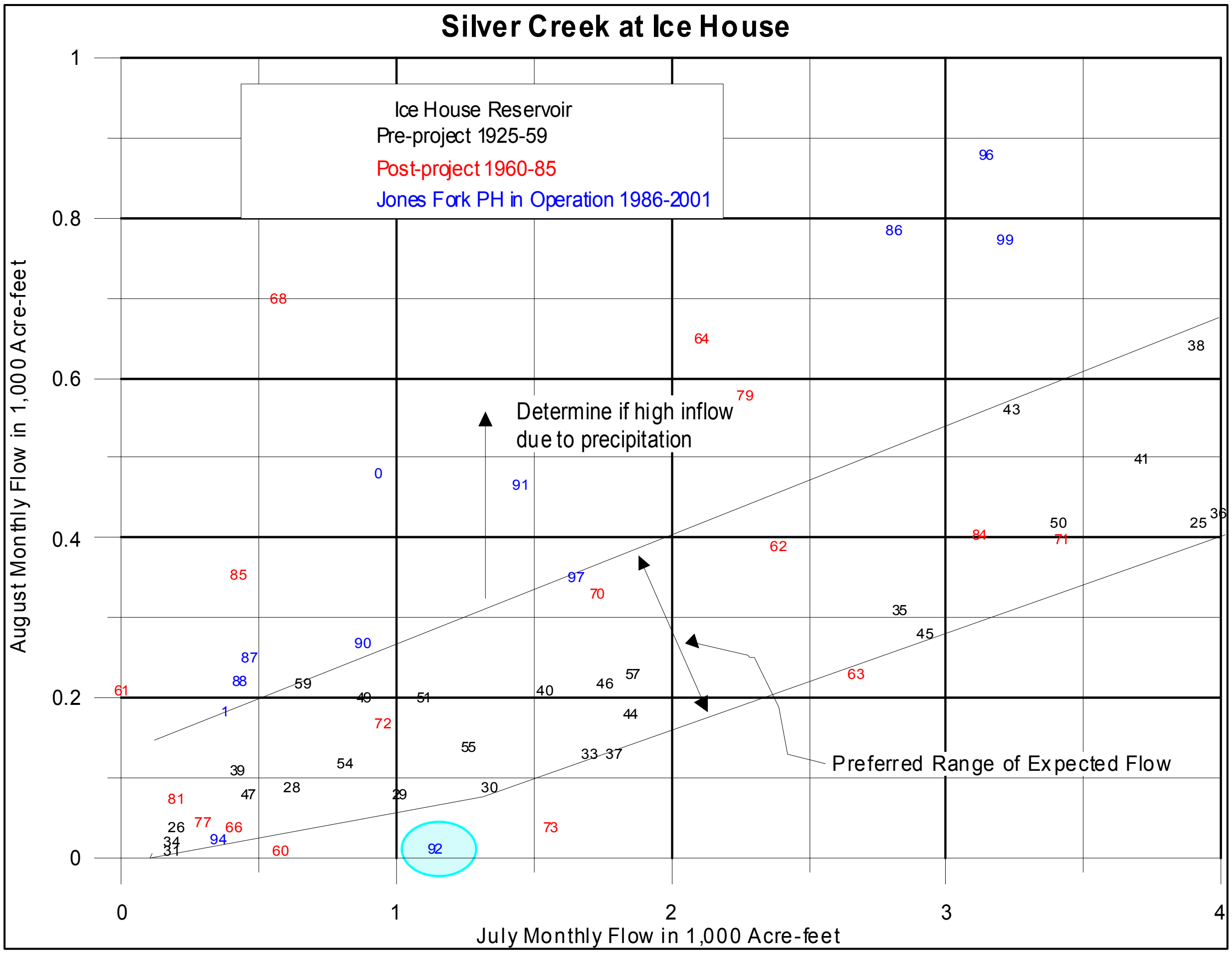


Figure 3.2.1-8. Silver Creek at Ice House, August Flow Versus July Flow

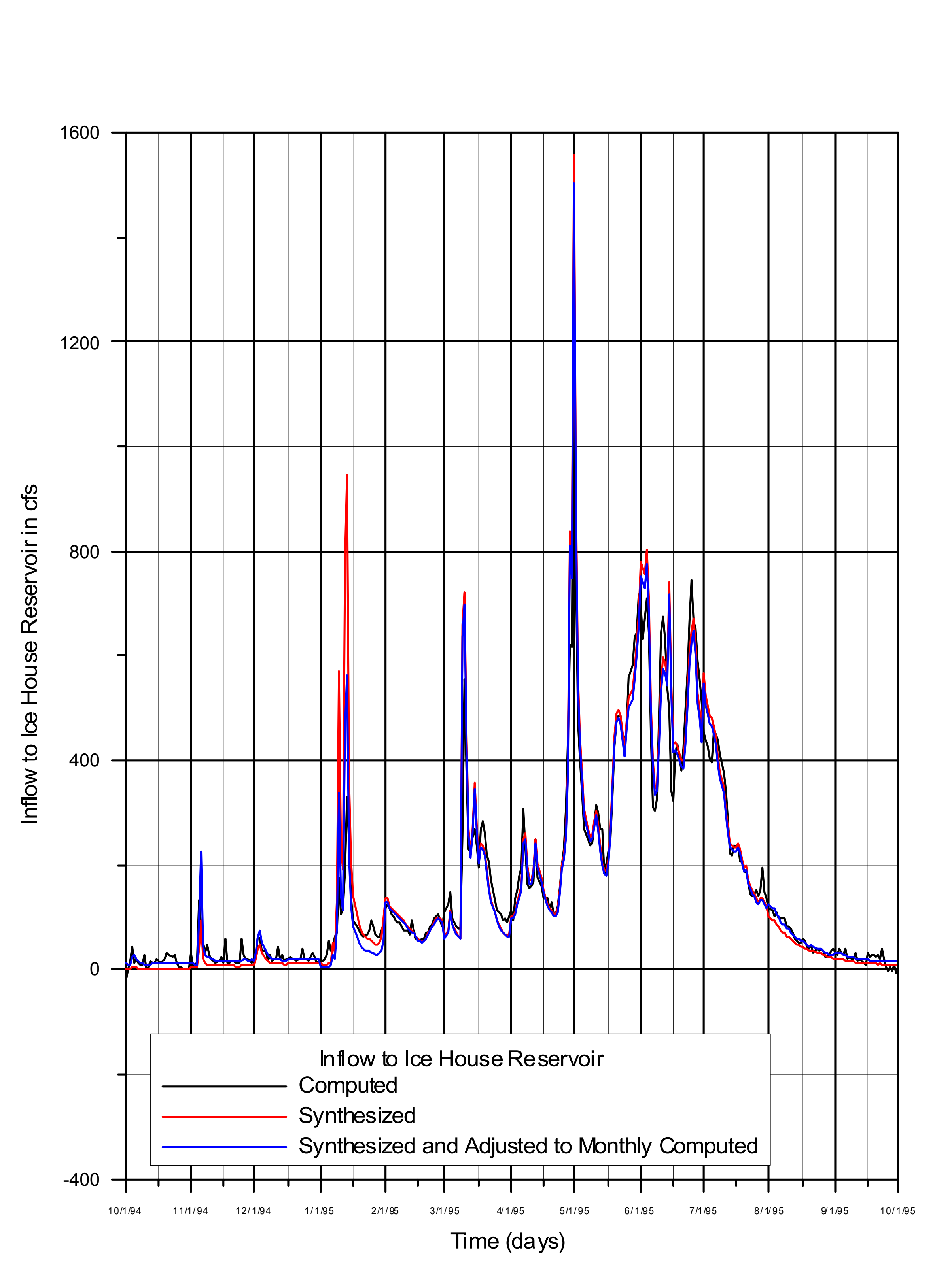


Figure 3.2.1-9. Unregulated Inflow to Ice House Reservoir, WY 1995

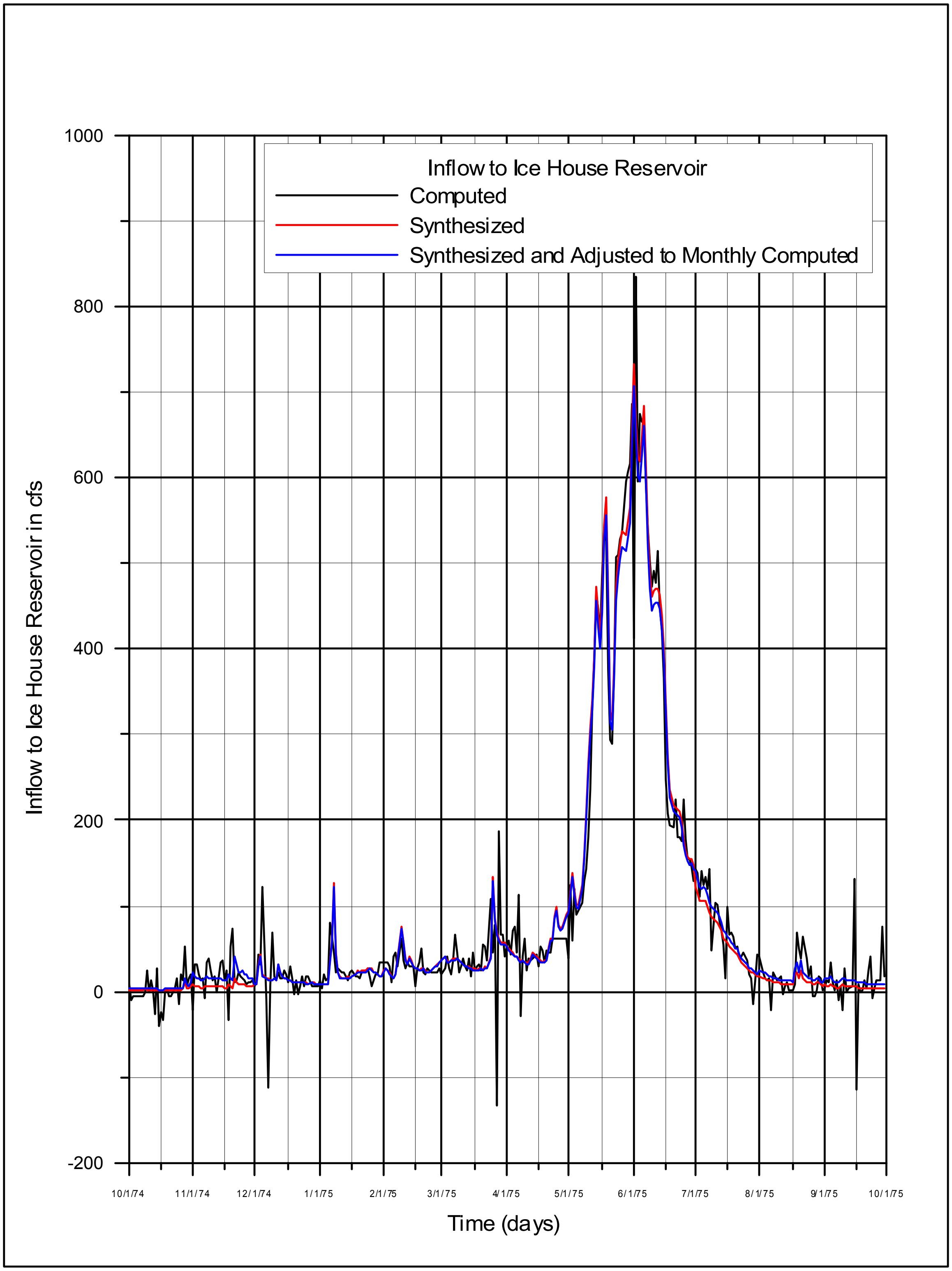


Figure 3.2.1-10. Unregulated Inflow to Ice House Reservoir, WY 1975

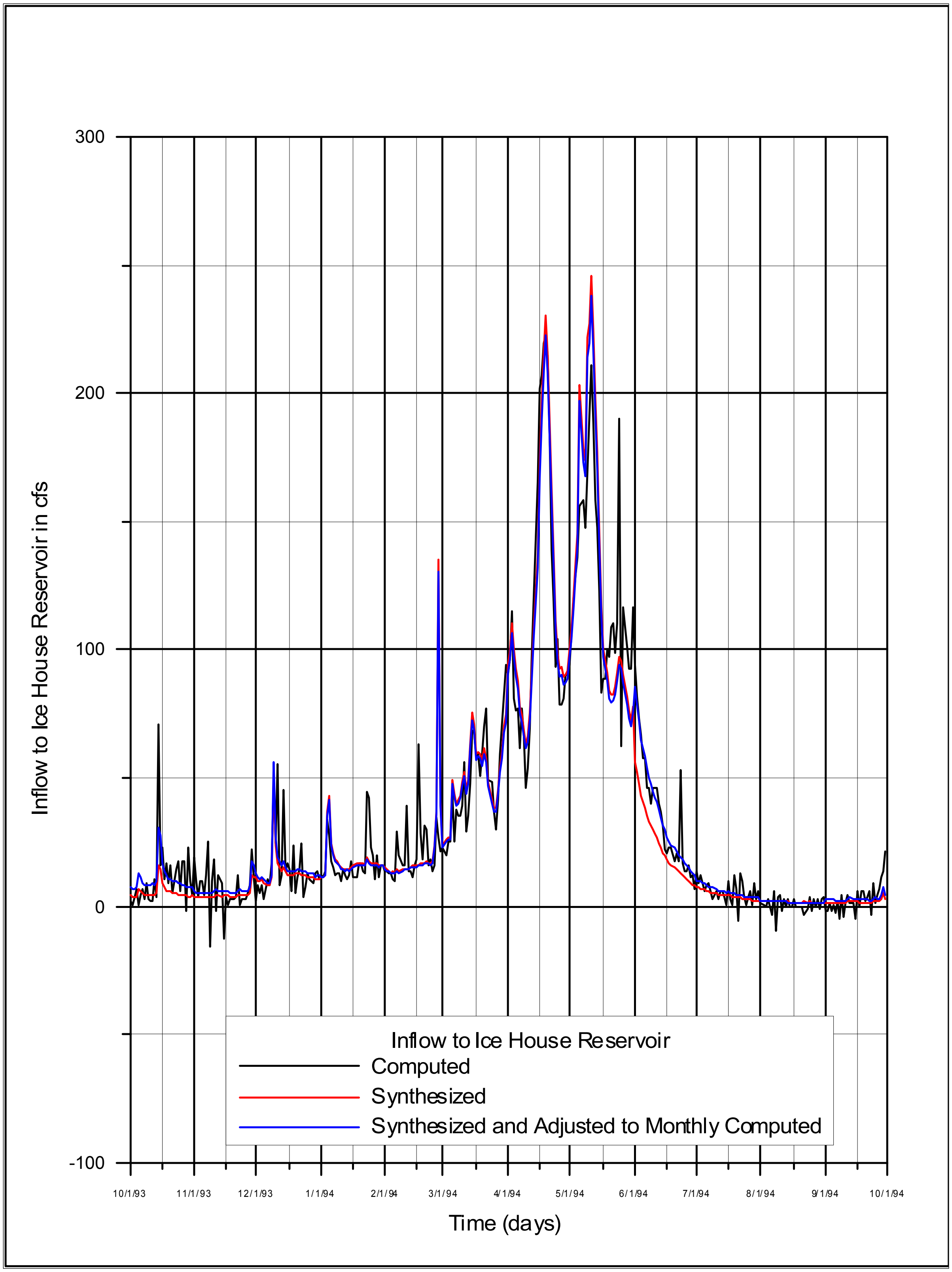


Figure 3.2.1-11. Unregulated Inflow to Ice House Reservoir, WY 1994

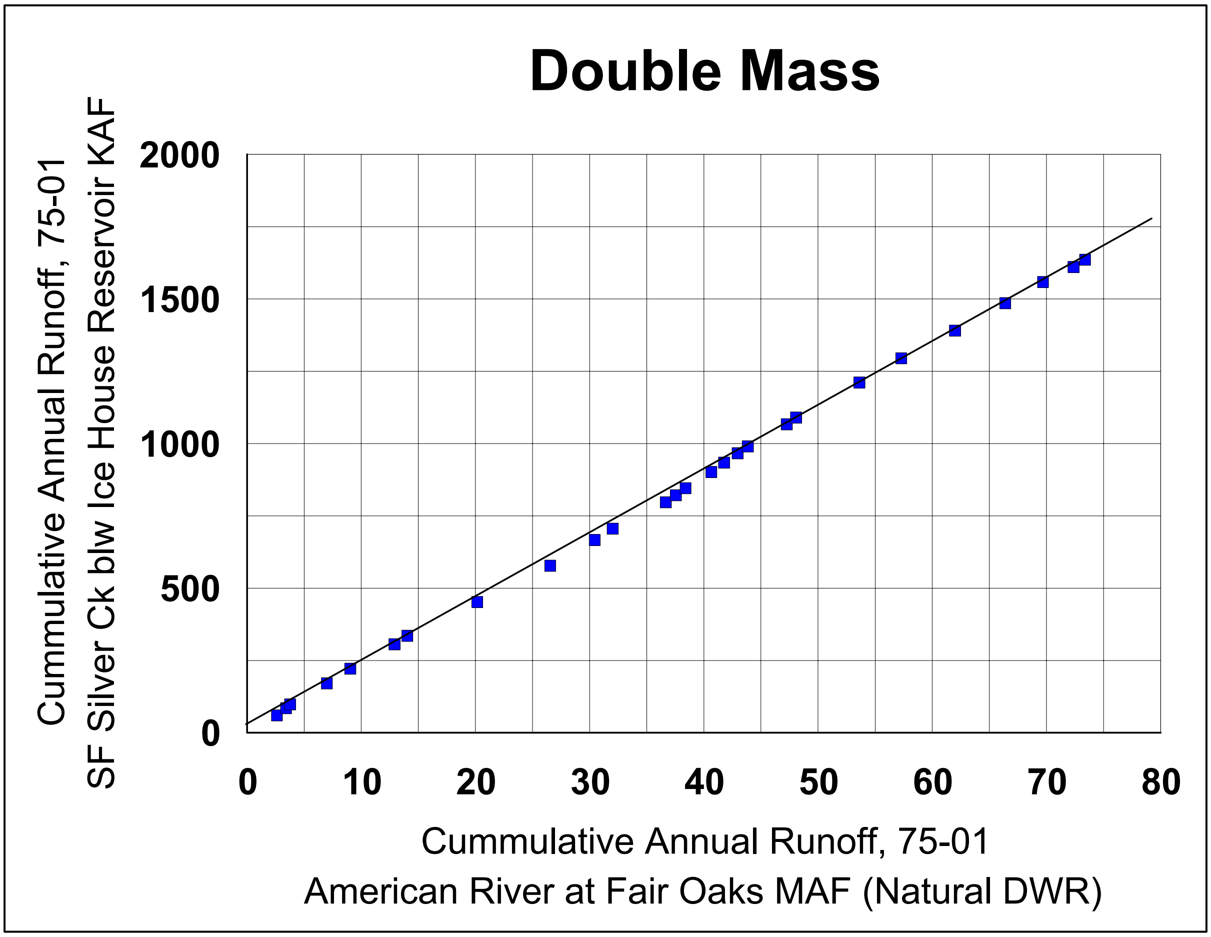


Figure 3.2.1-12. Double Mass – Cumulative Annual Runoff 75-01- Unregulated Inflow to Ice House Reservoir Versus Unregulated Inflow for the American River at Fair Oaks

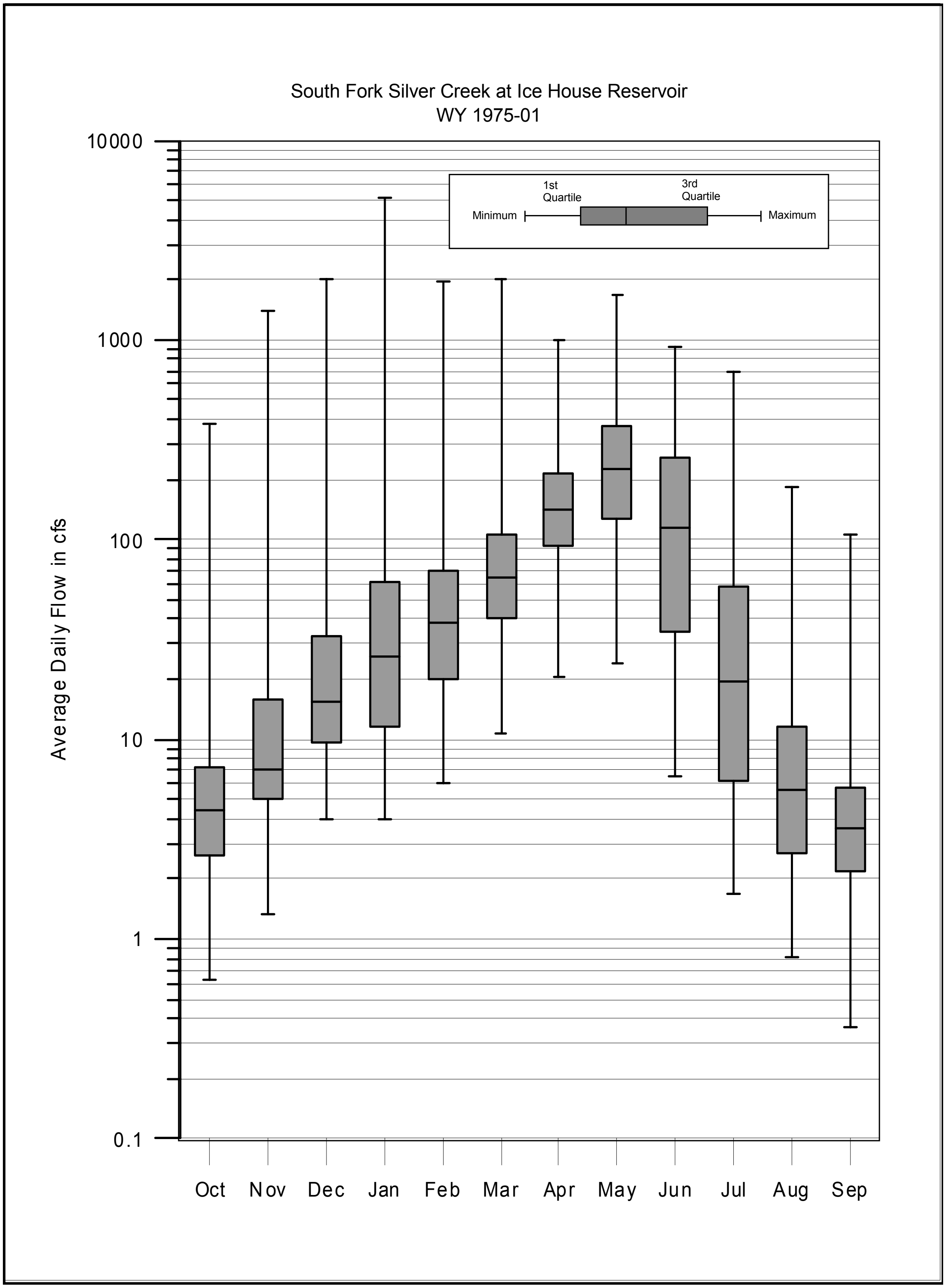


Figure 3.2.1-13. SF Silver Creek at Ice House Reservoir, Unregulated Inflow, Monthly Box-whisker Diagram

3.2.2 Rubicon River at Rubicon Reservoir

Rubicon Reservoir is located on the Rubicon River. The drainage area is about 26.5 square miles and ranges in elevation from 6,545 to almost 9,500 feet. The watershed is covered by granite. The dam was built in 1963.

Since 1993, SMUD has monitored all water management components required to compute the unregulated inflow on a daily basis (reservoir storage, diversion through Rubicon-Rockbound Tunnel, instream release and estimated spill). The computed unregulated inflow was initially calculated for this period of record using a mass balance procedure. The analysis produced several summer months with inflow computed as a negative value, primarily associated with low flow periods. As a means of reducing the number of computed negative values, the daily data were adjusted for net evaporation (Loon Lake net evaporation coefficients were assumed for Rubicon Reservoir). Though the net evaporation is small, about 2 cfs during the summer, in many years it exceeds the actual inflow to the reservoir.

Daily inflows to Rubicon Reservoir were synthesized based on the area/elevation and regression procedure. The method applied to synthesize the unregulated daily inflows to Rubicon Reservoir is very similar to the technique applied at Ice House. A multiple regression analysis is performed using monthly data for the 1993-2001 period and daily data are developed from the monthly equations. The monthly results appear reasonable, but comparison of daily synthesized flows to “computed” unregulated flow data for recent years (figures 3.2.2-1 and 3.2.2-2) are only considered to be fair in quality. The black line represents the computed daily inflow for Rubicon Reservoir based on a mass balance of gaged flows and computations. The red line represents the synthesized daily inflow based on the area/elevation and regression procedure.

The daily synthesized values do not replicate the “flashy” daily flow characteristics apparent in the computed flows. The final evaluation of the results demonstrated that the technique developed is best suited when nearby drainage basins exhibit similar soil characteristics. Because Rockbound Valley has extremely low levels of soil development, unlike the nearby drainages, the synthesis procedure did not provide satisfactory results on a daily basis.

To better synthesize a daily record, procedures using all available “in-basin” data were used to estimate the daily unregulated inflows for the investigation period. The available data over the investigation period varies but can be broken into three periods as described in Table 3.2.2-1.

Table 3.2.2-1. Computed Unregulated Inflow Data to Rubicon Reservoir

Period of Record	Quality of unregulated Flow Estimate and Comments
1993-2001: All components required to compute unregulated inflow are monitored (Figure 3.2.2-3)	Best: All data available to compute unregulated inflow except for spill that was estimated. Short periods of computed negative streamflow data were smoothed with surrounding data.
1975-1986: Estimated daily record based on computed unregulated inflow at the Rubicon River at Rubicon Springs, sporadic monthly storage data (Figure 3.2.2-4)	Better: Available data included some change in storage (sporadic), tunnel diversion, and flow at the Rubicon River at Rubicon Springs. Sporadic measurements above the reservoir to set the instream release flow below the reservoir. In addition to the sporadic storage data, dates of tunnel settings.

Table 3.2.2-1. Computed Unregulated Inflow Data to Rubicon Reservoir	
Period of Record	**Quality of unregulated Flow Estimate and Comments**
1987-1992: Based on Rubicon-Rockbound diversion and data from nearby gages (Figure 3.2.2-5)	Good: Unregulated inflow data were based on diversion data and estimates of flow below the reservoir. In 1991, a low-flow gage was installed below the reservoir.

Based on review of the records, the only data that are consistently available throughout the investigation period are: (1) the tunnel diversion and (2) the flow below the reservoir (missing data through a dry sequence 1987-1991). To evaluate the quality of computed unregulated flow estimates based solely on tunnel diversion and flow below the reservoir, the data for the period 1993-2001 was reanalyzed by computing the unregulated inflow based on the two components only. The two-component computed values were compared to the full-component computed values (i.e., unregulated flows computed from data for diversion, releases, spill, change in storage and evaporation). The results of the comparison for a wet year and dry year are provided in figures 3.2.2-6 and 3.2.2-7, respectively. The black line represents the computed daily inflow for Rubicon Reservoir based on a mass balance of gaged flows and computations. The blue line represents the synthesized daily inflow based solely on tunnel diversion and flow below the reservoir. As seen on Figure 3.2.2-6, the two-component computation will underestimate the inflow when there is spill or when the reservoir is being filled at the end of the runoff season (highlighted in red). In a dry year (Figure 3.2.2-7) it is apparent (highlighted in red) when the diversion gates are being removed and installed which results in large changes in reservoir storage. Apart from these limited difficulties, using only the diversion and the release below the reservoir provides a very satisfactory estimate of the unregulated inflow. This conclusion provided the opportunity to develop unregulated flow information for the 1975-1986 and 1987-1992 periods when less than a full record of all of the flow components necessary for a mass balance computation is available.

Methodology Applied: 1975-1986

For the 1975-86 period unregulated flow for the Rubicon River at Rubicon Springs was computed using the USGS gage data at this location. These estimates are improved with the addition of sporadic Rubicon Reservoir storage information, net evaporation and information for the opening and closure dates of the tunnel. The final data are adjusted proportionately by area to estimate the Rubicon River at Rubicon Reservoir:

Rubicon R. at Rubicon Reservoir (flow in cfs) = Rubicon R. at Rubicon Springs (flow in cfs) times Rubicon R. at Rubicon Reservoir drainage area (26.5) divided by Rubicon R. at Rubicon Springs drainage area (31.4)

The flow adjustment described above assumes that the runoff per square mile is about equal for the two drainage basins.

Methodology Applied: 1987-1992

For the 1987-91 period, there are no continuous estimates of releases from Rubicon Reservoir. Thus, these values are estimated from other available data. One source of data is the sporadic measurements above the reservoir that are used to set the reservoir release during the summer months. Another source of information is the results of the synthesis procedure. Although the synthesis procedure using nearby drainage gage data yielded only fair results, the low flow estimates nonetheless provided guidance for estimating flows during the summer months. The results shown in figures 3.2.2-1 and 3.2.2-2, illustrate that the synthesis procedure performed well during the summer months.

By water year 1992, SMUD installed a low flow gage below the reservoir. SMUD has also estimated the spill below Rubicon Reservoir for the period 1992-2001. These unregulated inflow estimates appear to be very good.

Consistency of Simulated Record: 1975-2001

As a final evaluation of the quality of the unregulated inflow data for the full investigation period (1975-2001), a consistency (or homogeneity) analysis was performed using the double mass procedure comparing this location's inflow with the unregulated inflow data for the South Fork Silver Creek at Ice House Reservoir. The initial double mass plot indicated the period 1975-86 was not consistent with the latter record. The inconsistency is thought to be due to the procedure that calculated the unregulated flow for the period 1975-86 from the computed unregulated flow at Rubicon River at Rubicon Springs. Based on the results illustrated in the double mass diagram, the runoff per square mile into the Rubicon Reservoir appears to be greater than the runoff per square mile for the Rubicon River at Rubicon Springs. The adjustment used to develop a consistent record required an increase in the daily unregulated inflow for the period 1975-1986 by 3 percent:

Rubicon R. at Rubicon Reservoir (flow in cfs) =	Rubicon R. at Rubicon Springs (flow in cfs) times Rubicon R. at Rubicon Reservoir drainage area (26.5) divided by Rubicon R. at Rubicon Springs drainage area (31.4) times 1.03

Another way to interpret the adjustment is that the runoff per square mile is about 3 percent greater for the Rubicon River at Rubicon Reservoir than the Rubicon River at Rubicon Springs. The final double mass diagram is provided in Figure 3.2.2-8.

A box-whisker diagram describing the daily flow characteristics by month is provided as Figure 3.2.2-9. The average annual runoff at Rubicon Reservoir is 79,000 acre-feet. A table of monthly runoff at this site for the period 1975-2001 is included in Appendix B.

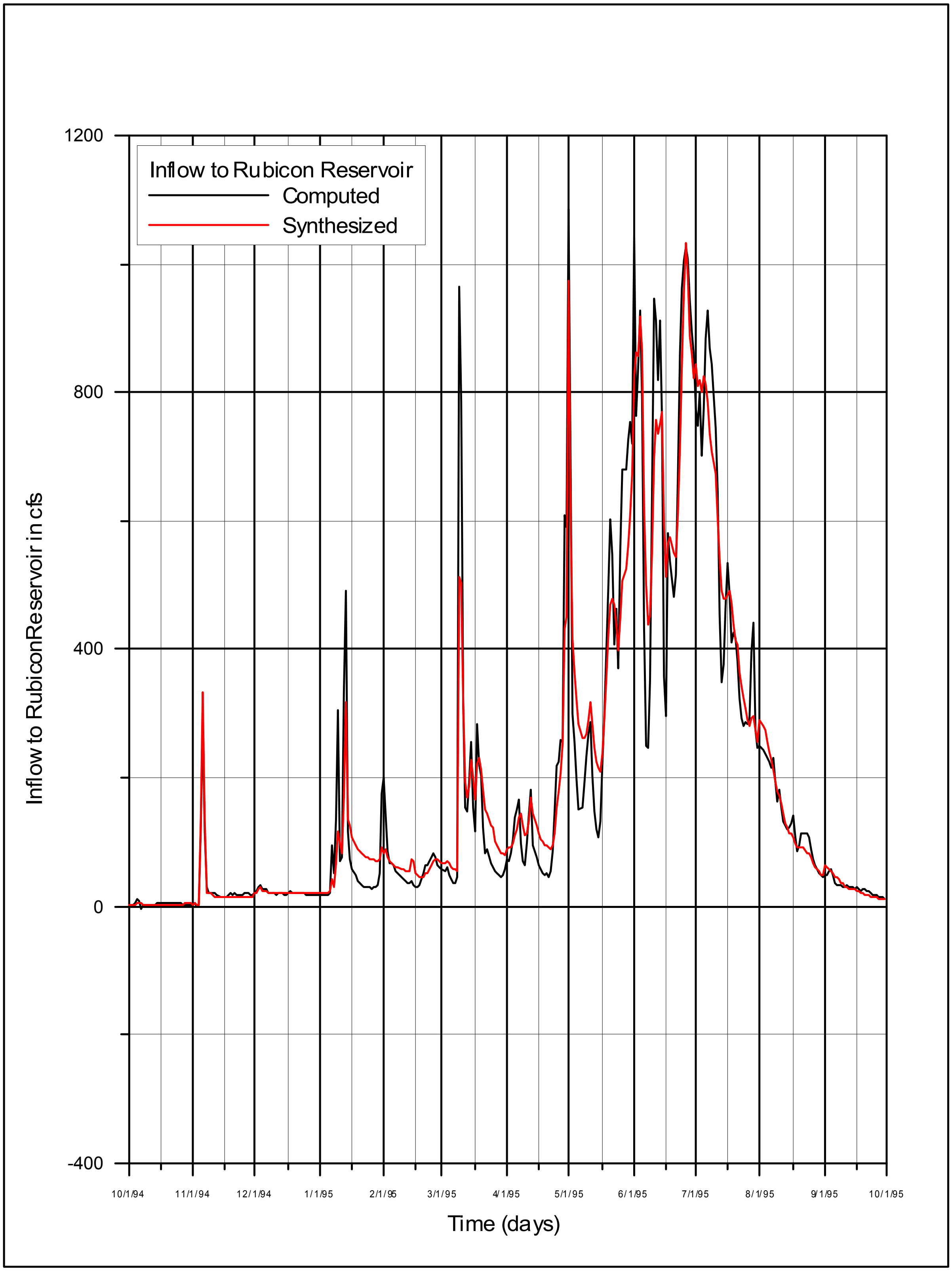


Figure 3.2.2-1. Unregulated Inflow to Rubicon Reservoir, WY 1995

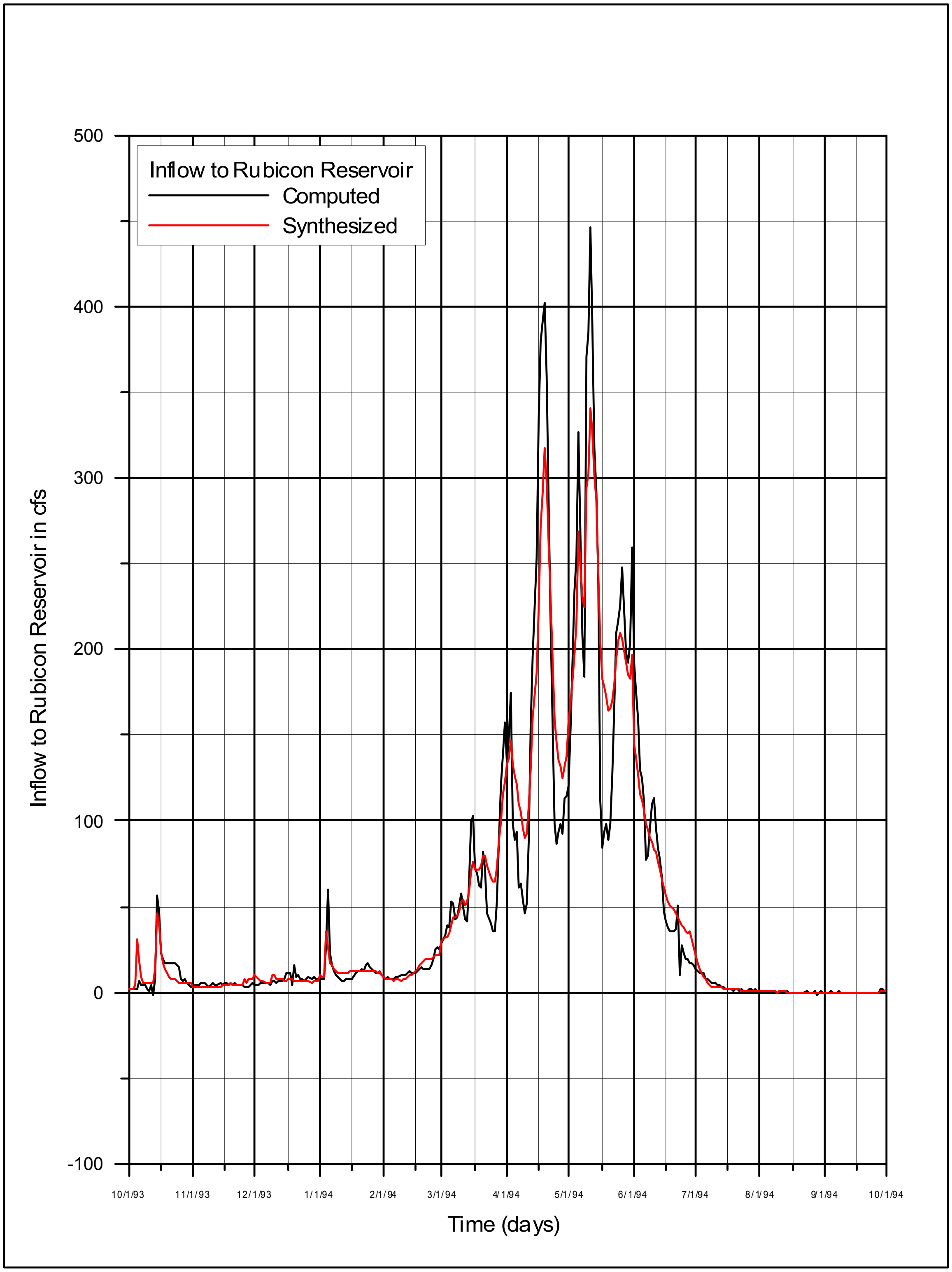


Figure 3.2.2-2. Unregulated Inflow to Rubicon Reservoir, WY 1994

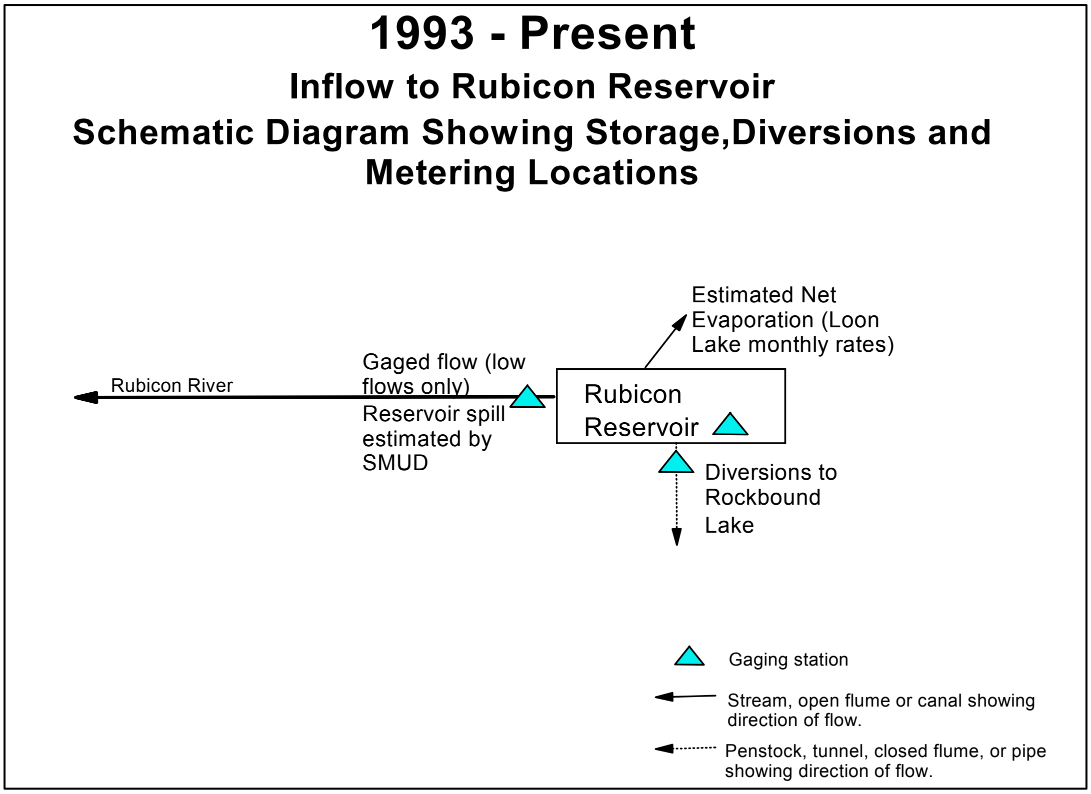


Figure 3.2.2-3. Inflow to Rubicon Reservoir – Schematic Diagram Showing Storage, Diversions and Metering Locations, 1993-Present

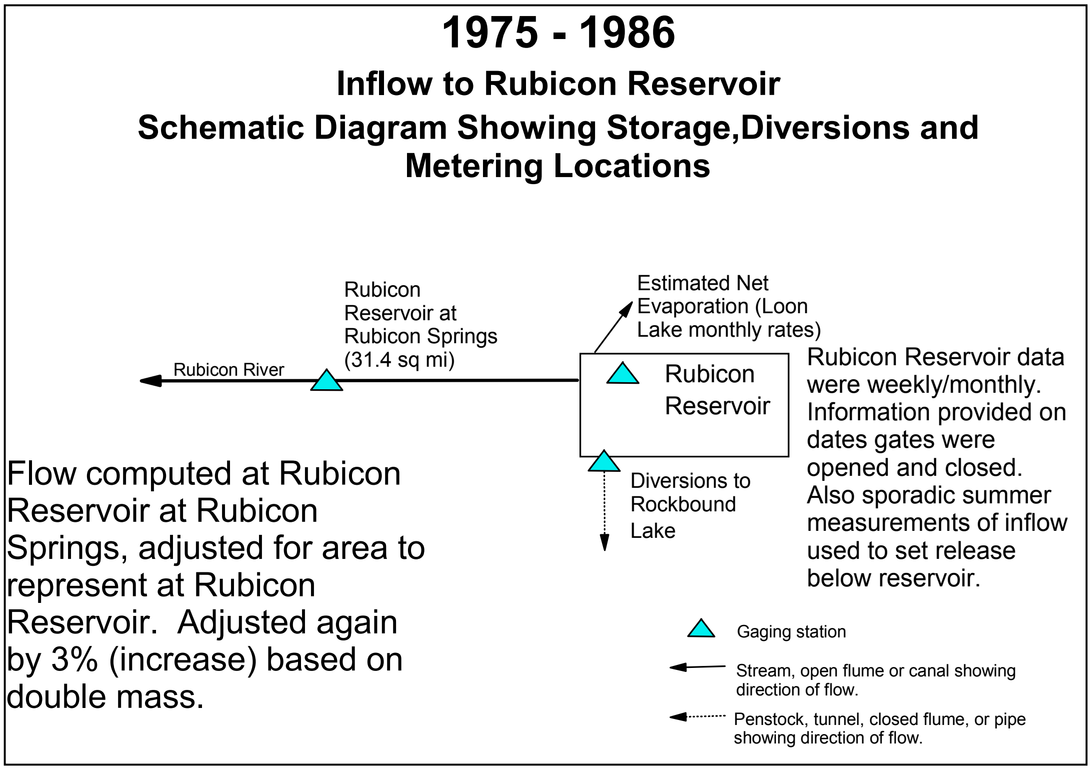


Figure 3.2.2-4. Inflow to Rubicon Reservoir – Schematic Diagram Showing Storage, Diversions and Metering Locations, 1975-1986

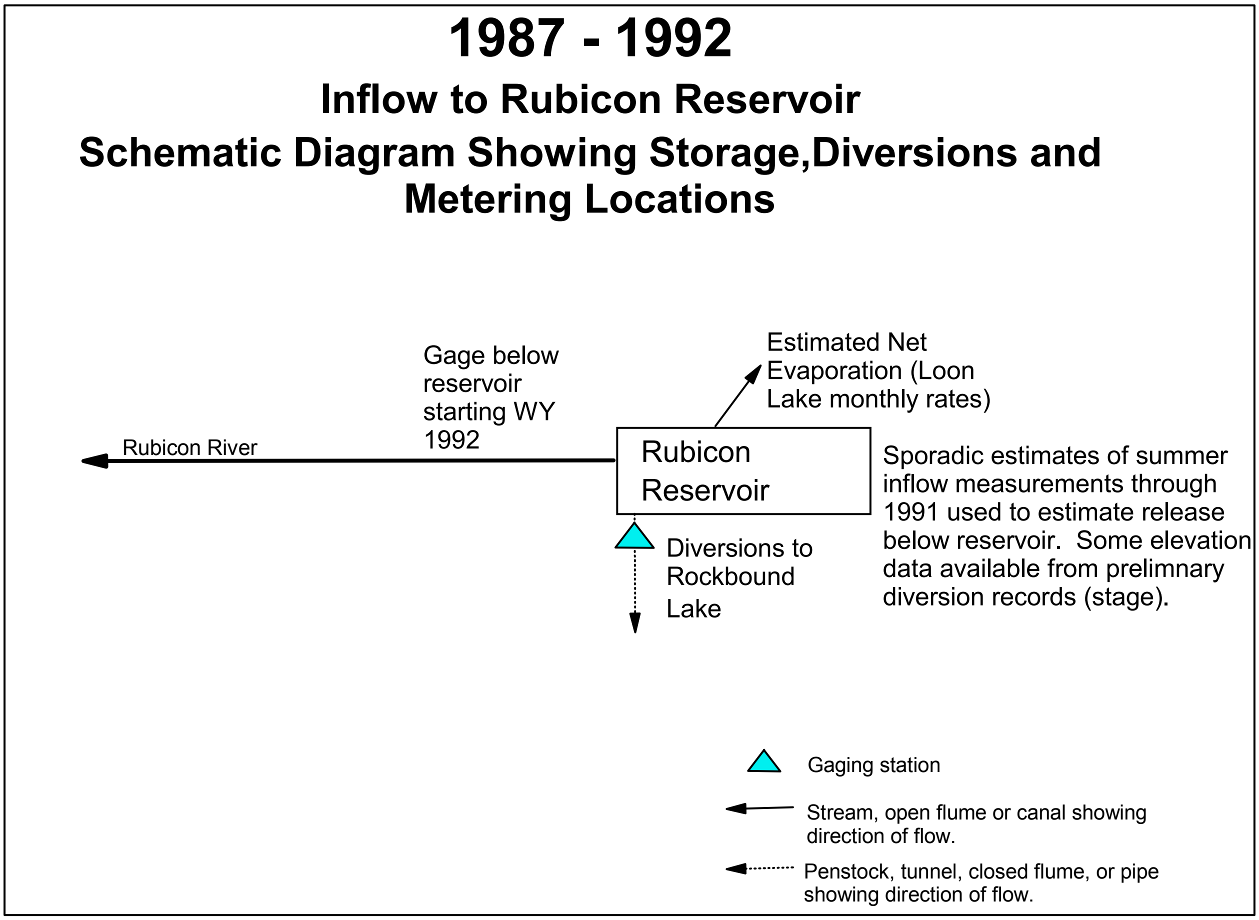


Figure 3.2.2-5. Inflow to Rubicon Reservoir – Schematic Diagram Showing Storage, Diversions and Metering Locations, 1987-1992

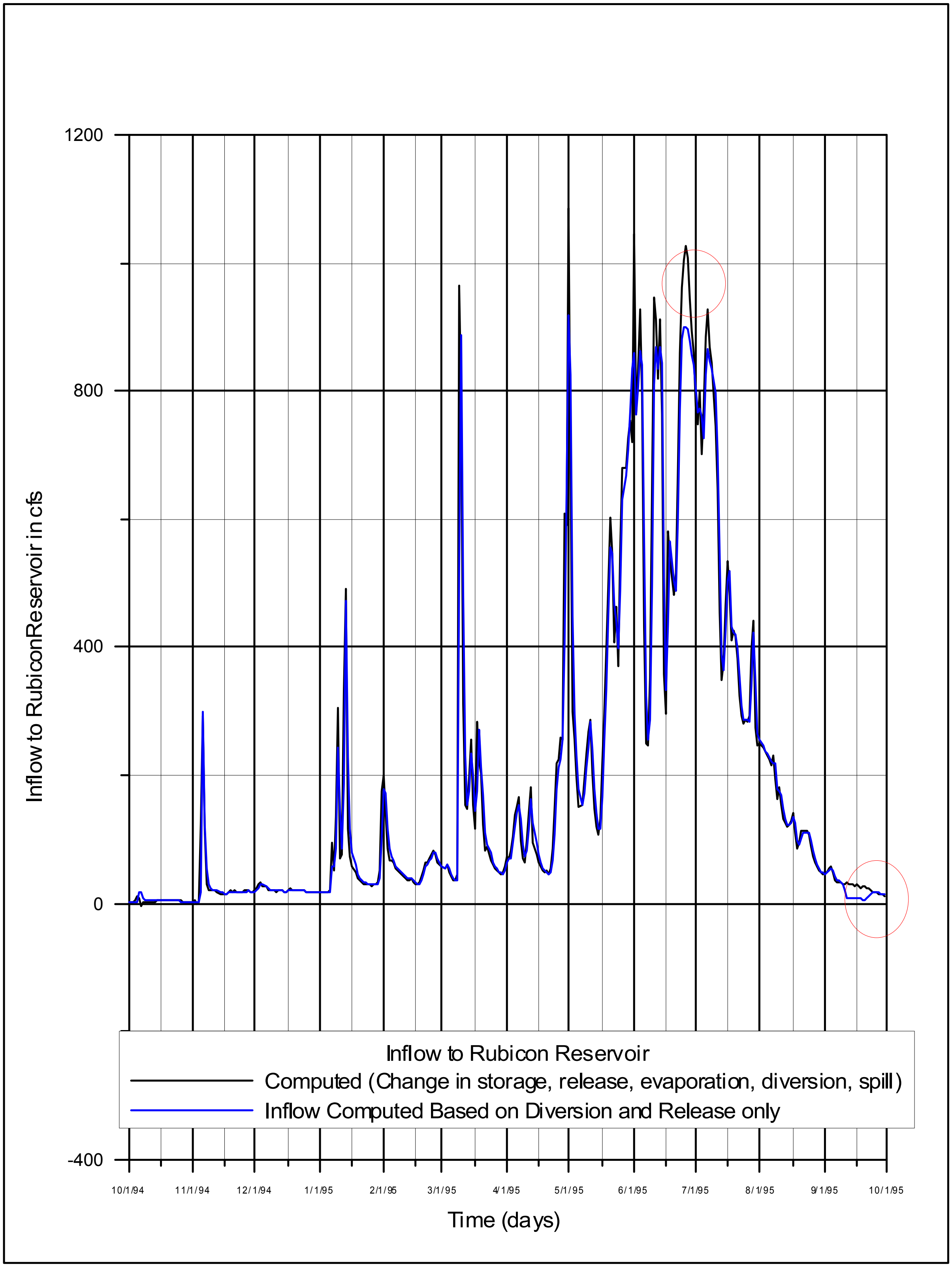


Figure 3.2.2-6. Unregulated Inflow to Rubicon Reservoir, WY 1995

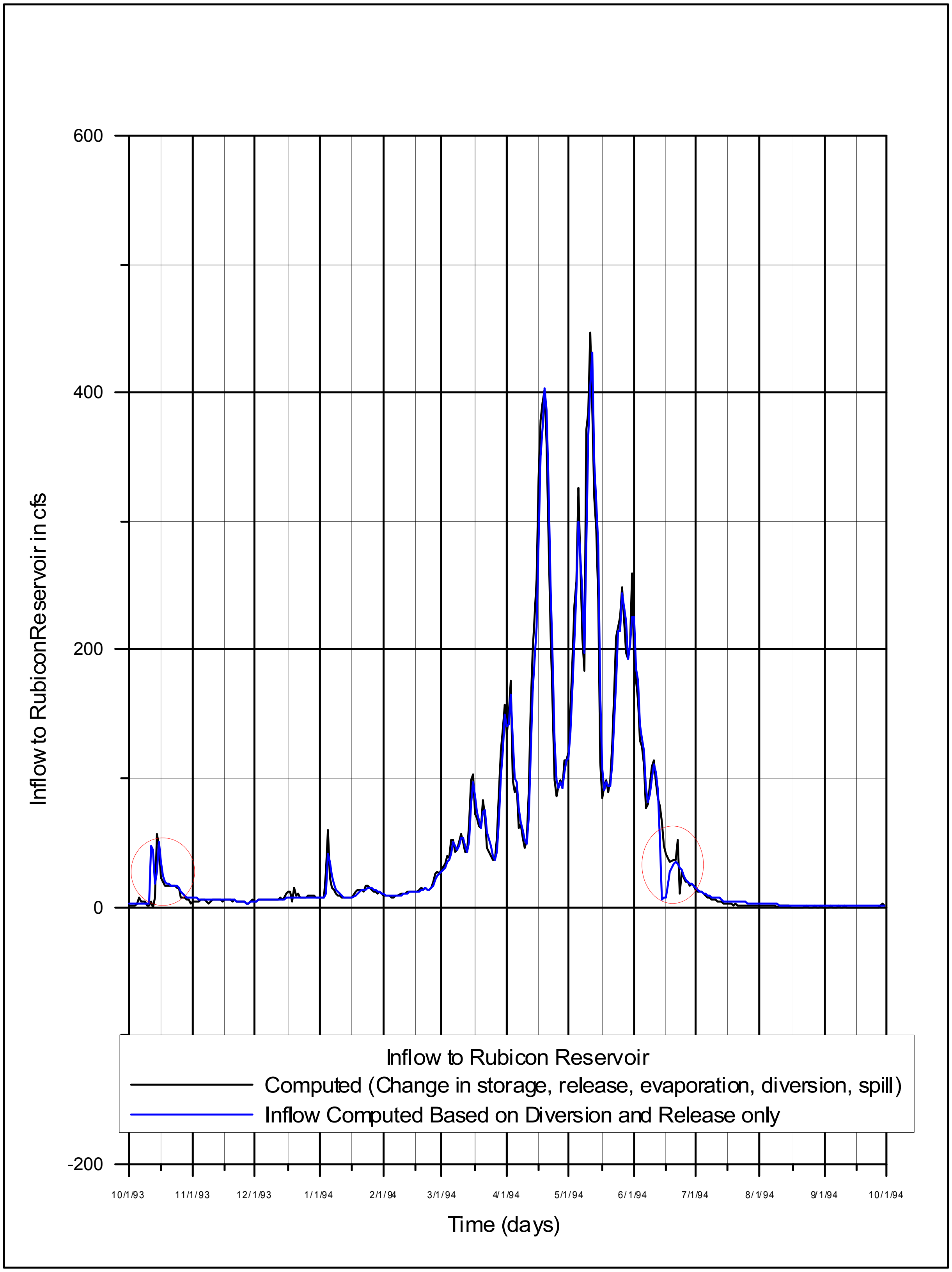


Figure 3.2.2-7. Unregulated Inflow to Rubicon Reservoir, WY 1994

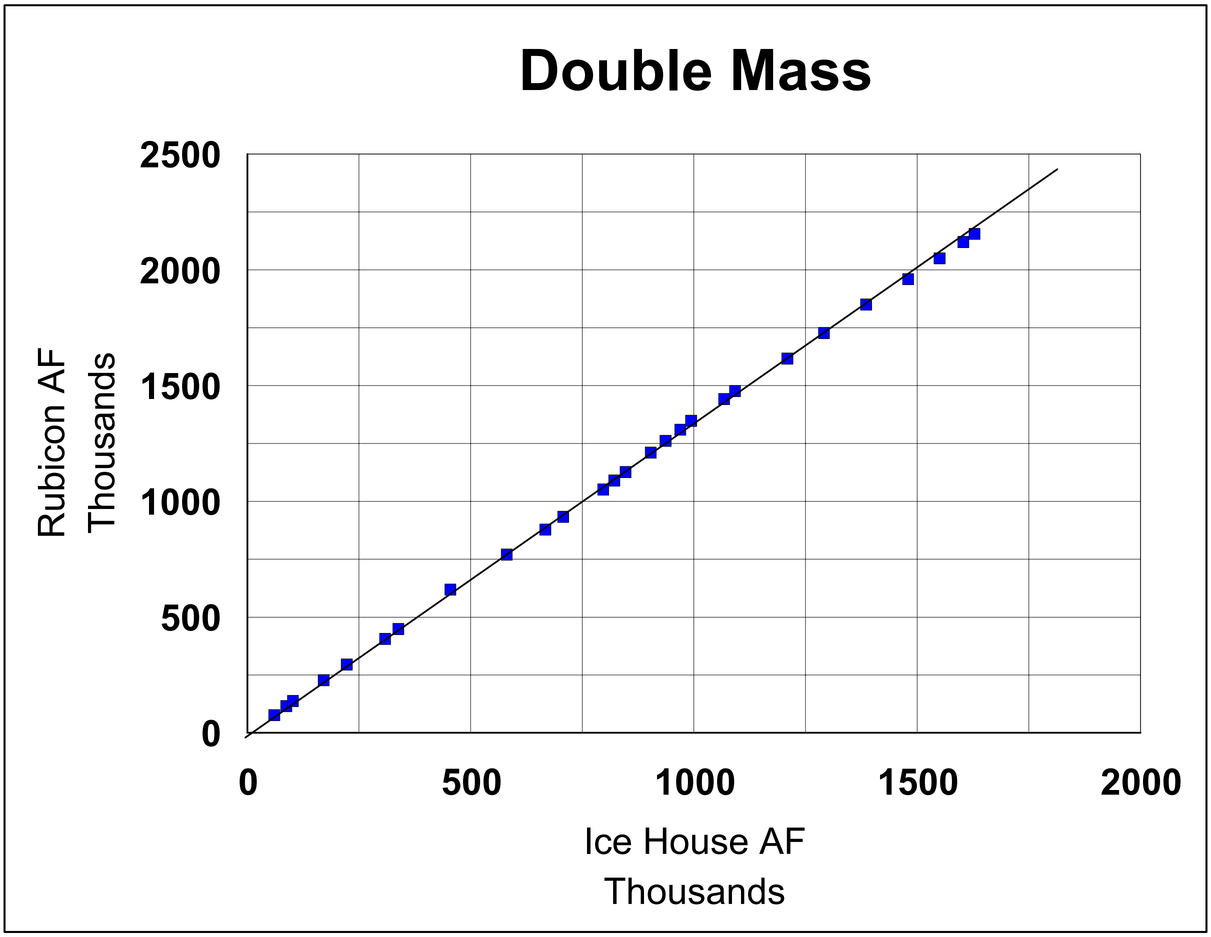


Figure 3.2.2-8. Double Mass – Unregulated Inflow to Rubicon Reservoir Versus Unregulated Inflow to Ice House Reservoir

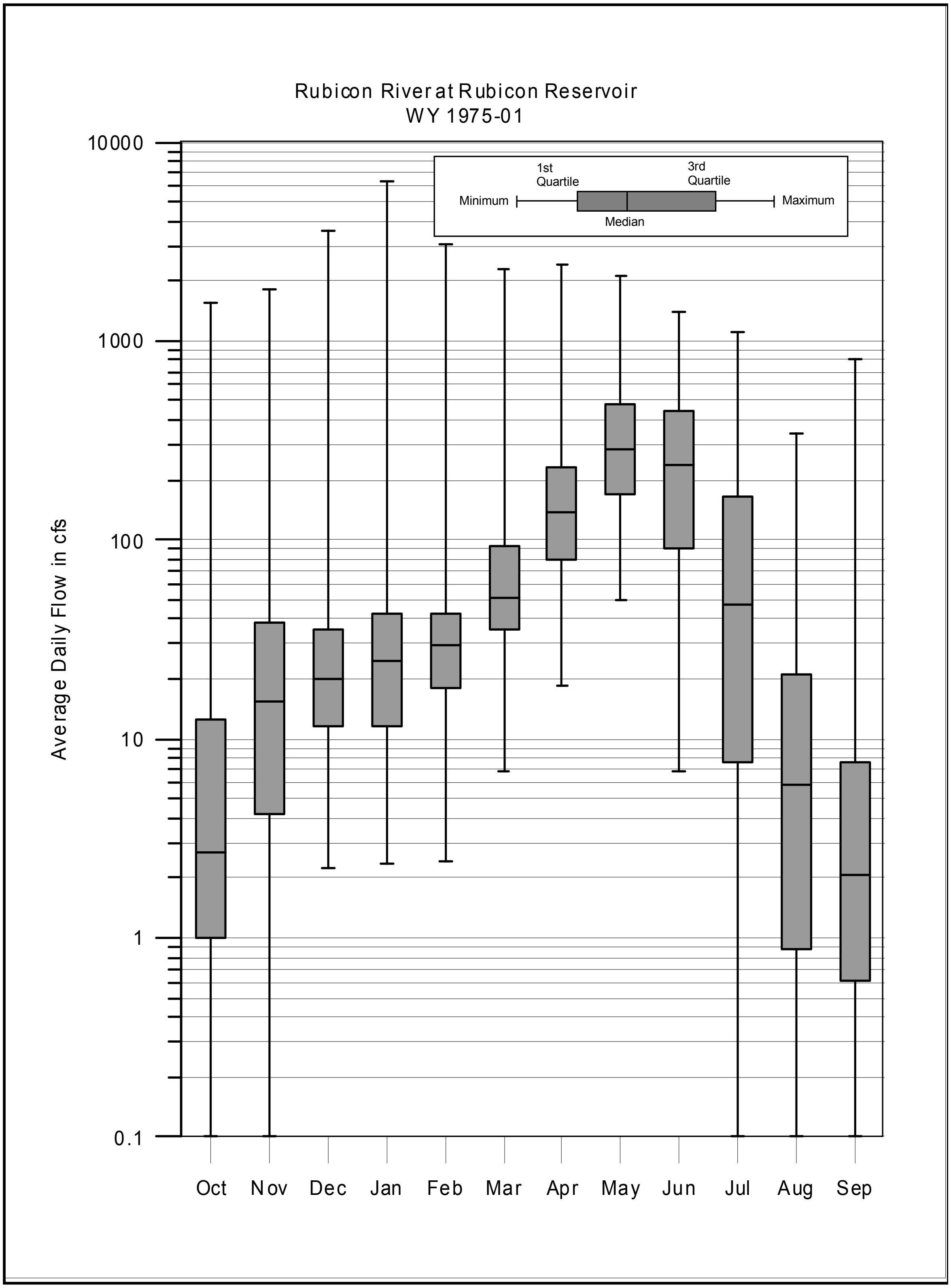


Figure 3.2.2-9. Rubicon River at Rubicon Res., Unregulated Inflow, WY 1975-01, Monthly Box-whisker diagram

3.2.3 Little Rubicon River at Buck Island Reservoir

Buck Island Reservoir is located on the Little Rubicon River. The drainage area is about 26.5 square miles and ranges in elevation from 6,440 to almost 9,500 feet. The watershed is covered by granite. The dam was built in 1963.

As with the Rubicon Reservoir system, SMUD has, since 1993, monitored all water management components required to compute the unregulated inflow on a daily basis (reservoir storage, diversion through Rubicon-Rockbound Tunnel, instream release and estimated spill). The computed unregulated inflow was calculated using a mass balance procedure. An initial analysis resulted in the inflow being computed as a negative value in several summer months, primarily associated with low flow periods. As a means of reducing the number of computed negative values, the daily data were adjusted for net evaporation (Loon Lake net evaporation coefficients were assumed for Buck Island Reservoir). Though the net evaporation is small, about 1 cfs during the summer, in many years it exceeds the actual inflow to the reservoir.

Available data for the site are summarized in Table 3.2.3-1.

Table 3.2.3-1. Computed Unregulated Inflow Data to Buck Island Reservoir

Period of Record	Use in Computing Unregulated Inflow
1993-2001: All components required to compute unregulated inflow are monitored (Figure 3.2.3-1)	Best: All data available to compute unregulated inflow (estimated spills). Short periods of computed negative streamflow data were smoothed with surrounding data. Diversions into the basin are lagged for 12 hours[1].
1975-1992: Estimated daily record includes diversions in and out of basin (Figure 3.2.3-2)	Good: It was determined that the same procedure used on the Rubicon will be applied at Buck Island. The unregulated inflow is be estimated as: Diversions out of the basin Diversions into the basin (lagged by 12 hours)[1] plus Estimate of net evaporation plus Estimate of instream release (1 cfs)

[1]Based on conversations with SMUD staff

Using the same approach applied to the Rubicon River, the daily inflow was estimated from the available “in-basin” data. Because a record for the full complement of water management components is not available for the entire period of investigation, an analysis was performed to evaluate the validity of computing inflow values from the partial information. This was accomplished by taking the data for the full-component period (1993-2001) and computing the inflow based on the water management components available for the 1975-1992 period (i.e., difference in diversions in and out of the basin). The partial-component computed values are then compared with the full-component computed values (including diversions, release and spill, change in storage and evaporation) for the period 1993-2001. Results of the comparison for a dry year, wet year and flood event are provided in figures 3.2.3-3 through 3.2.3-5, respectively. The black line represents the computed daily inflow for Buck Island Reservoir based on a mass balance of gaged flows and computations. The blue line represents the synthesized daily inflow based solely on partial-component data.

As seen in these figures, the partial-component computational procedure will underestimate the inflow when there is spill (Figure 3.2.3-5) or when the reservoir is being filled at the end of the runoff season. During the summer months the inflows are estimated to be too high because the instream release was made from water in storage. Daily unregulated flow estimates for the Rubicon River at Rubicon Reservoir were used to refine values for the spill and summer flow periods. For example, the computed inflow to Buck Island Reservoir for the month of July 1990 was greater than expected since the instream release more than likely was made from storage. These data would require adjustment. To make the adjustment, the inflow to Buck Island Reservoir was re- estimated using the daily inflow to Rubicon Reservoir (Rubicon Reservoir inflow multiplied by 0.2033 to adjust for differences in area). Next, these daily estimates were compared to Buck Island daily flows. The Buck Island computed flows were replaced with the estimate made using the Rubicon Reservoir inflow data. This procedure was not built into the spreadsheet but performed by hand checking each month and day.

Unregulated inflow data for this site were tested for consistency (or homogeneity) for the investigation period 1975 through 2001 through a comparison to the unregulated inflow for the South Fork Silver Creek at Ice House, and are illustrated in Figure 3.2.3-6. The data appear homogenous.

A box-whisker diagram describing the daily flow characteristics by month is provided as Figure 3.2.3-7. The average annual runoff at Buck Island Reservoir is 22,000 acre-feet. A table of monthly runoff at this site for the period 1975-2001 is included in Appendix B.

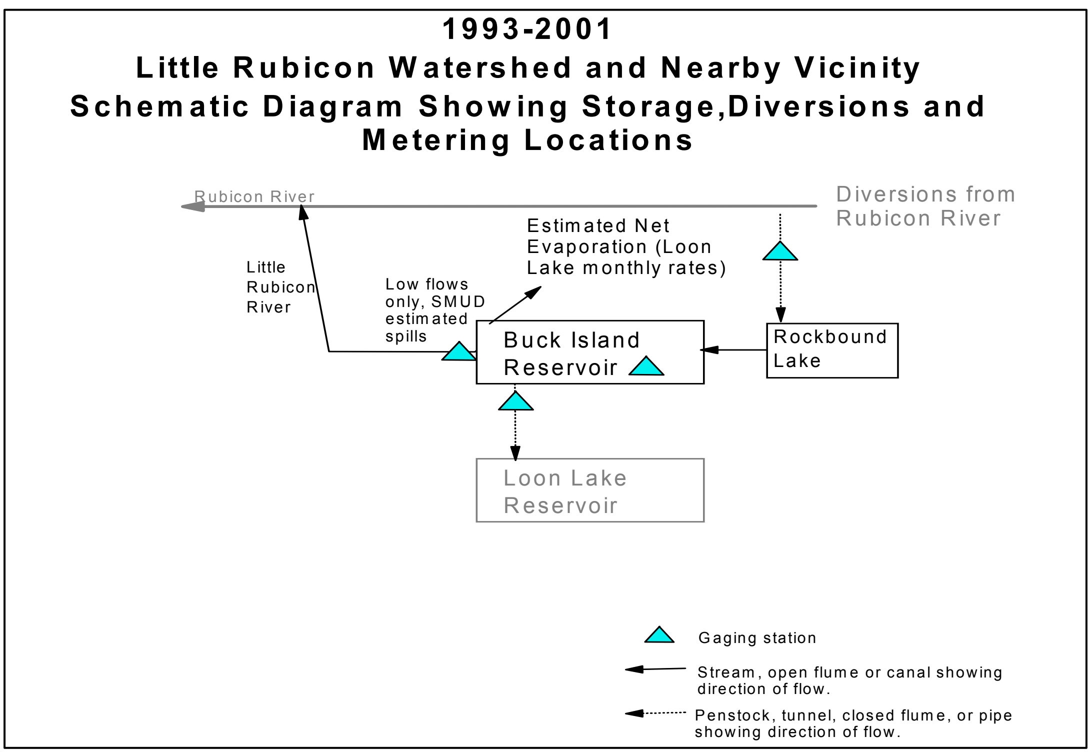


Figure 3.2.3-1. Little Rubicon Watershed and Nearby Vicinity – Schematic Diagram Showing Storage, Diversions and Metering Locations – 1993-2001

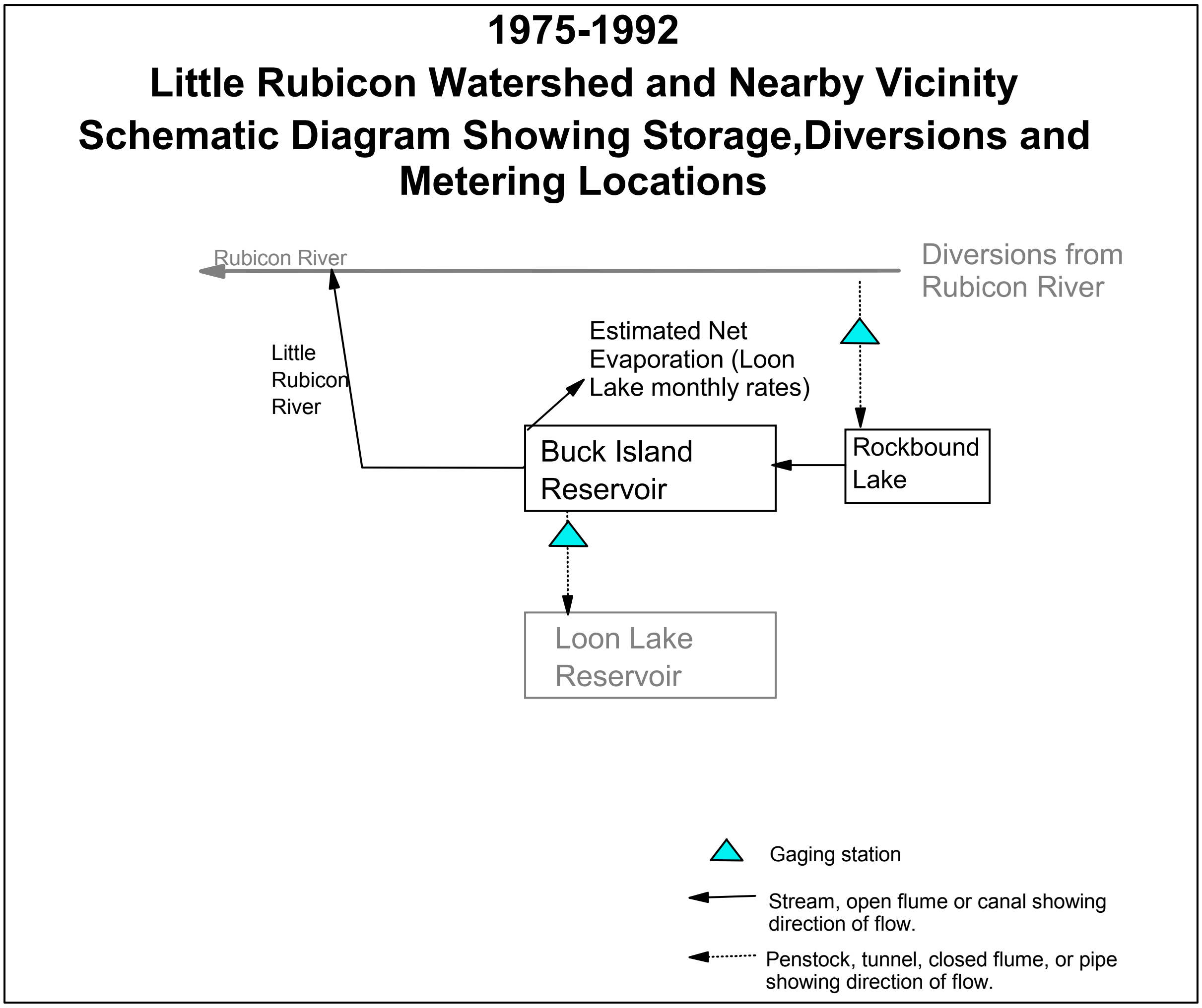


Figure 3.2.3-2. Little Rubicon Watershed and Nearby Vicinity – Schematic Diagram Showing Storage, Diversions and Metering Locations – 1975-1992

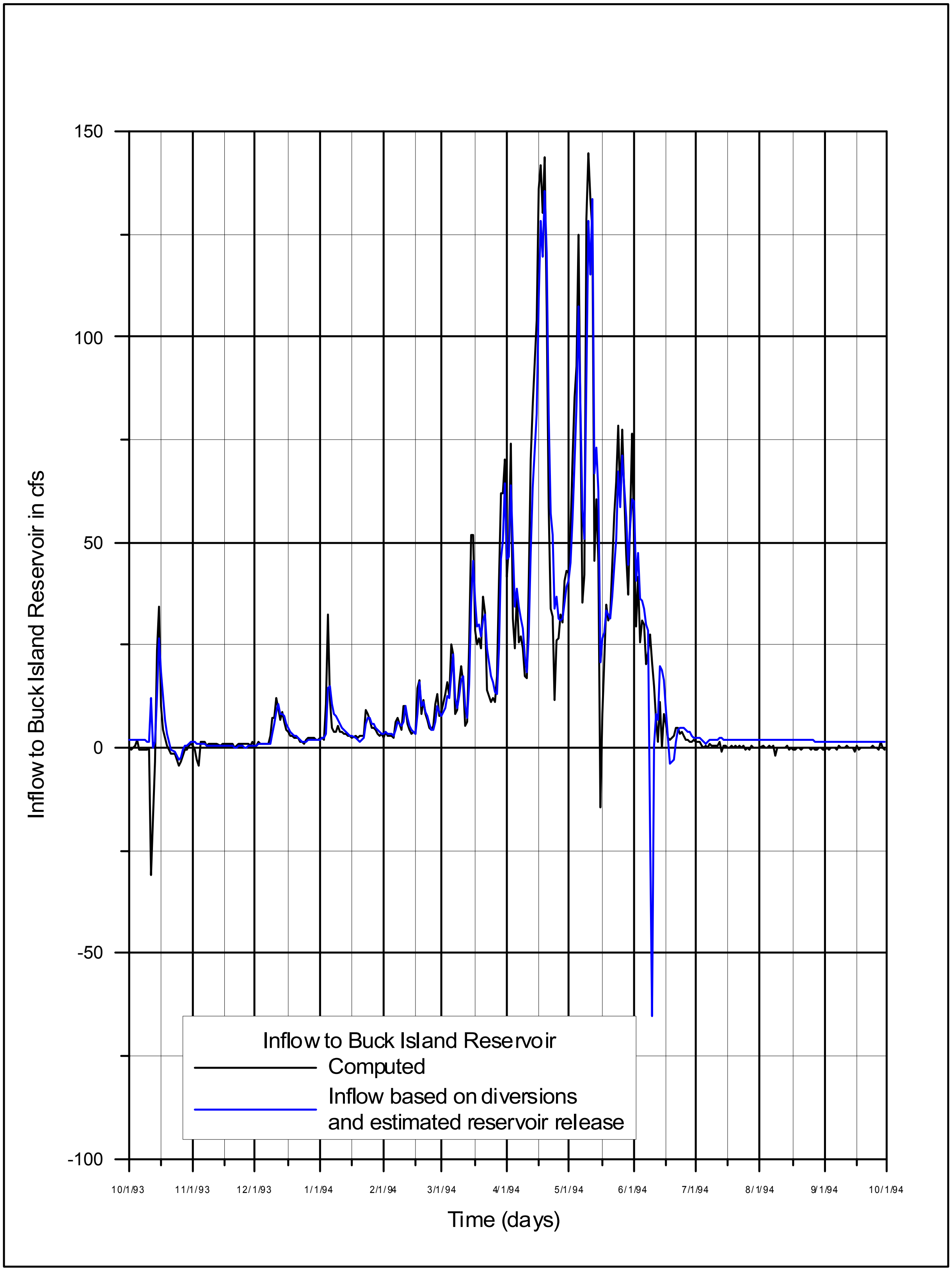


Figure 3.2.3-3. Unregulated Inflow to Buck Island Reservoir, WY 1994

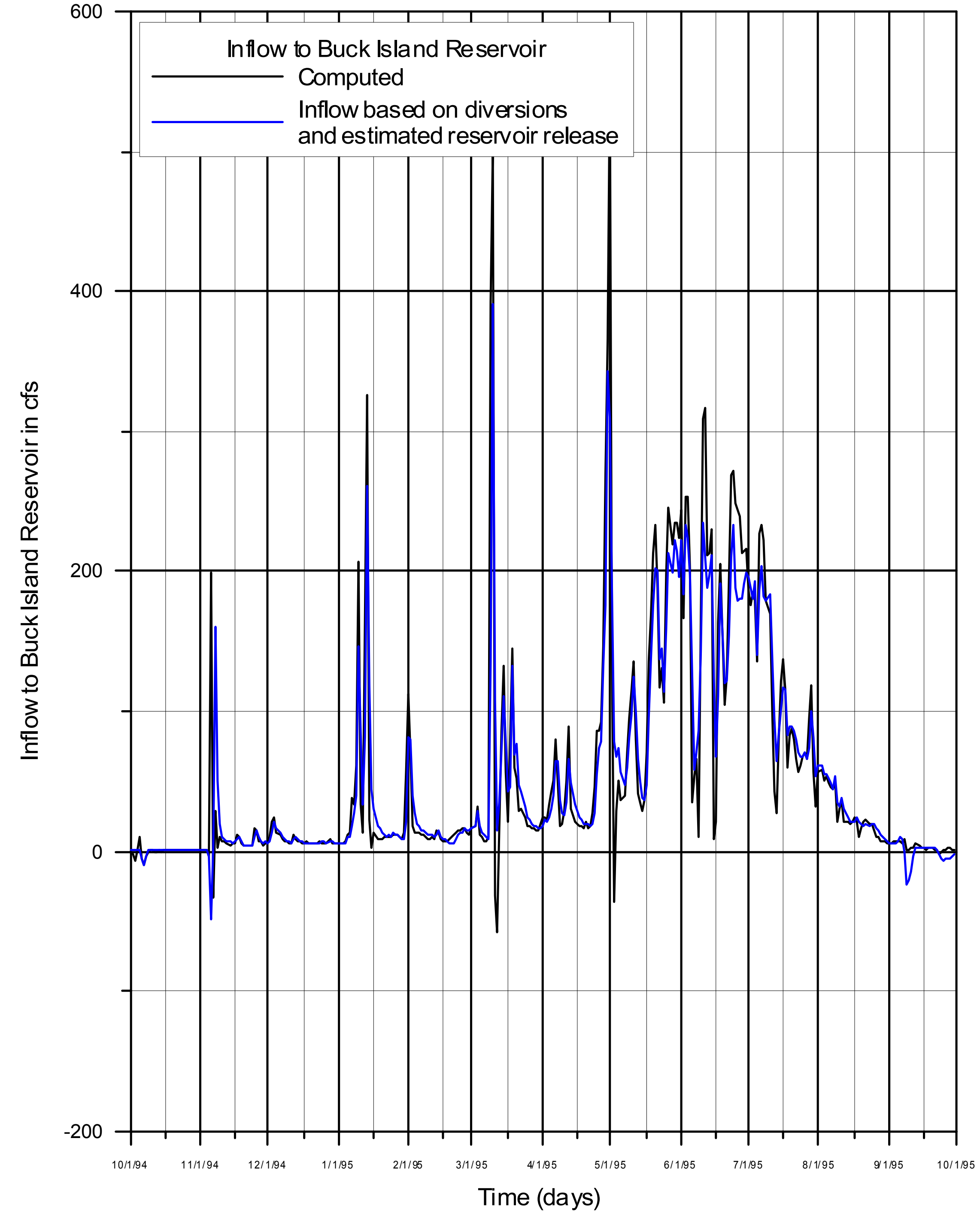


Figure 3.2.3-4. Unregulated Inflow to Buck Island Reservoir, WY 1995

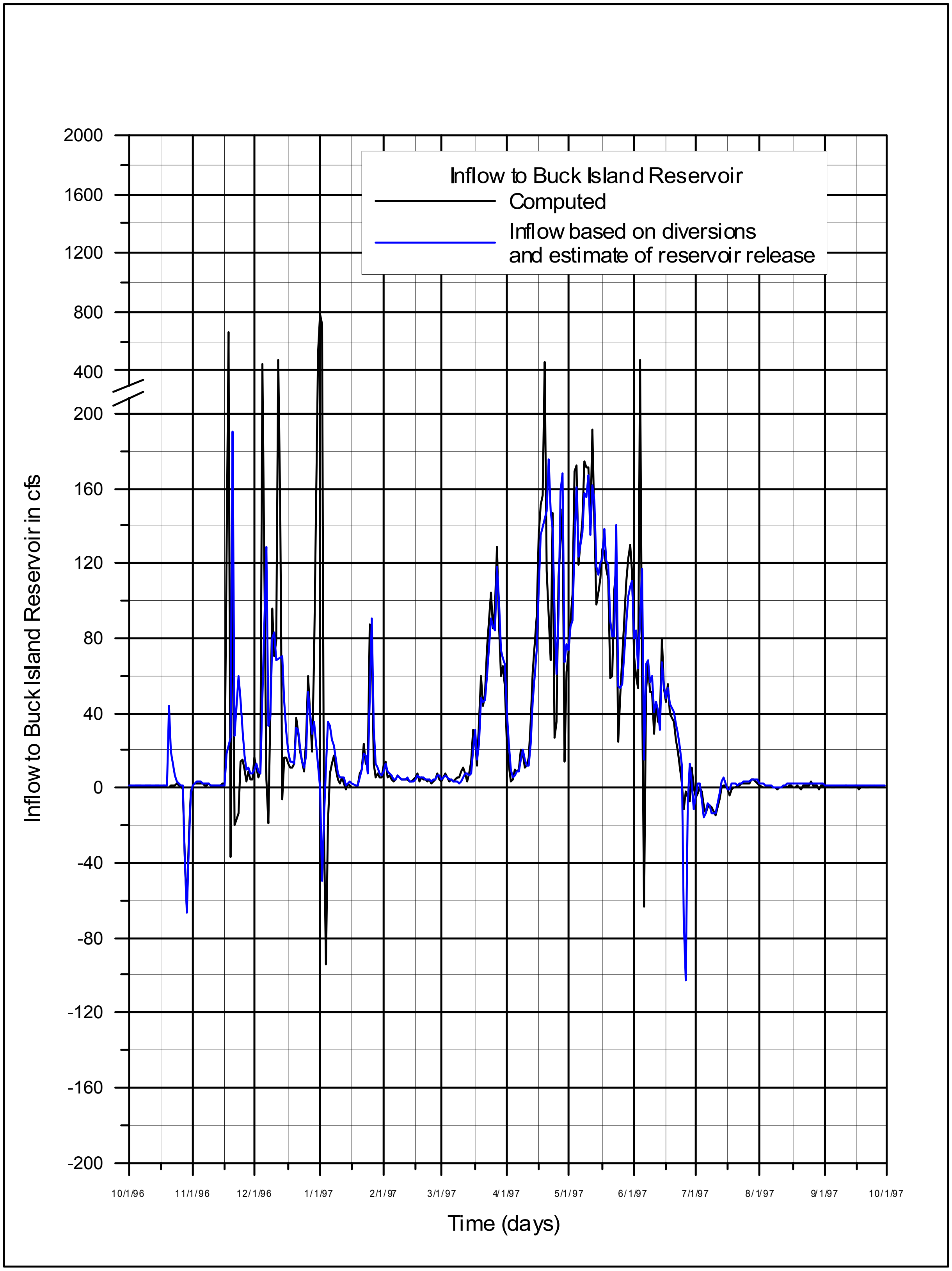


Figure 3.2.3-5. Unregulated Inflow to Buck Island Reservoir, WY 1997

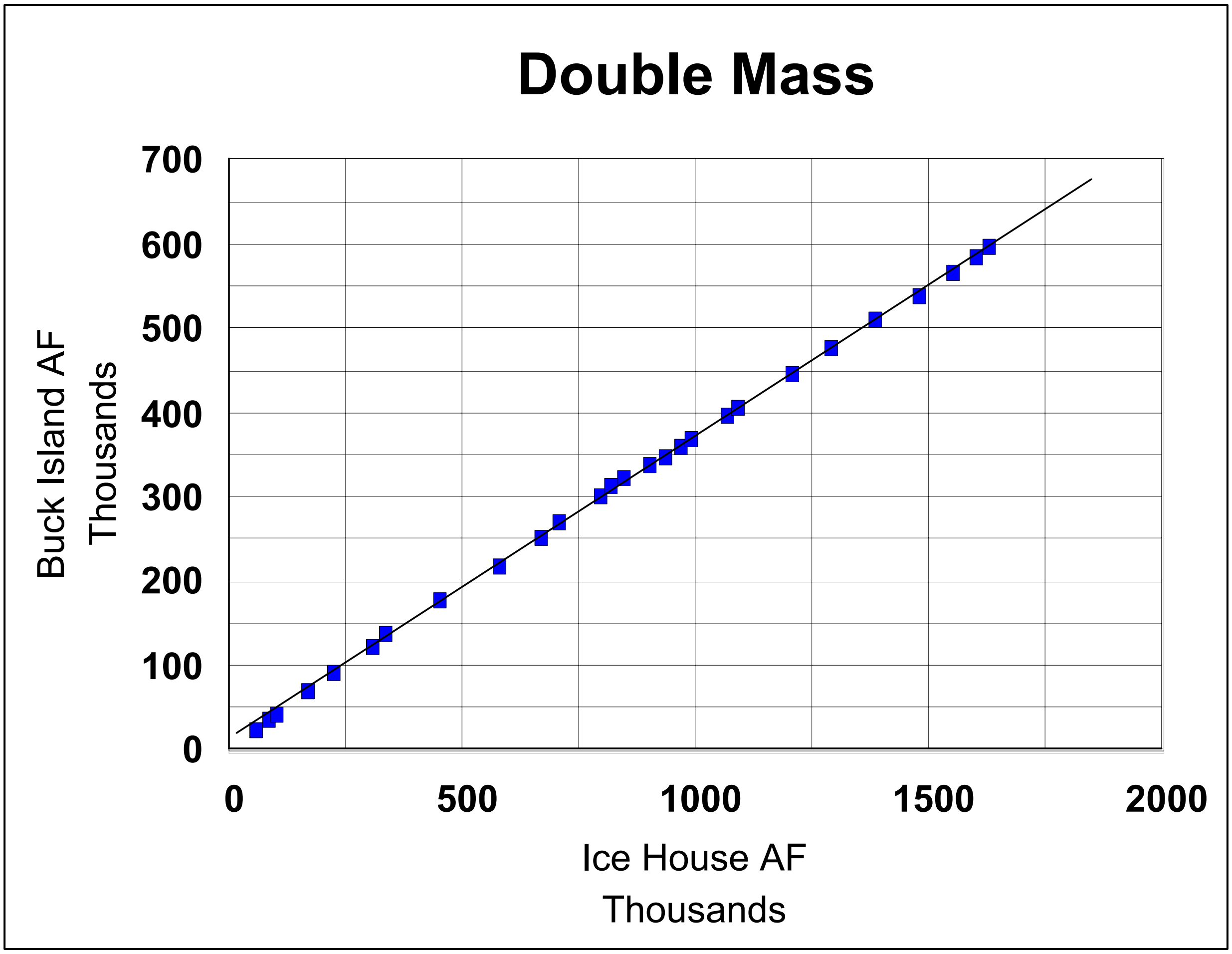


Figure 3.2.3-6. Double Mass – Unregulated Inflow to Buck Island Reservoir Versus Unregulated Inflow to Ice House Reservoir

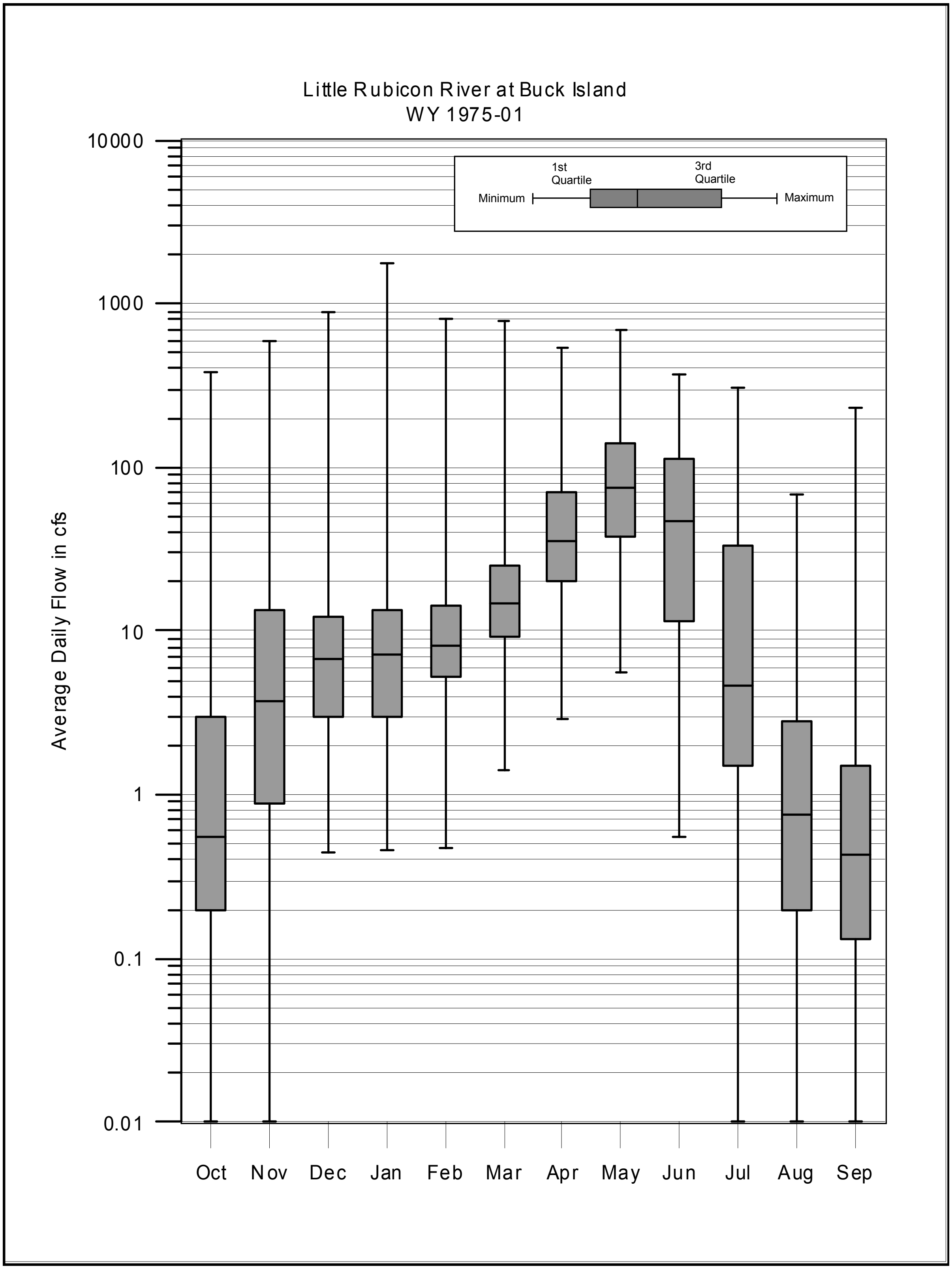


Figure 3.2.3-7. Little Rubicon River at Buck Island, Unregulated Inflow, WY 1975-01, Monthly Box-whisker Diagram

3.2.4 Gerle Creek and South Fork Rubicon River

There are four computation nodes for the Gerle Creek and South Fork Rubicon River (SFRR) elements of the UARP (figures 3.2.4-1 and 3.2.4-2):

- Gerle Creek at Loon Lake Reservoir
- Gerle Creek at Gerle Reservoir
- South Fork Rubicon River at Robbs Peak Diversion Dam
- SFRR below Gerle Creek near Georgetown (validation point only)

The Gerle Creek drainage area at Loon Lake Dam is 8.0 square miles and ranges in elevation from 6,410 to over 7,500 feet. The watershed is primarily granite rock. The present dam was built in 1963.

The Gerle Creek drainage area at Gerle Creek Dam is 30.7 square miles and ranges in elevation from 5,230 to over 8,000 feet. The watershed is a combination of granite and timber area with more developed soils. The facility was completed in 1962.

The SFRR drainage area at Robbs Peak Diversion Dam is 15.2 square miles and ranges in elevation from 5,230 to almost 9,000 feet. The watershed is a combination of granite and timber area with more developed soils. The facility was completed in 1962. SMUD monitors the combined releases at Gerle Creek Reservoir and Robbs Peak Diversion Dam and also estimates the spill at these sites. The combined flow from the Gerle-Robbs drainage (excluding inflow to Loon Lake) has been computed by SMUD on a daily basis since 1993.

The final node is the USGS gage located on the SFRR downstream of Gerle Creek. The gage was installed in 1961 and has a drainage area of about 47.7 square miles. The station name is SFRR below Gerle Creek near Georgetown.

The analysis started at the headwaters of the Gerle Creek drainage at Loon Lake Reservoir. Sufficient data are available to compute the unregulated inflow to the reservoir using a mass balance procedure. Though the watershed is high in elevation, and it might be expected that the winter/spring flow pattern would be similar to the Rubicon or Little Rubicon rivers, 30% of the drainage area is covered by lake surface which significantly affects the seasonal inflow pattern. Examples of the computed inflow are provided in figures 3.2.4-3 through 3.2.4-5. These figures illustrate that there are large fluctuations in these data that require smoothing. In addition, some of the low flows during the summer and fall months appear inconsistent when compared to inflows on the Rubicon and Little Rubicon rivers.

To smooth the large data fluctuations and adjust the questionable data, seasonal “smoothing” procedures were applied. During the winter months, computed daily inflow values are adjusted to be the two-day rolling average of values. This procedure produced good results without overly “smoothing out” high flow events. During the summer months where flows normally have less variability, the computed daily inflow values are adjusted to represent a three- to five-day rolling average of values, always attempting to smooth the flows and remove computed negative values. An example of the impact of the adjustments is illustrated in Figure 3.2.4-6 (smoothed). The black line represents the computed daily inflow for Loon Lake based on a mass balance of gaged flows and computations. The red line represents the smoothed daily inflow.

Despite the smoother unregulated inflow estimates, large inflow fluctuations were still of concern. Therefore, a second estimate of inflow to Loon Lake was developed that is dependent on the computed unregulated inflow for the SFRR below Gerle Creek. The unregulated inflow at this location is computed for the investigation period using a mass balance procedure. The data also required some smoothing, and an additional adjustment was made based on the inflow estimates to the Silver Creek at Union Valley Reservoir. A comparison of the computed and estimated (smoothed) daily flow values for the SFRR below Gerle Creek is provided in figures 3.2.4-7 through 3.2.4-9. The black line represents the computed daily flow for SFRR below Gerle Creek based on a mass balance of gaged flows and computations. The blue line represents the smoothed flows.

The SFRR below Gerle Creek unregulated flow data were tested for consistency (or homogeneity) by comparing these data to the unregulated inflow for the South Fork Silver Creek at Ice House (Figure 3.2.4-10). These data appear homogenous.

Following completion of the SFRR below Gerle Creek daily flow estimates, the second Loon Lake inflow data set was derived as a percentage of the total flow (estimated based on the drainage area):

Loon Lake inflow = 0.155254 * SFRR below Gerle Creek

This Loon Lake inflow estimate (SFRR Estimate) was compared with the initial computed flow for Loon Lake. The final daily values were based on an equal percentage of the smoothed-computed values and the SFRR Estimate.

Loon Lake inflow = 0.5 * (0.155254 * SFRR below Gerle Creek + computed smooth Loon Lake estimate)

Figures 3.2.4-11 through 3.2.4-13 compare the initial computed and the final daily flows for a wet, average and dry year, respectively. The black line represents the computed daily flow for SFRR below Gerle Creek based on a mass balance of gaged flows and computations. The red line represents the final synthesized flows.

A box-whisker diagram describing the Loon Lake monthly unregulated daily flow characteristics is provided as Figure 3.2.4-14. The average annual runoff at Loon Lake is 20,000 acre-feet. A table of monthly runoff at this site for the period 1975-2001 is included in Appendix B.

The combined unregulated inflow to Gerle Creek Reservoir and the SFRR flow into Robbs Peak Diversion Dam is referred to hereinafter as the Gerle-Robbs drainage. The full complement of water management components required to compute the unregulated inflow for Gerle-Robbs has not been monitored over the entire investigation period. However, there are sufficient data to

compute the unregulated inflow to Gerle-Robbs using a mass balance procedure for the period 1993 through 2001.
A second estimate of unregulated inflow to Gerle-Robbs was computed based on the unregulated inflow to the SFRR below Gerle Creek for the same period, 1993-2001. The values were computed as follows:

Remaining Flow = SFRR below Gerle Creek – Loon Lake inflow (computed previously)

Accretions to Gerle Creek Reservoir = 0.572077 * Remaining Flow

SF Rubicon inflow to Robbs Peak Diversion Dam = 0.384073 * Remaining Flow

Unregulated flow above USGS gage = SFRR below Gerle Creek – Loon Lake inflow – Accretions to Gerle Creek Reservoir - SF Rubicon inflow to Robbs Peak Diversion Dam

The unregulated inflow to Gerle-Robbs using both procedures is displayed graphically in figures 3.2.4-15 and 3.2.4-16 for a wet and a dry year, respectively. The black line represents the computed daily flow for Gerle-Robbs below Gerle Creek based on a mass balance of gaged flows and computations. The blue line represents the synthesized flows. The estimate of unregulated inflow to Gerle-Robbs based on the unregulated flow of SFRR below Gerle Creek appeared quite satisfactory and therefore this procedure is used to estimate the unregulated inflow to Gerle-Robbs for the remaining investigation period, 1975-1992. Figure 3.2.4-17 is a plot of the synthesized inflow to Robbs-Gerle for water year 1975. The total inflow for water year 1975 is close to the average annual flow for the investigation period.

A box-whisker diagram describing the monthly unregulated daily flow characteristics for Gerle Creek at Gerle Creek Reservoir and SFRR at the Robbs Peak Diversion Dam are displayed in figures 3.2.4-18 and 3.2.4-19, respectively. The average annual runoff at Gerle Creek at Gerle Creek Reservoir is 54,000 acre-feet and the average annual runoff at SFRR at the Robbs Peak Diversion Dam is 50,000 acre-feet. A table of monthly runoff at these sites for the period 1975-2001 is included in Appendix B.

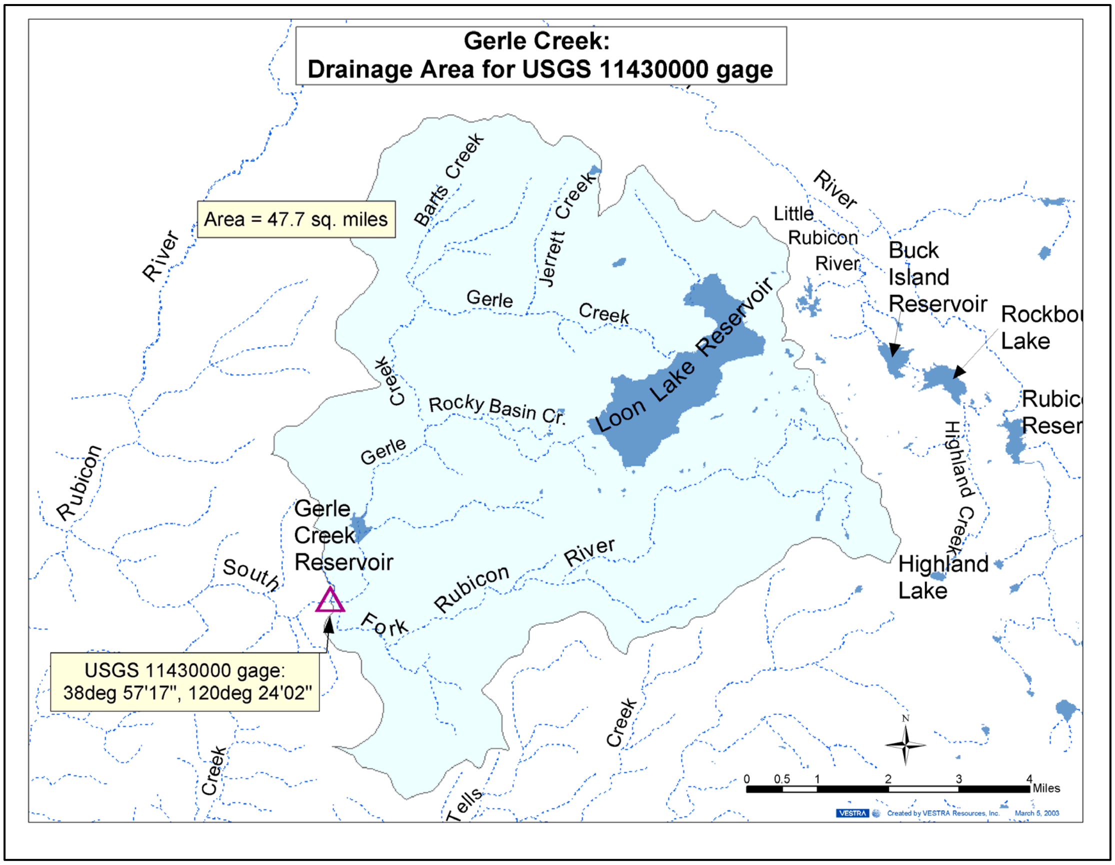


Figure 3.2.4-1. Gerle Creek Drainage Area

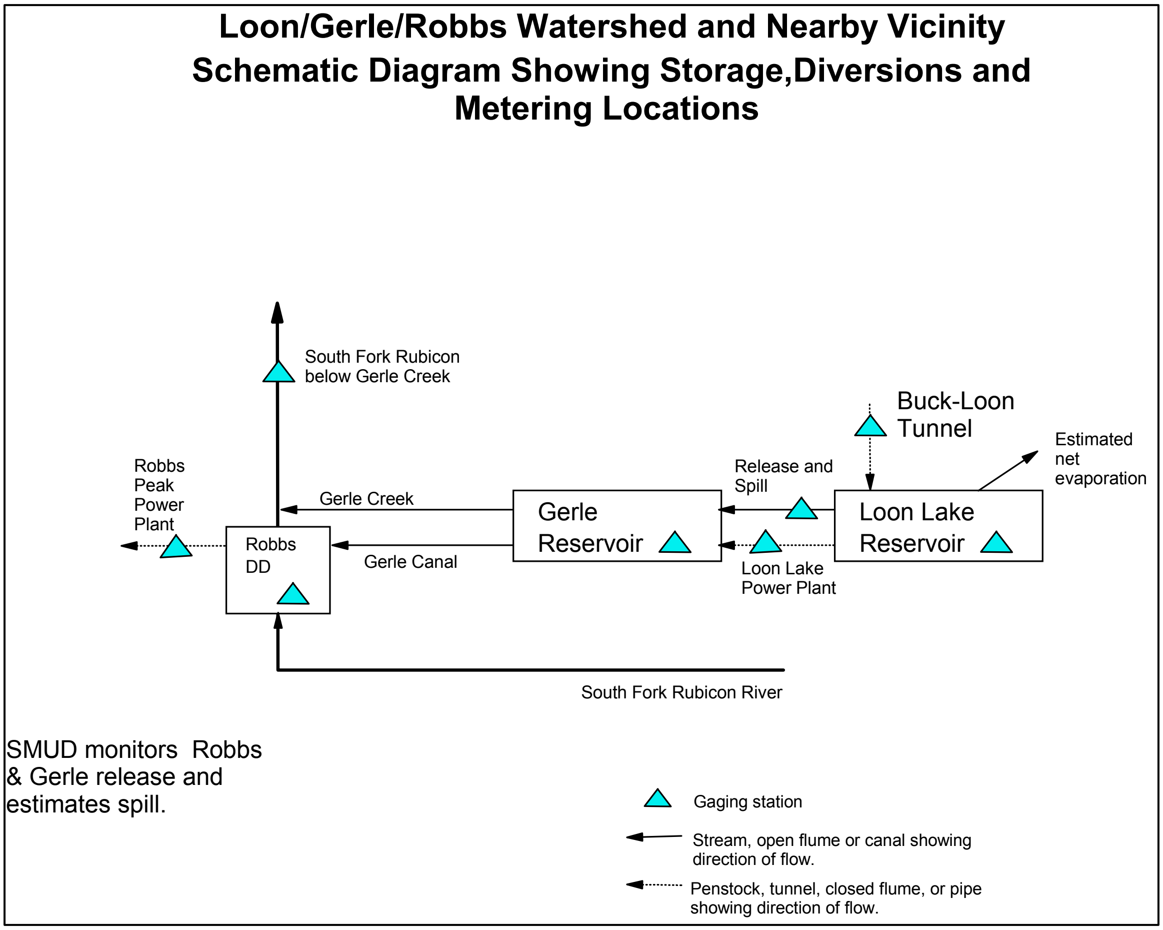


Figure 3.2.4-2. Loon/Gerle/Robbs Watershed and Nearby Vicinity – Schematic Diagram Showing Storage, Diversions and Metering Locations

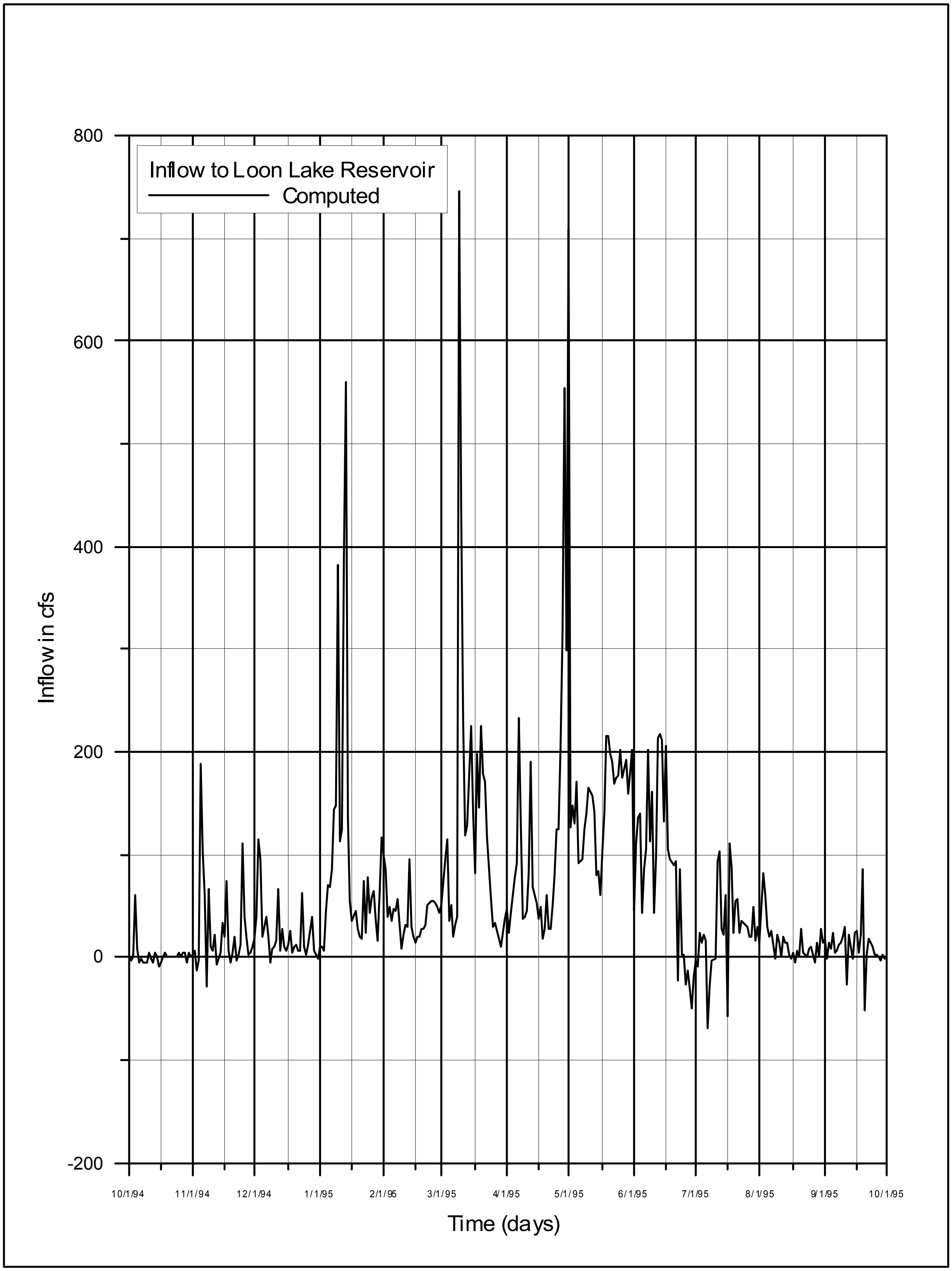


Figure 3.2.4-3. Unregulated Inflow to Loon Lake Reservoir, WY 1995

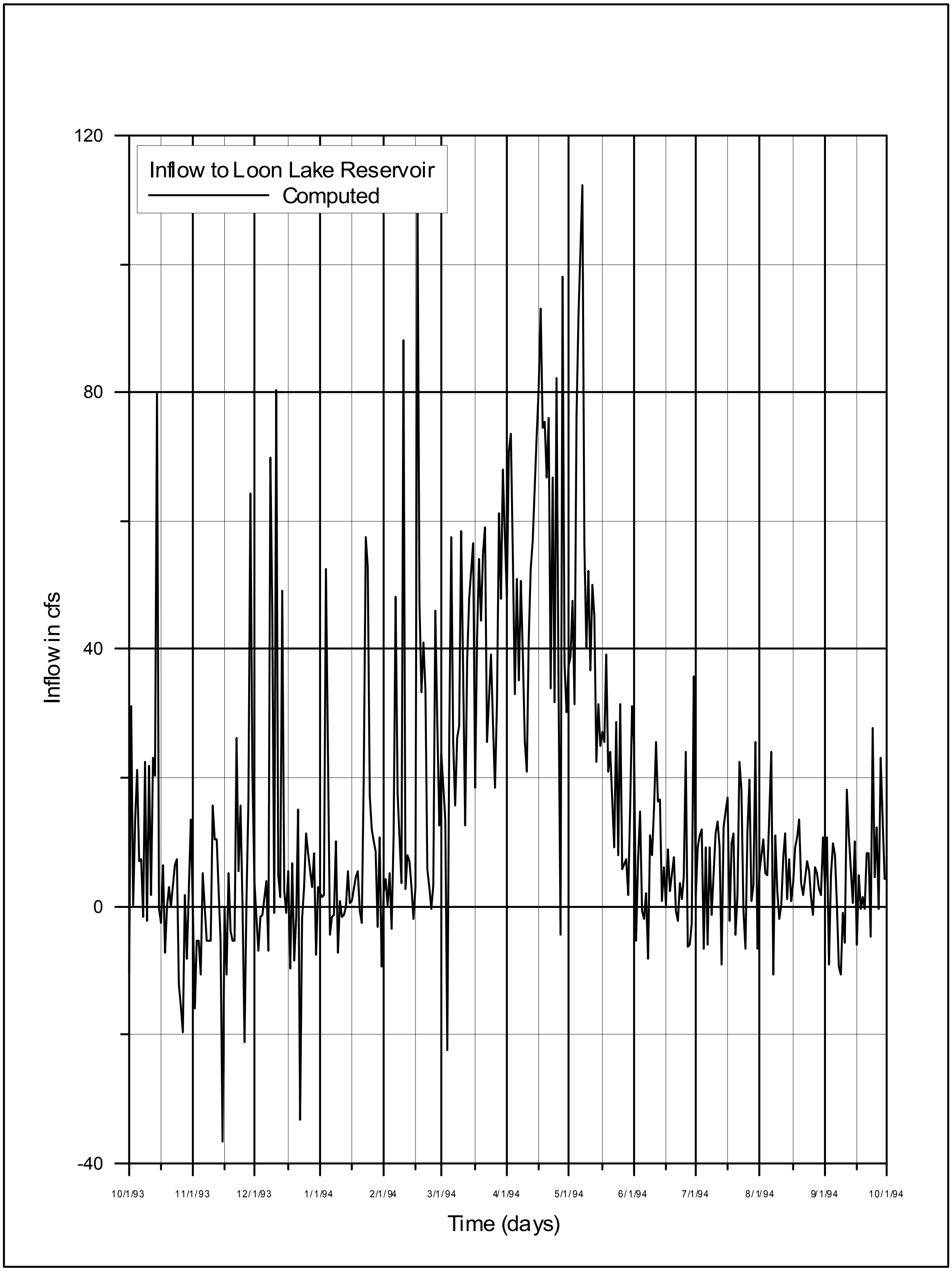


Figure 3.2.4-4. Unregulated Inflow to Loon Lake Reservoir, WY 1994

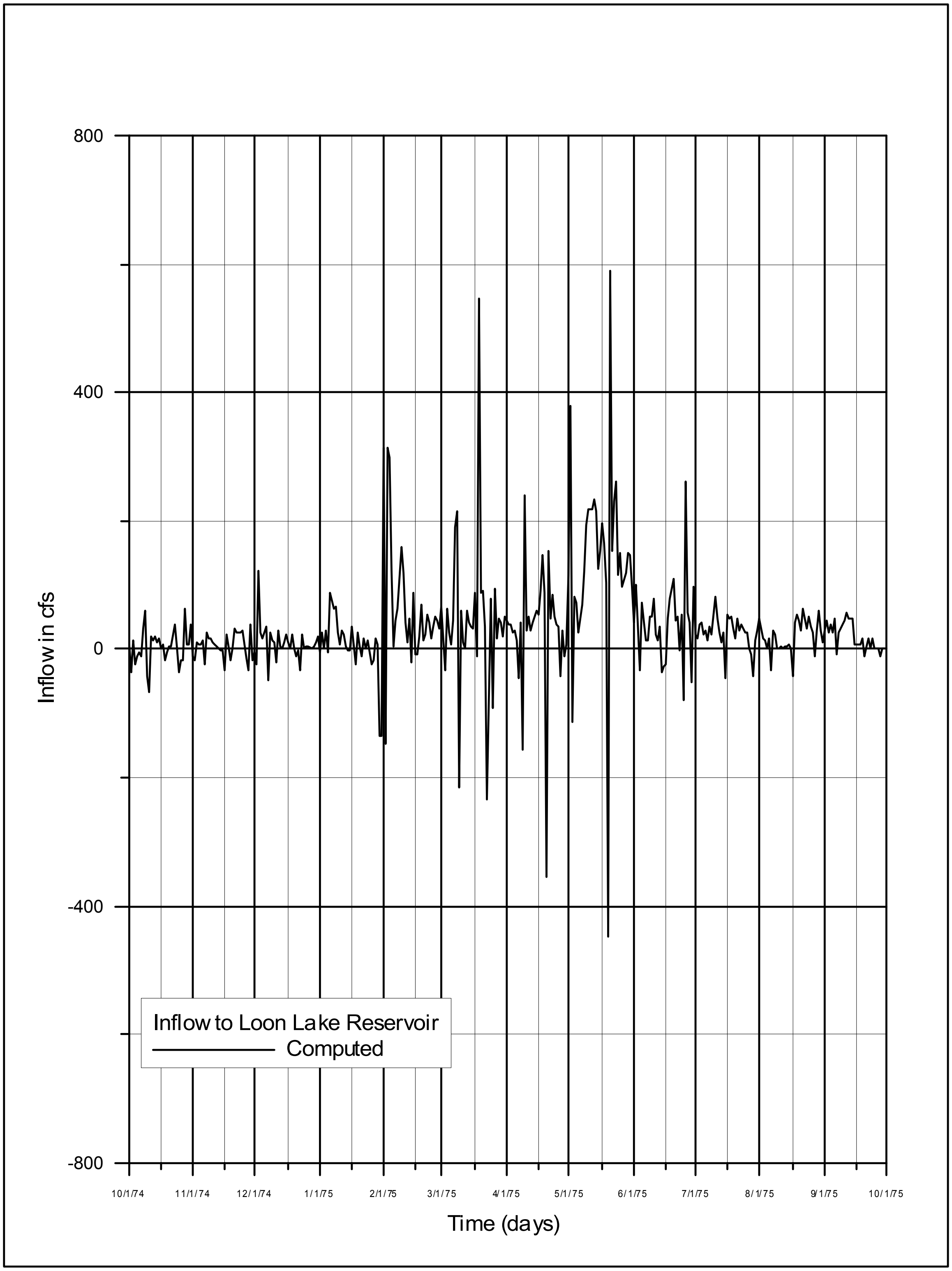


Figure 3.2.4-5. Unregulated Inflow to Loon Lake Reservoir, WY 1975

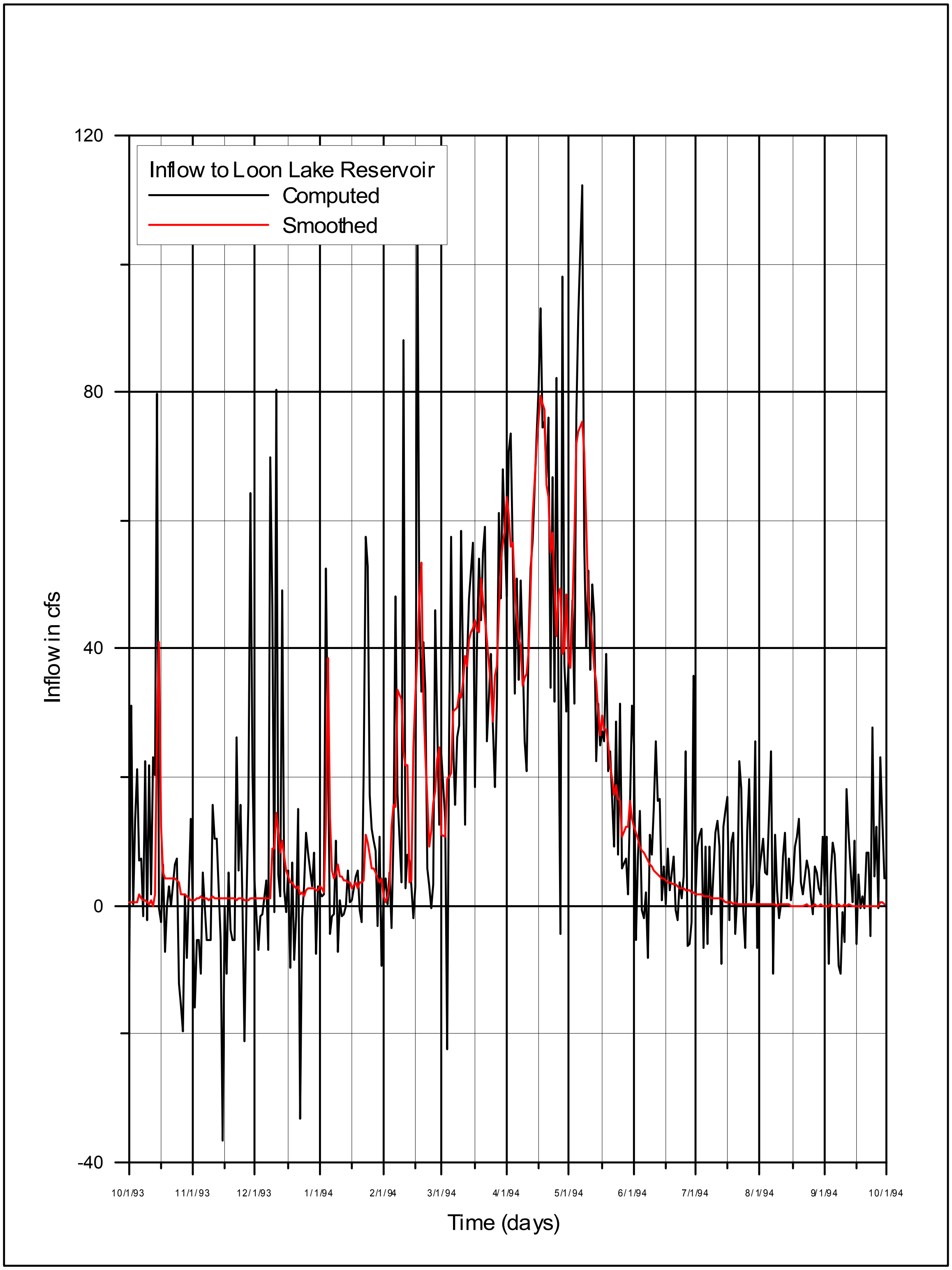


Figure 3.2.4-6. Unregulated Inflow to Loon Lake Reservoir, WY 1994

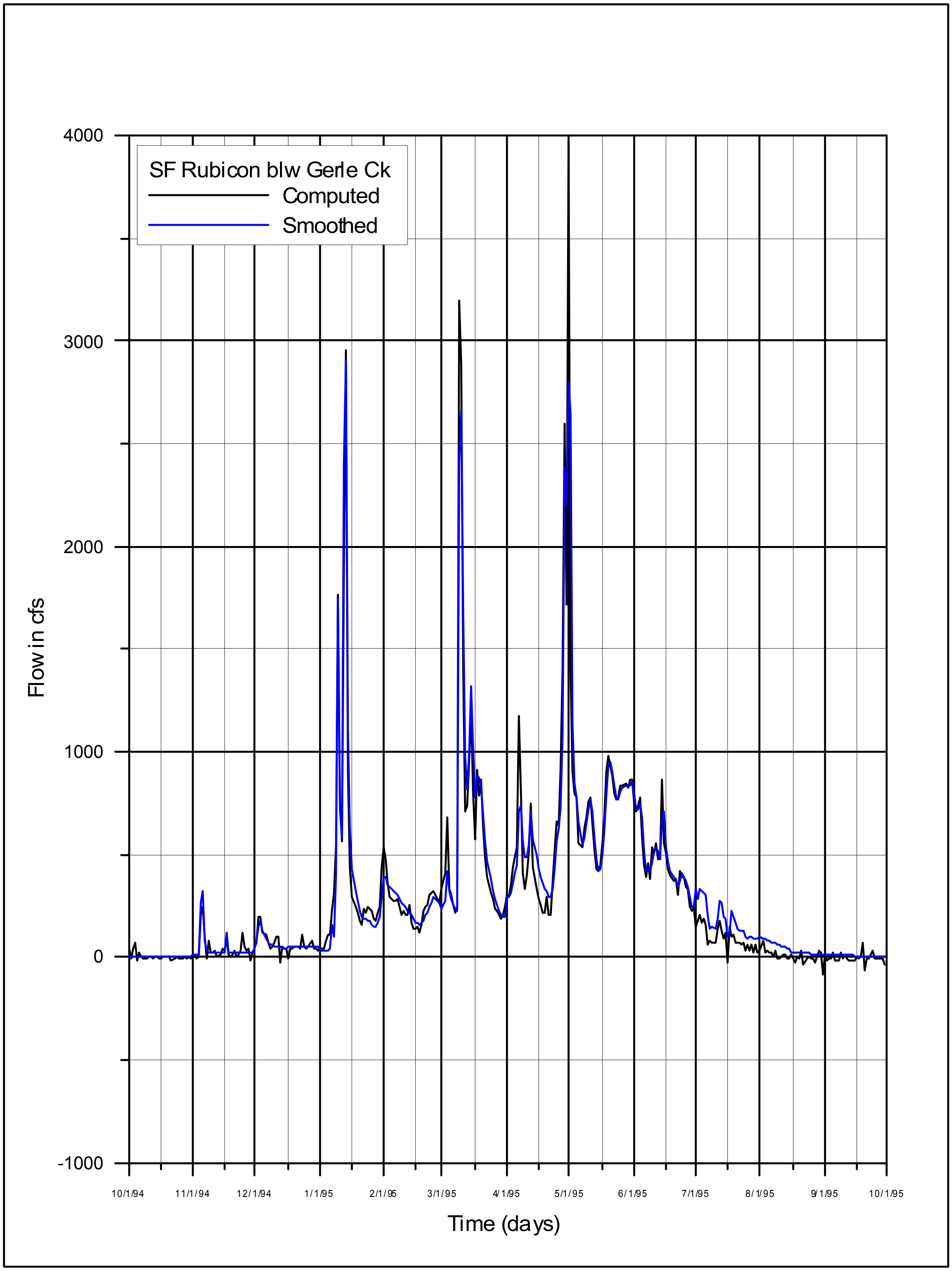


Figure 3.2.4-7. SF Rubicon below Gerle Creek, WY 1995

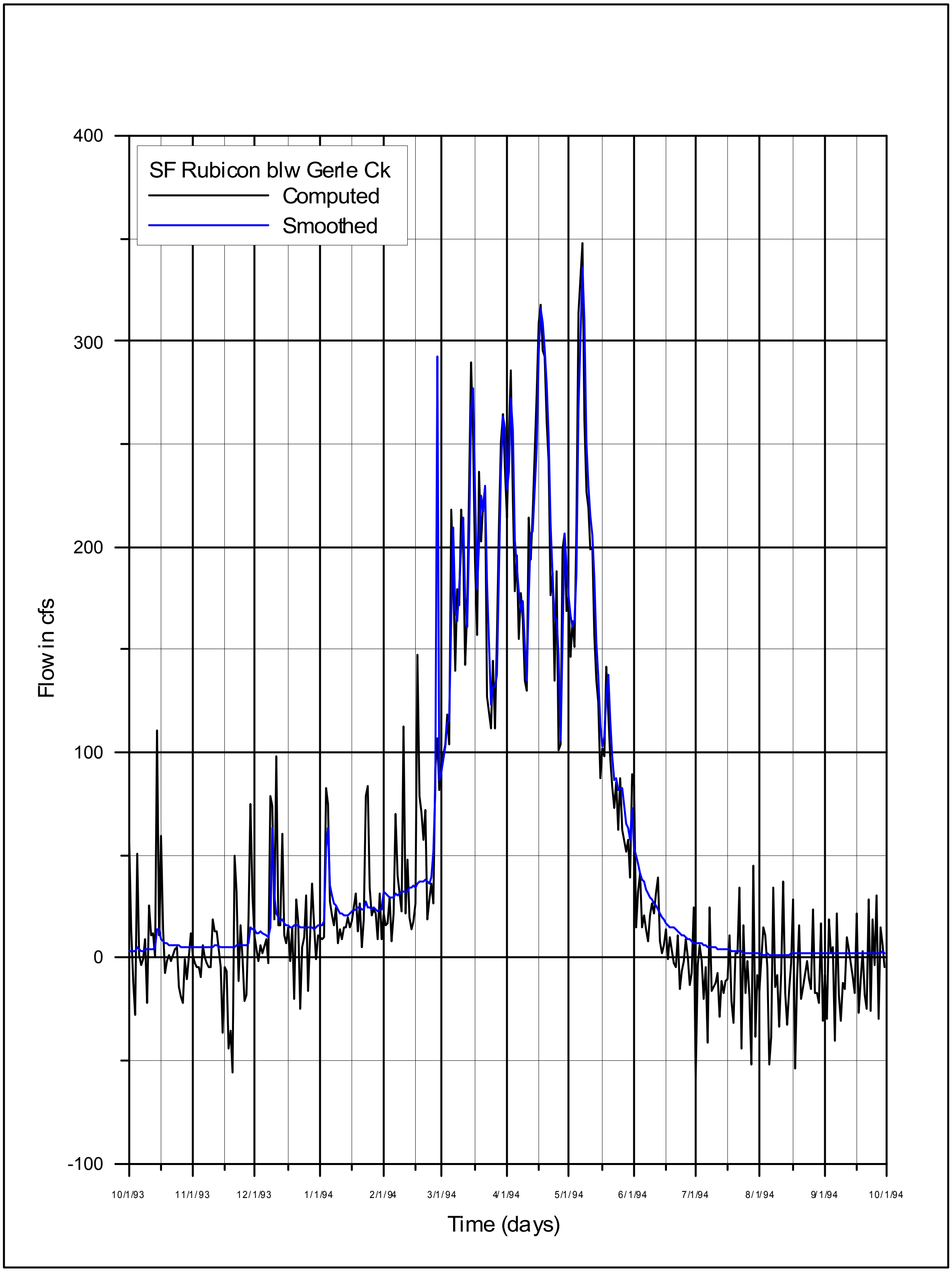


Figure 3.2.4-8. SF Rubicon below Gerle Creek, Unregulated Inflow, WY 1994

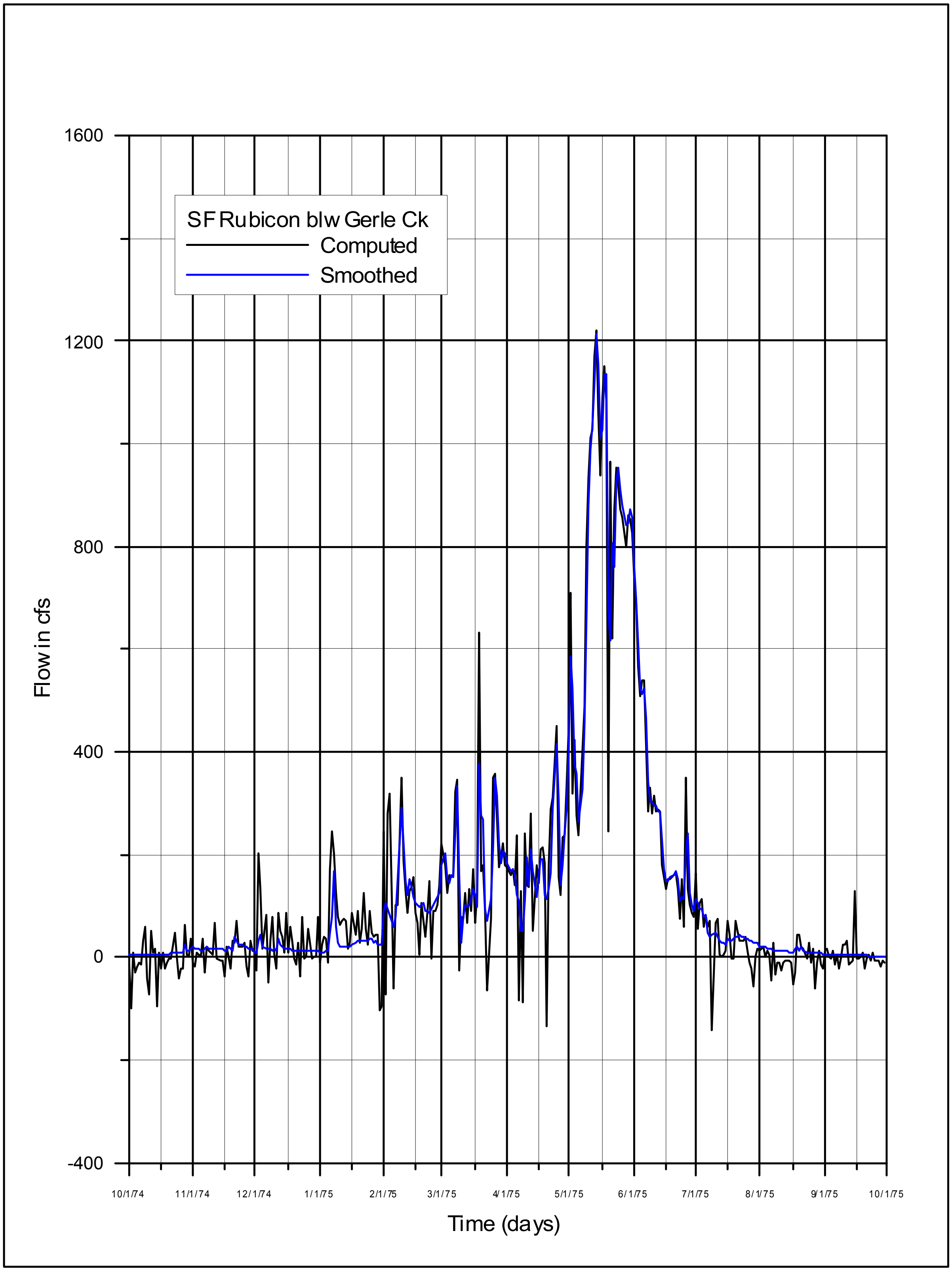


Figure 3.2.4-9. SF Rubicon below Gerle Creek, Unregulated Inflow, WY 1975

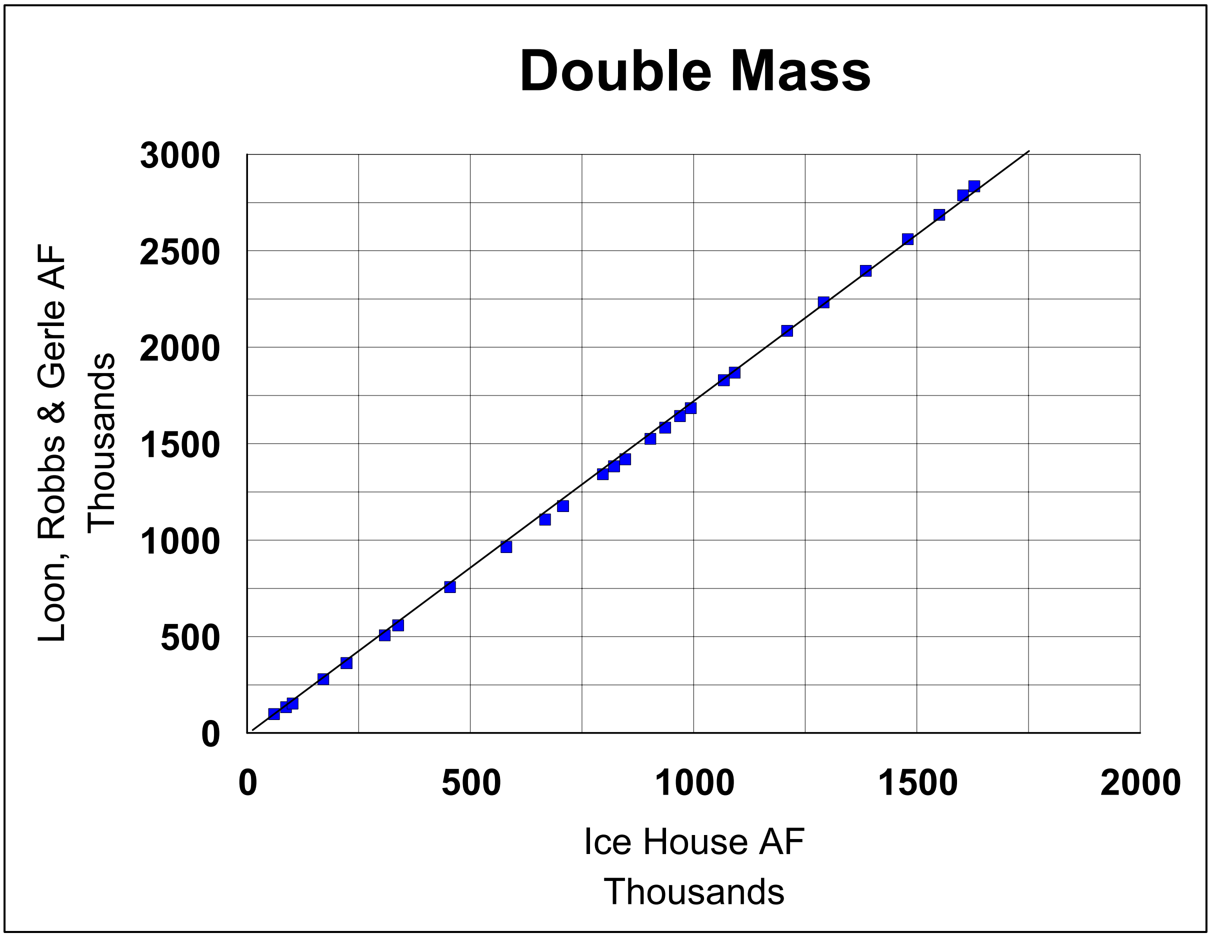


Figure 3.2.4-10. Unregulated Inflow to Loon, Robbs and Gerle Reservoirs Versus Unregulated Inflow to Ice House Reservoir

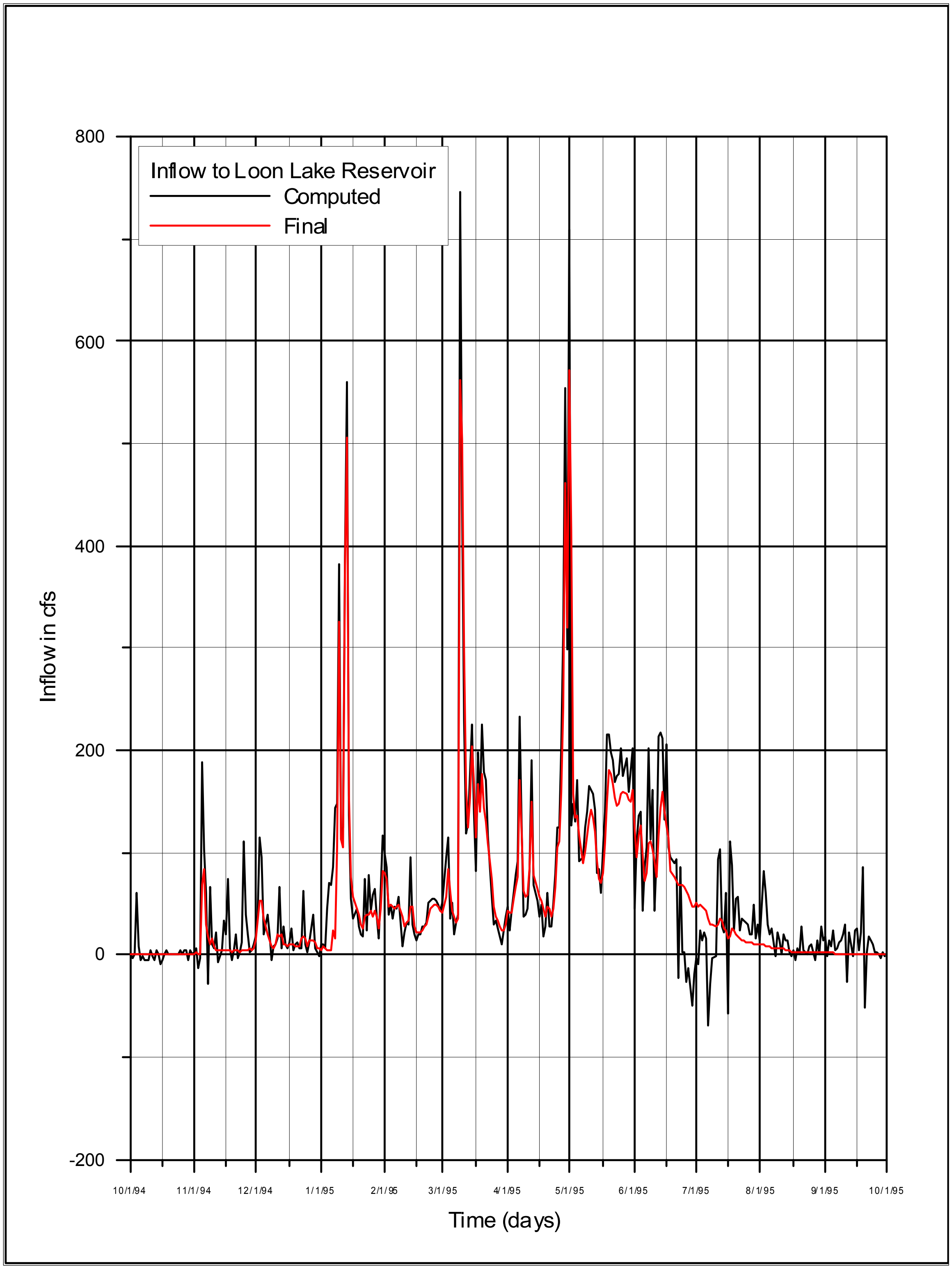


Figure 3.2.4-11. Unregulated Inflow to Loon Lake Reservoir, WY 1995

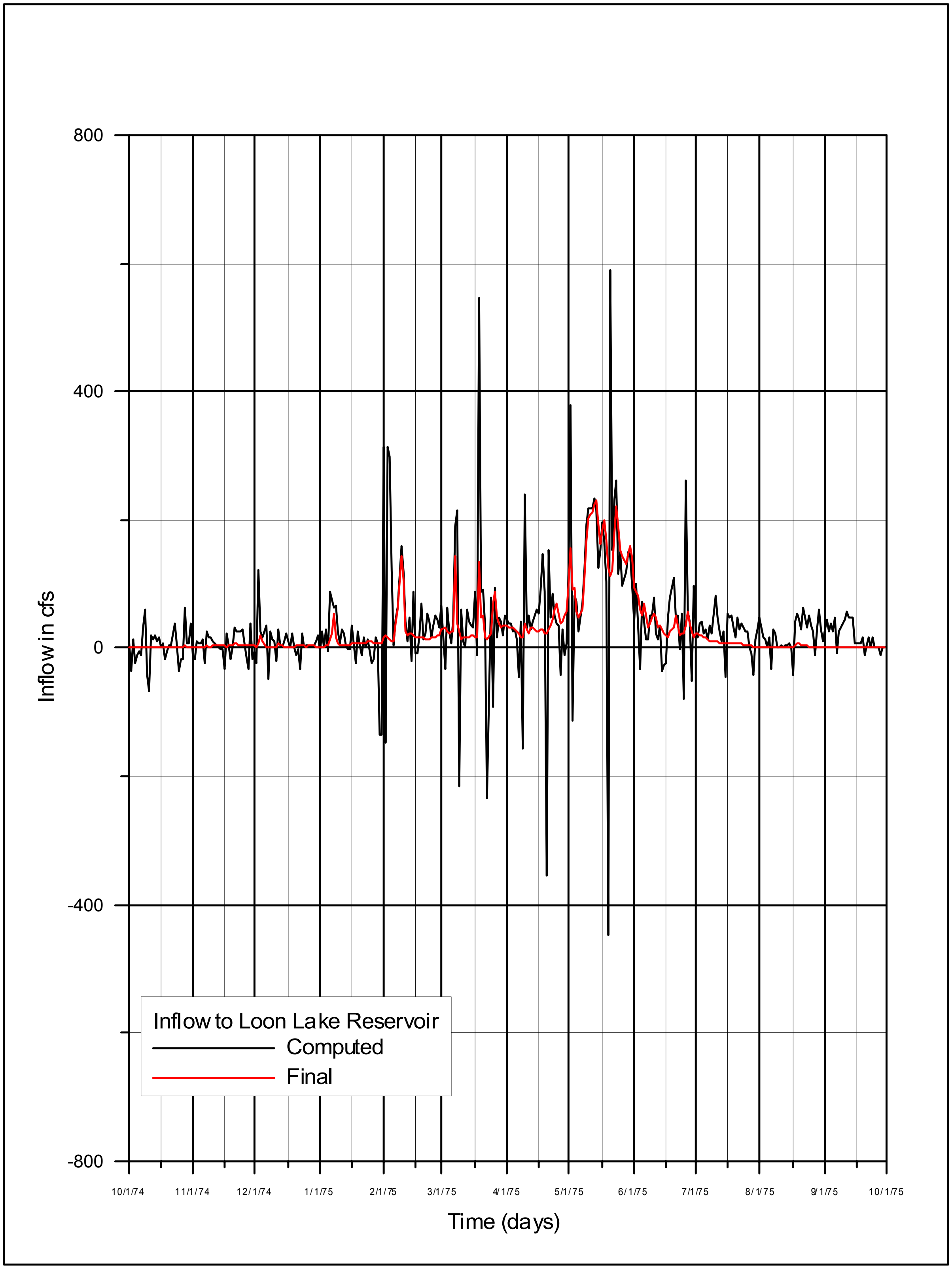


Figure 3.2.4-12. Unregulated Inflow to Loon Lake Reservoir, WY 1975

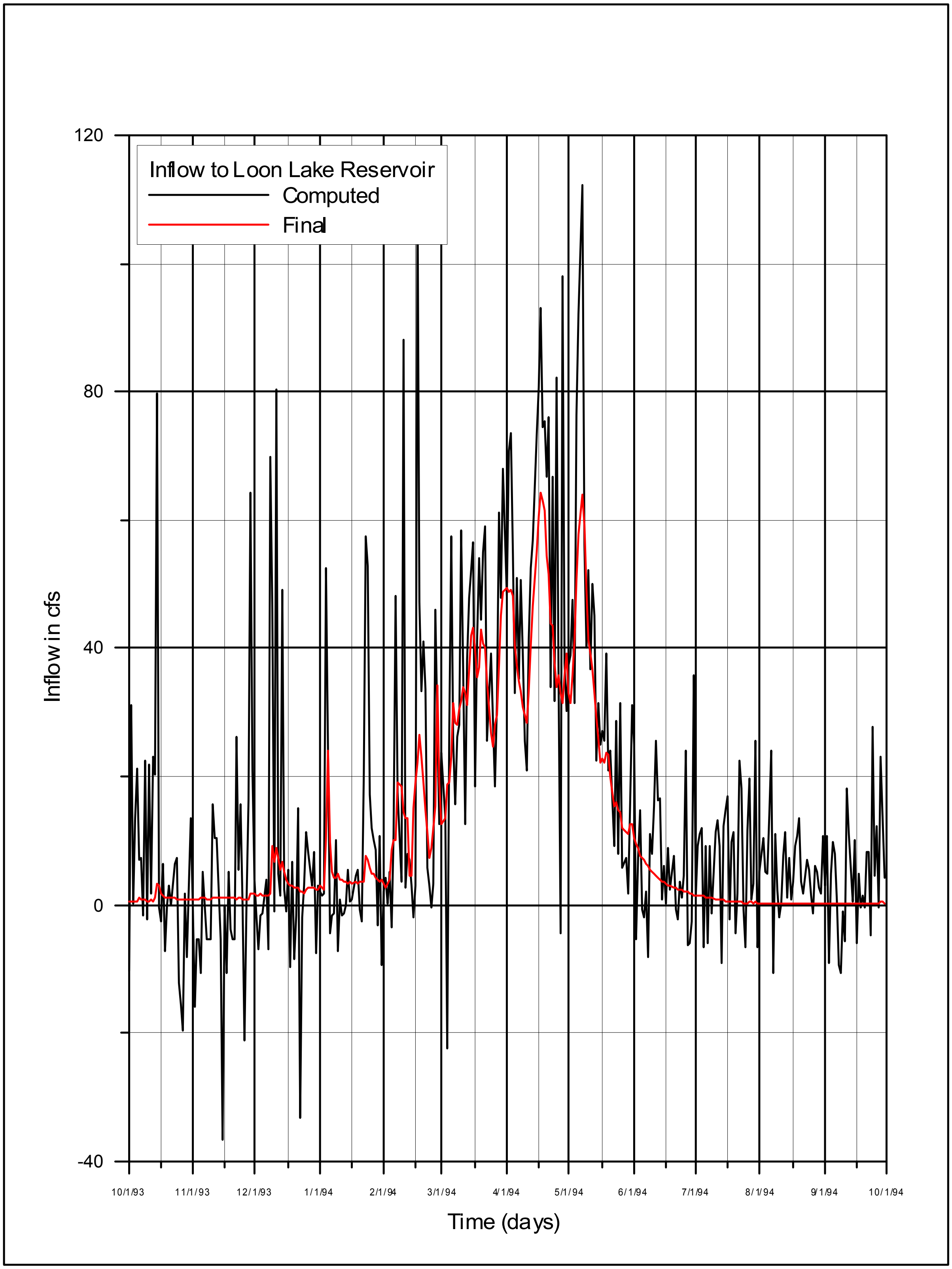


Figure 3.2.4-13. Unregulated Inflow to Loon Lake Reservoir, WY 1994

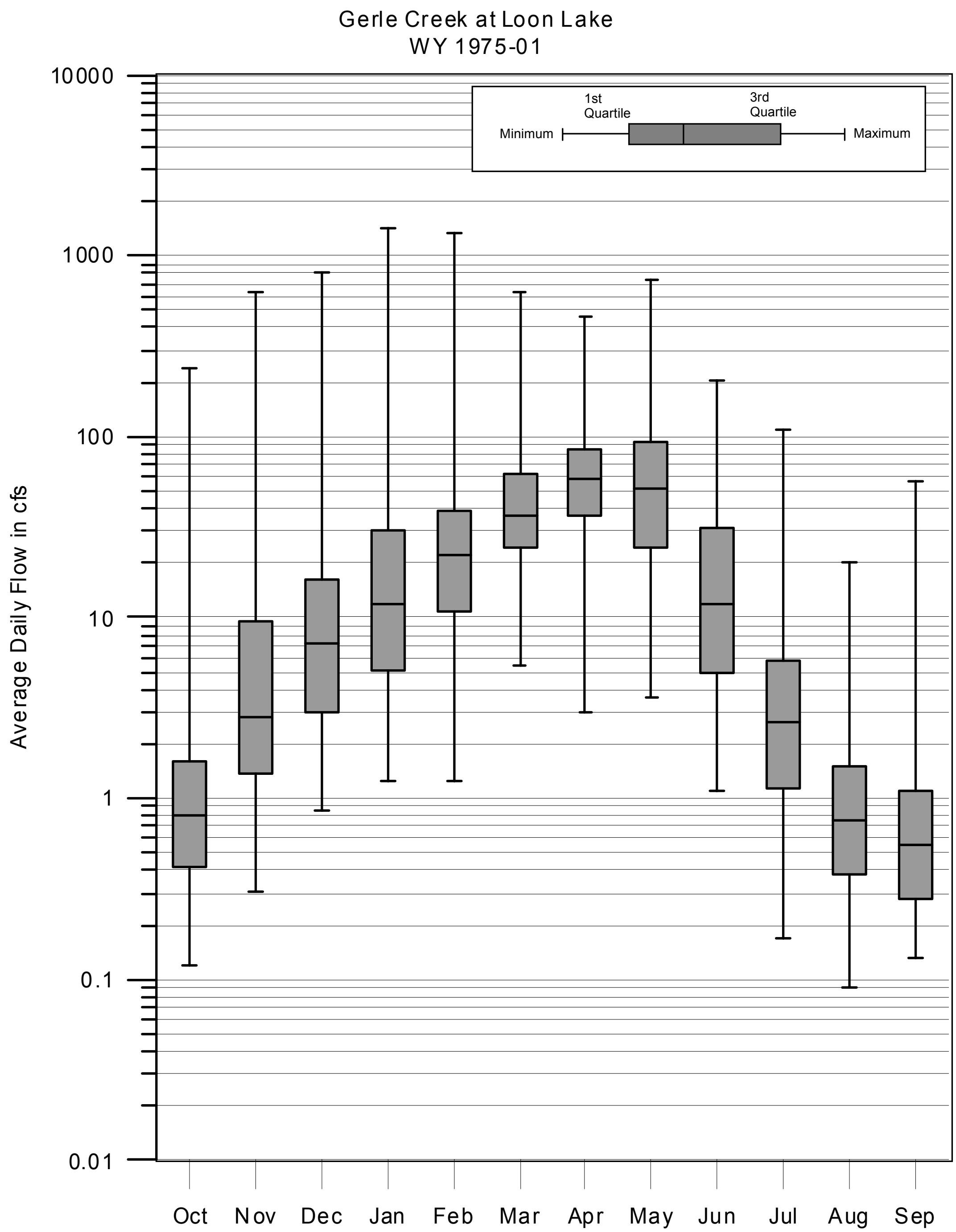


Figure 3.2.4-14. Gerle Creek at Loon Lake, Unregulated Inflow, WY 1975-01, Monthly Box-whisker Diagram

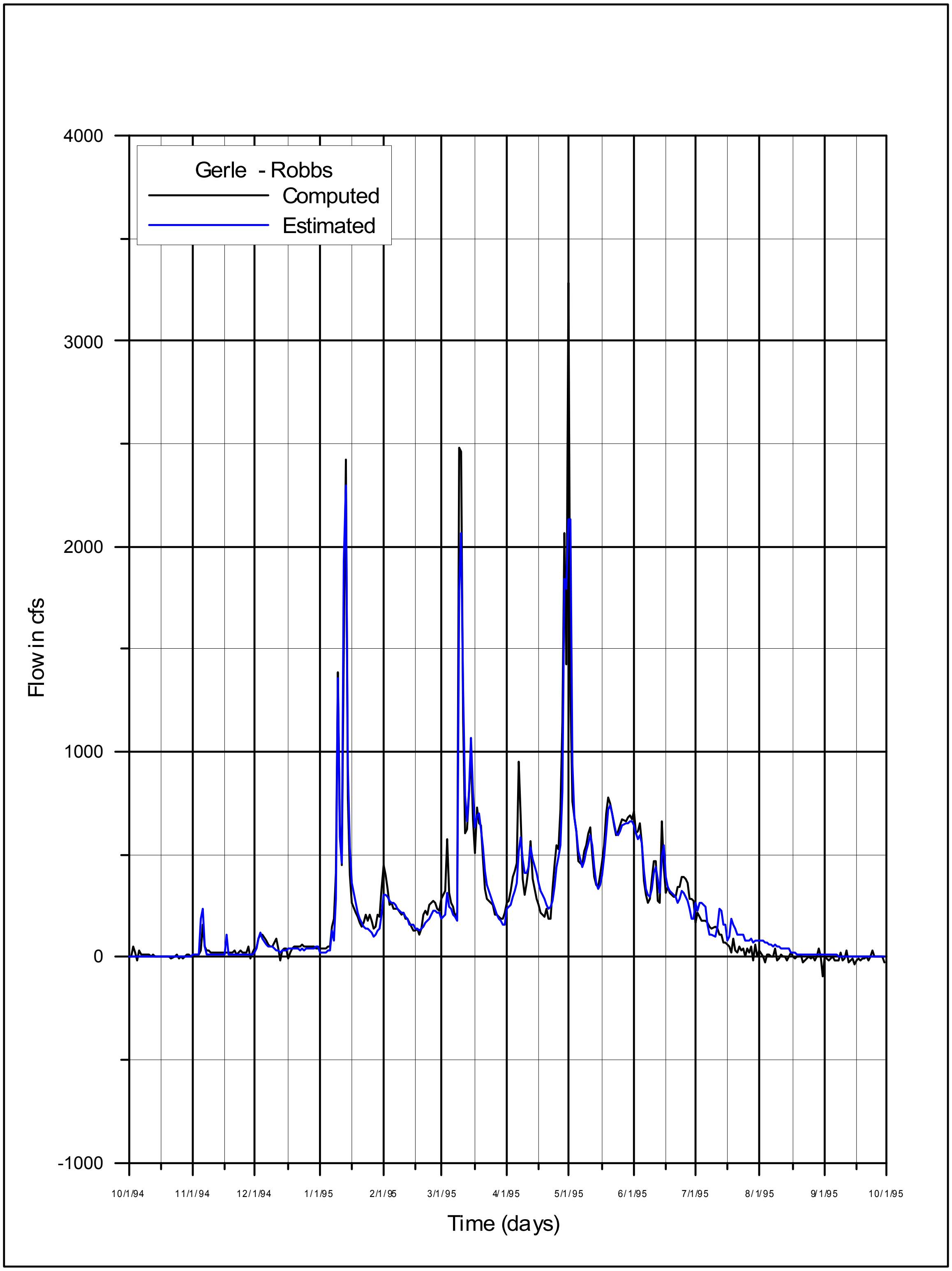


Figure 3.2.4-15. Gerle – Robbs Unregulated Inflow, WY 1995

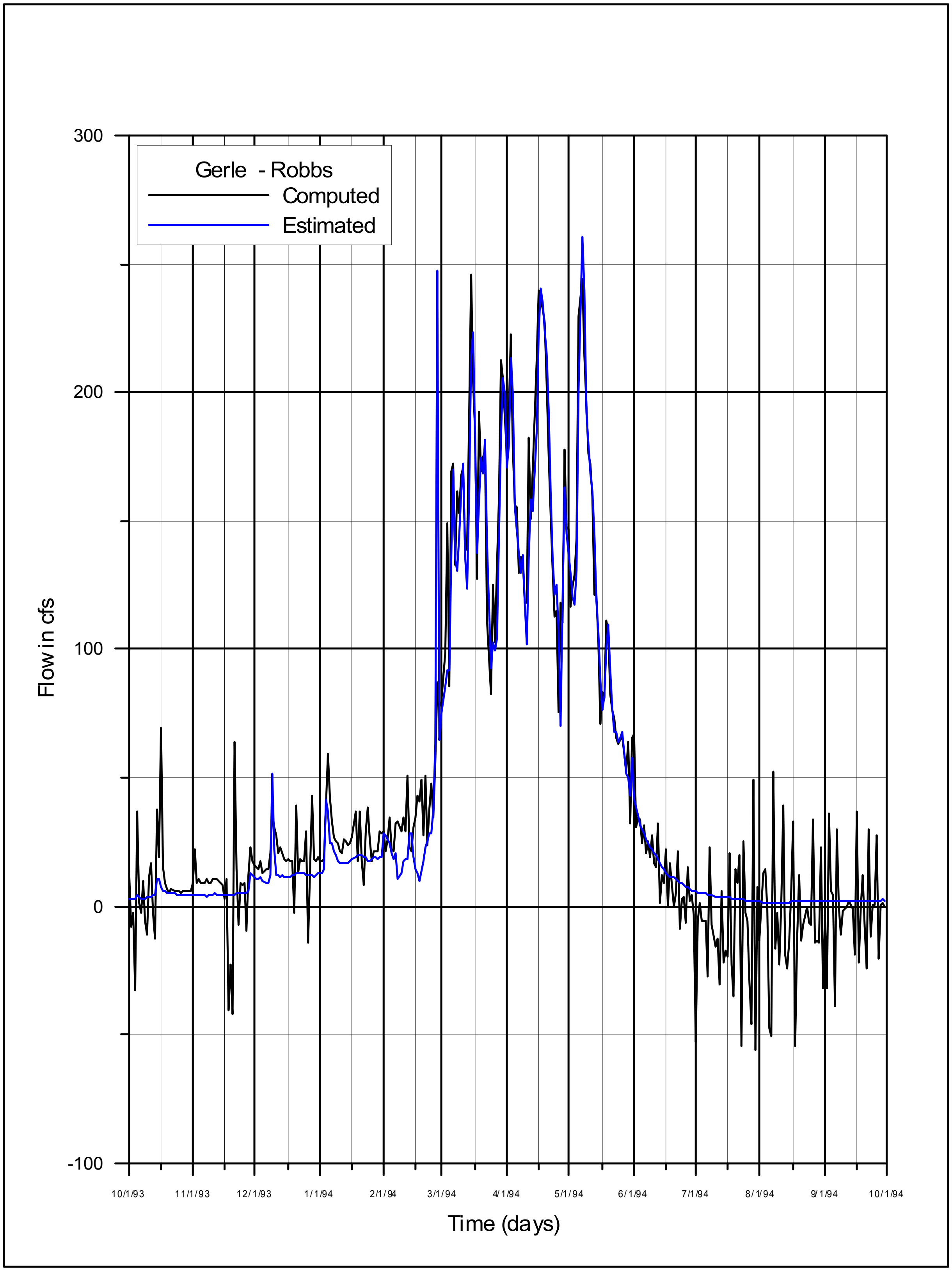


Figure 3.2.4-16. Gerle – Robbs Unregulated Inflow, WY 1994

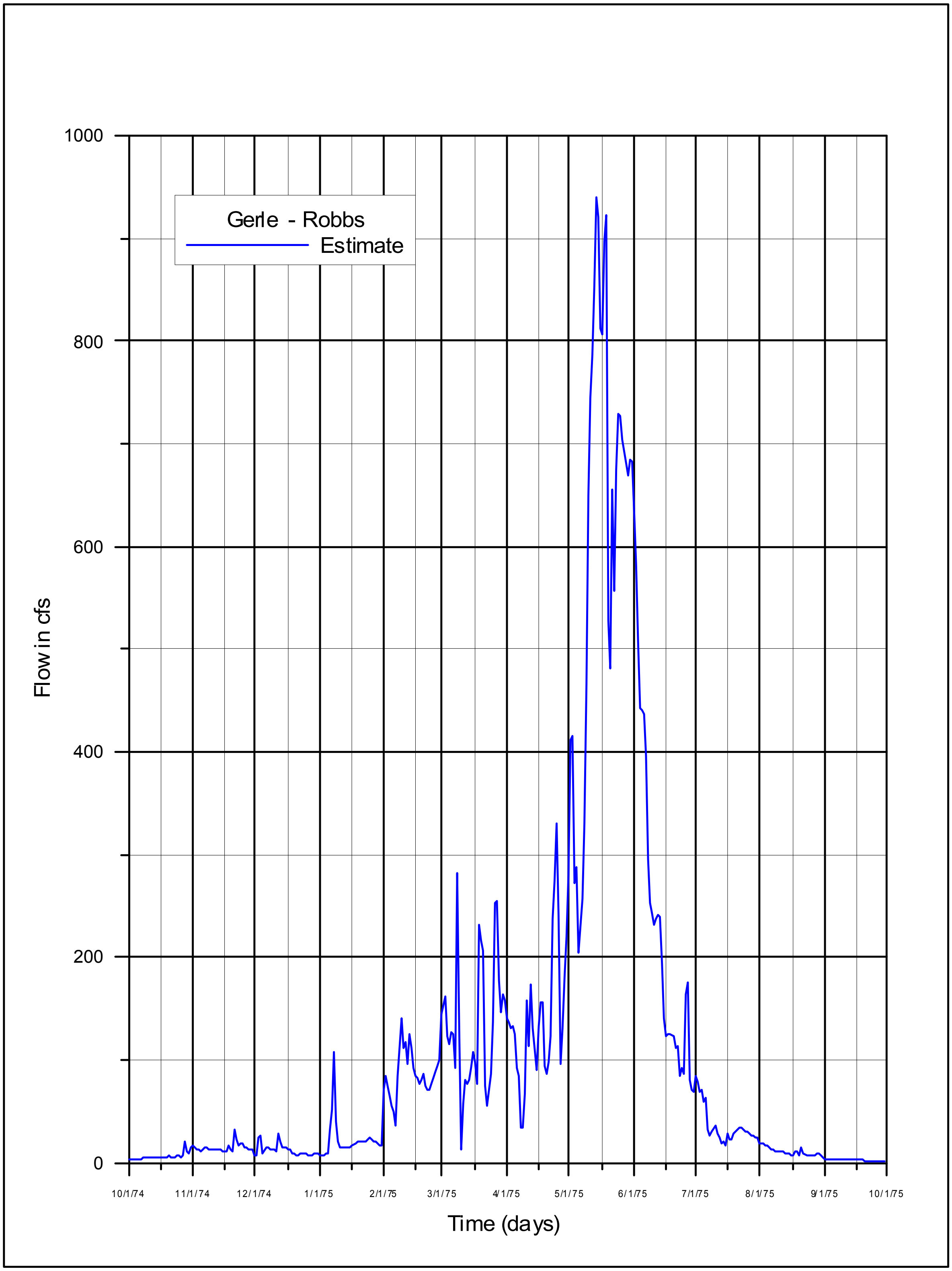


Figure 3.2.4-17. Gerle – Robbs Unregulated Inflow, WY 1975

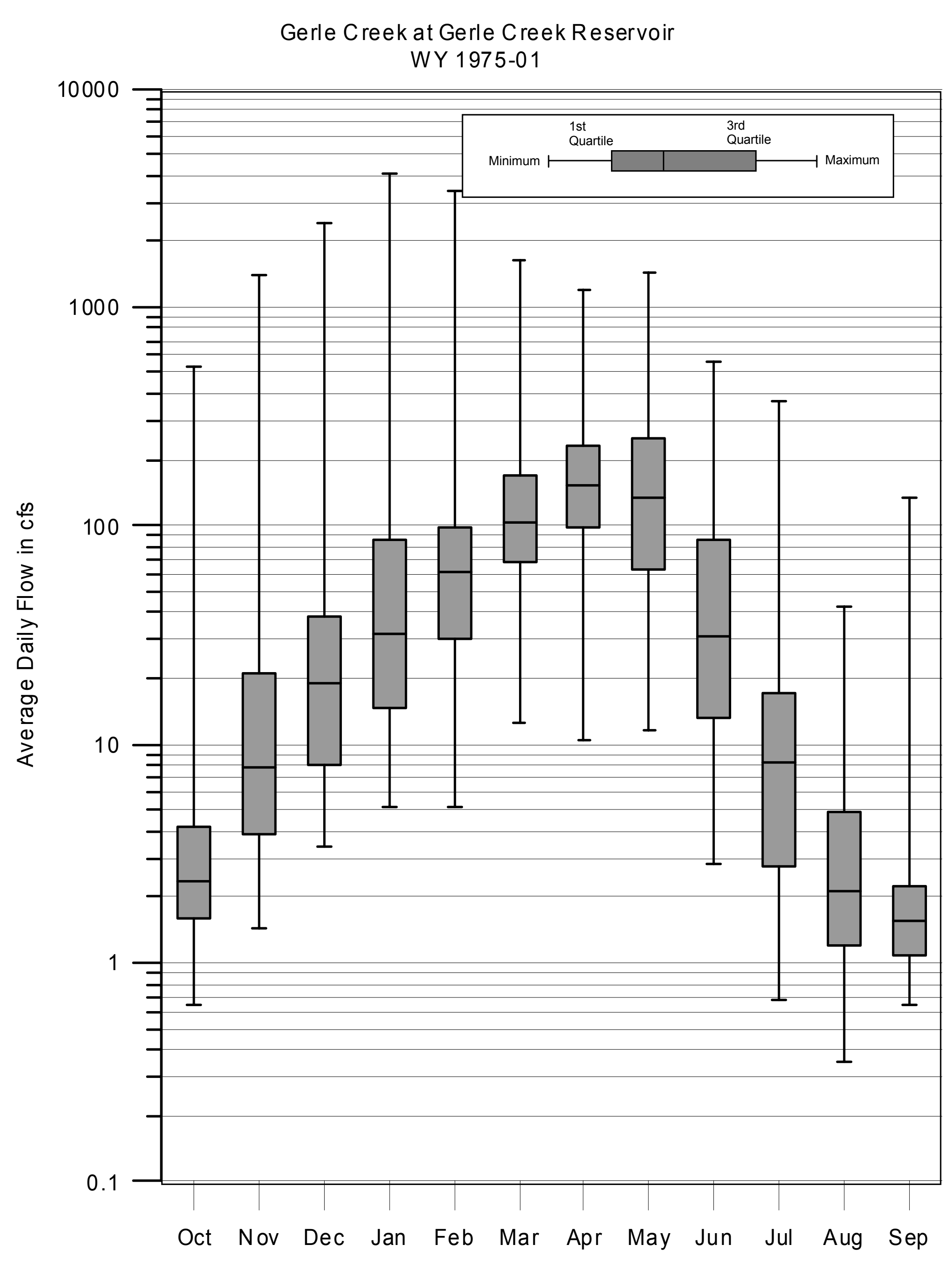


Figure 3.2.4-18. Gerle Creek at Gerle Creek Reservoir Unregulated Inflow, WY 1975-01, Monthly Box-whisker Diagram

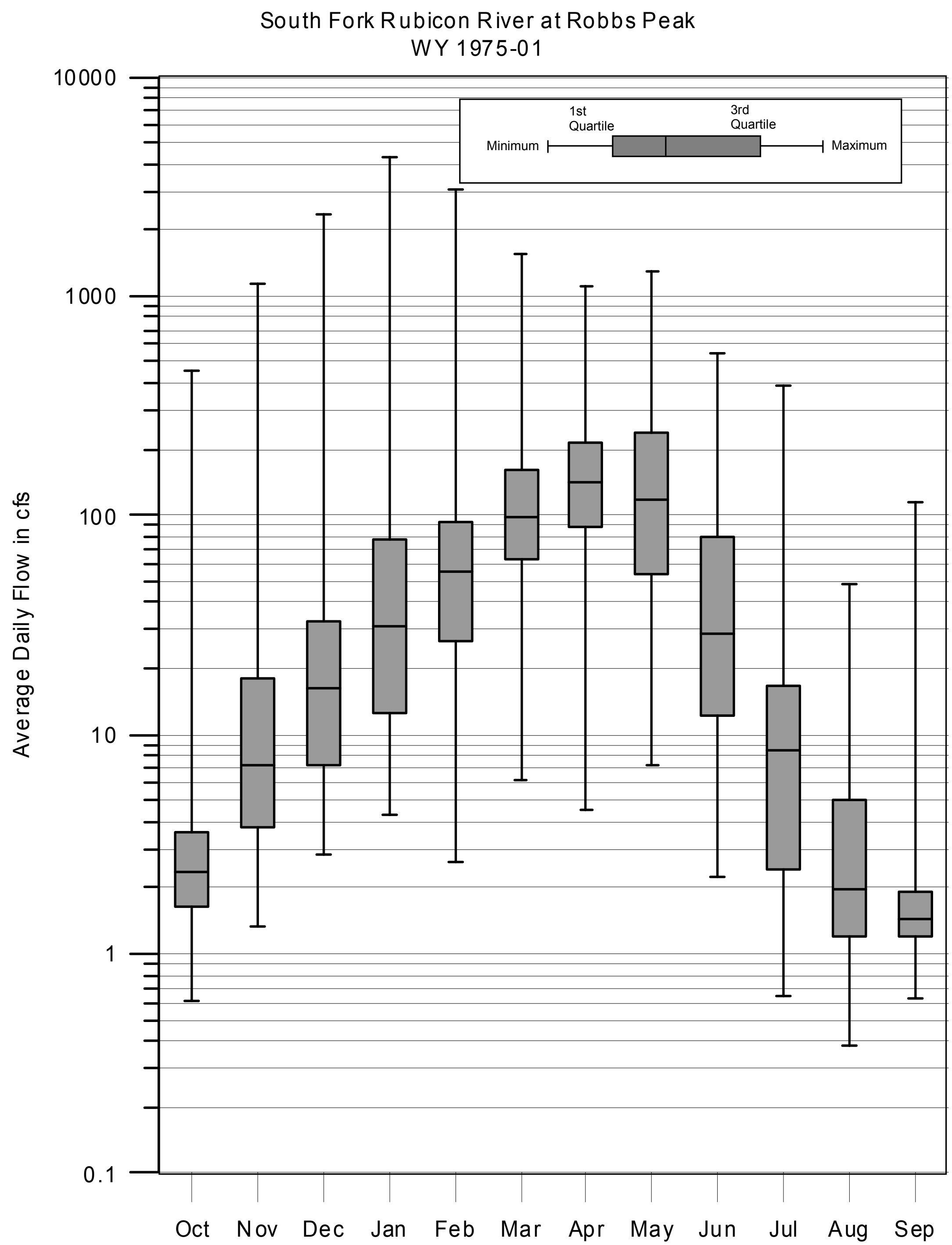


Figure 3.2.4-19. SF Rubicon River at Robbs Peak Unregulated Inflow, WY 1975-01, Monthly Box-whisker Diagram

3.2.5 Silver Creek at Union Valley Reservoir

Union Valley Reservoir is located on Silver Creek. The drainage area is about 83.9 square miles and ranges in elevation from 4,870 to 8,500 feet. The watershed is a combination of granite in the upper reaches of the watershed with timber area and better developed soils at the lower elevations. The unregulated inflow to Union Valley Reservoir is provided from three primary tributary streams: Tells Creek, Big Silver Creek, and Jones Fork Silver Creek.

The USGS began collecting streamflow data on Silver Creek at Union Valley in October 1924. The original gage was located at the location of the current dam site. The gage was removed in 1960 during the construction of the dam. The reservoir was completed in 1962. Since 1962, the flow of Silver Creek is regulated by Union Valley Reservoir and receives diversions from the Rubicon River, by Robbs Peak Powerhouse. To compute the local unregulated inflow to Union Valley Reservoir, SMUD adjusts the measured flow on Silver Creek to account for the change in Union Valley Reservoir storage, net evaporation, reservoir spill and diversions into the basin. Spill from the reservoir has been estimated by SMUD staff.

In April of 1985, Jones Fork Powerhouse was completed. With the addition of the powerhouse, flow was diverted from the South Fork of Silver Creek into Union Valley Reservoir. A schematic of the system is provided in Figure 3.2.5-1.

Daily data are available to compute the unregulated inflow into Union Valley Reservoir for the entire investigation period using a mass balance procedure. Examples of the "computed" unregulated flow are provided in figures 3.2.5-2 through 3.2.5-4. As seen in these figures, the computation resulted in some computed negative inflows and large daily fluctuations. These daily fluctuations are probably due to questionable storage data (i.e., wind and erroneous readings). The data inconsistencies were modified through a combination of professional judgment and a comparative review of pre- and post-project flow relationships between Silver Creek at Union Valley and the South Fork Silver Creek at Ice House. An example of the modified daily inflow is provided in figures 3.2.5-5 through 3.2.5-7. The black line represents the computed daily flow for Silver Creek at Union Valley based on a mass balance of gaged flows and computations. The final smoothed data are displayed in blue.

Unregulated inflow data for the site were tested for consistency (or homogeneity) for the investigation period 1975 through 2001 through a comparison to the unregulated inflow for the South Fork Silver Creek at Ice House, and appear as Figure 3.2.5-8. The data appear homogenous.

A box-whisker diagram describing the daily flow characteristics by month is provided as Figure 3.2.5-9. The average annual runoff at Union Valley Reservoir is 179,000 acre-feet. A table of monthly runoff at this site for the period 1975-2001 is included in Appendix B.

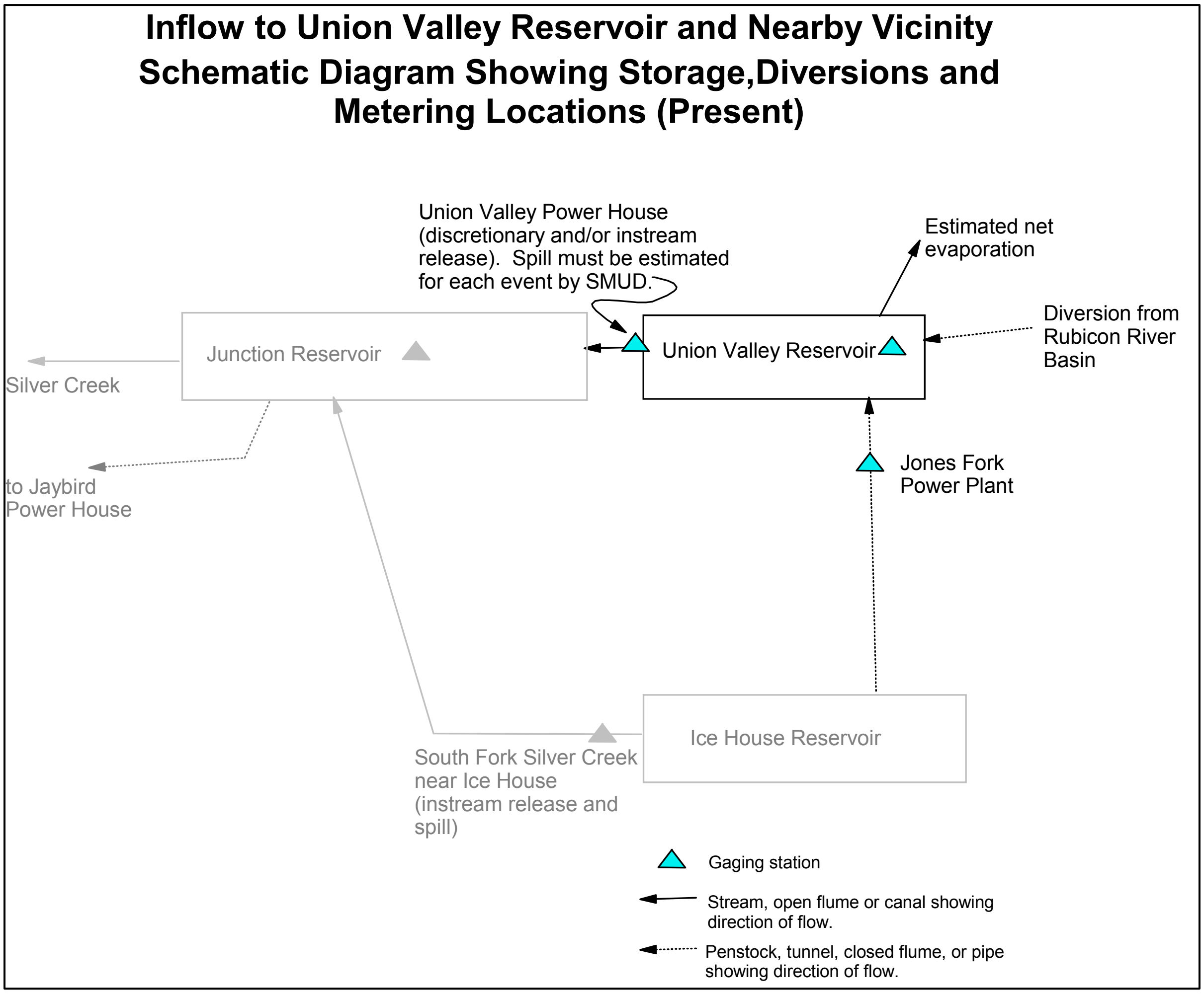


Figure 3.2.5-1. Inflow to Union Valley Reservoir and Vicinity – Schematic Diagram Showing Storage, Diversions and Metering Locations (Present)

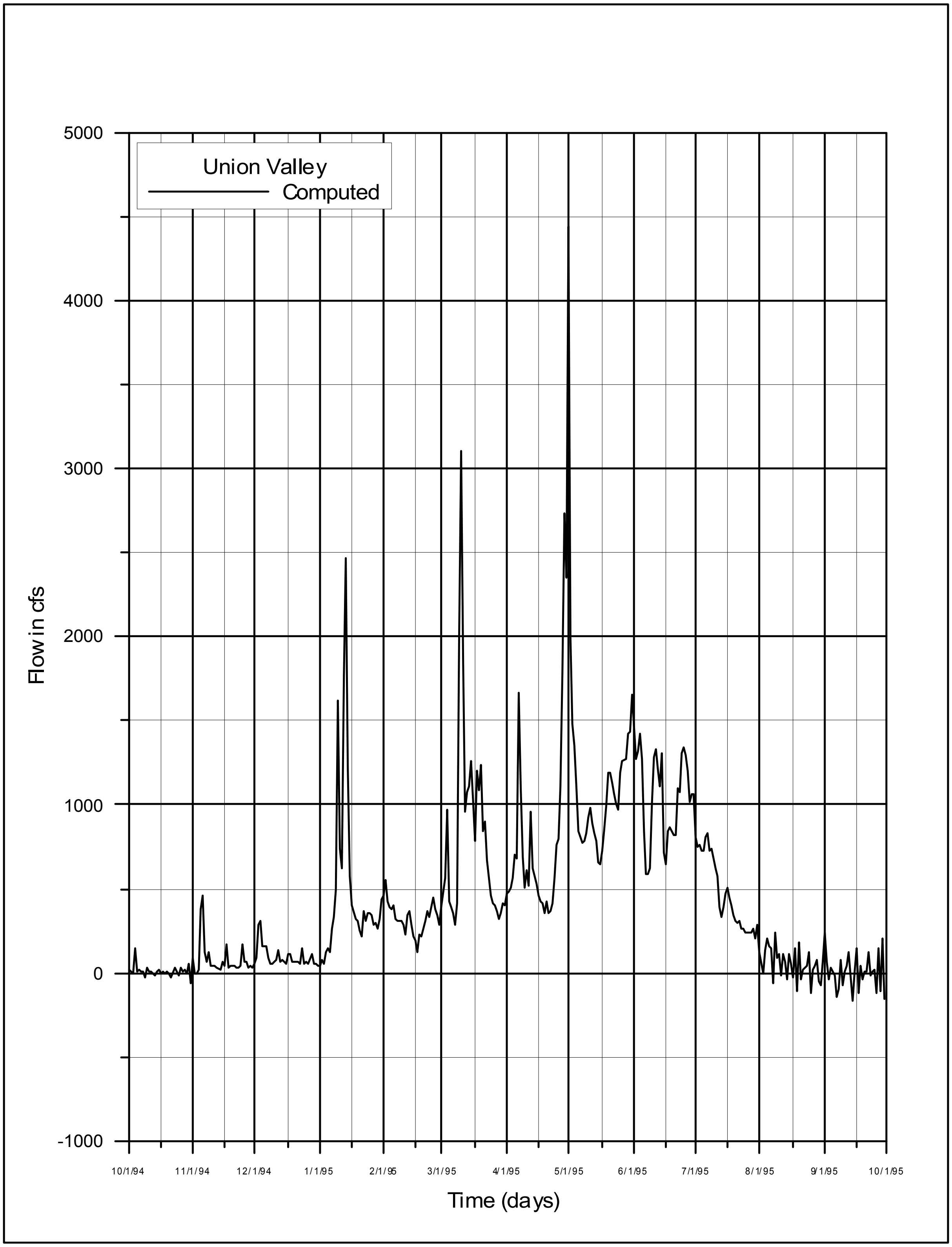


Figure 3.2.5-2. Unregulated Inflow to Union Valley Reservoir, WY 1995

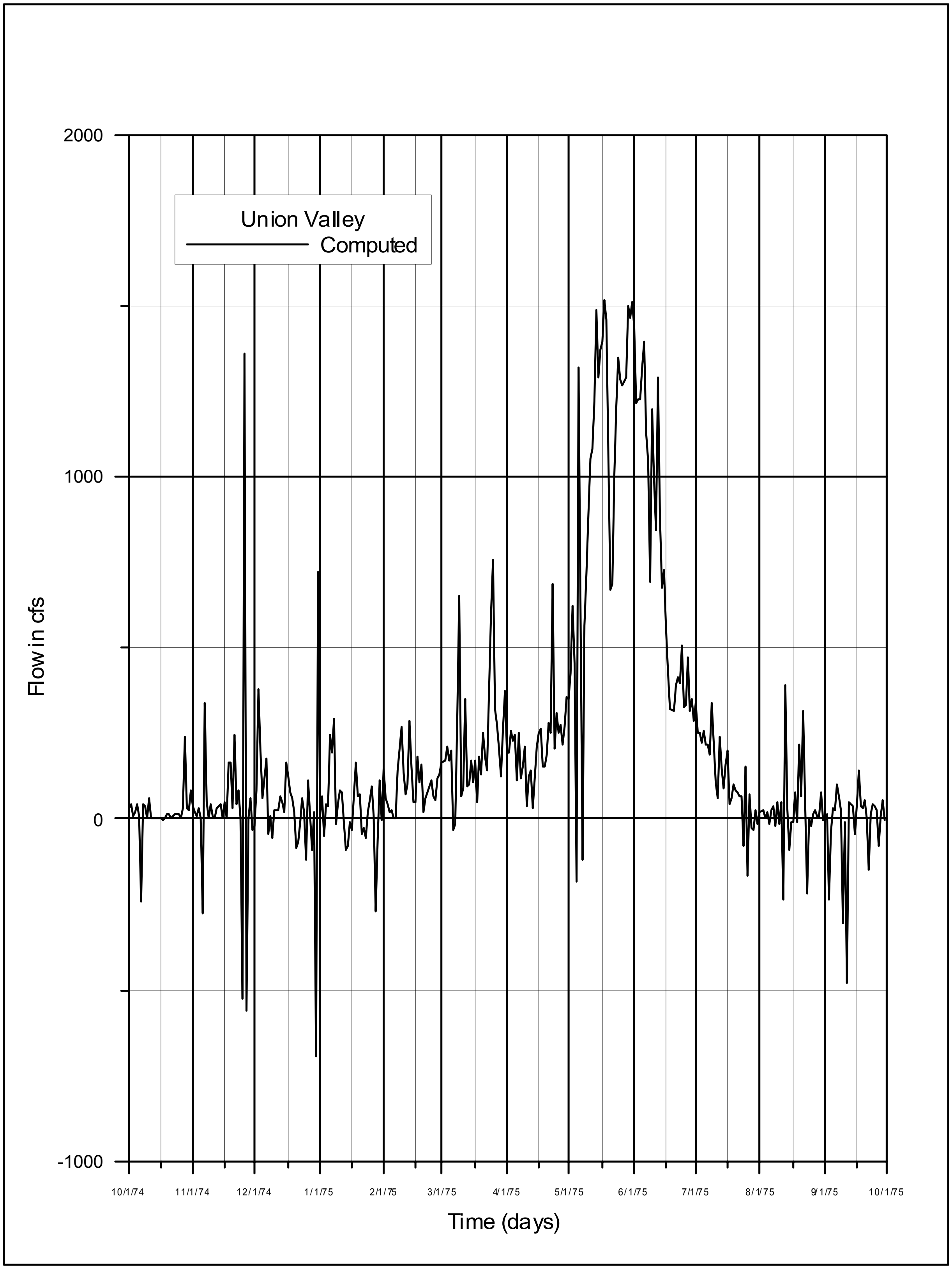


Figure 3.2.5-3. Unregulated Inflow to Union Valley Reservoir, WY 1975

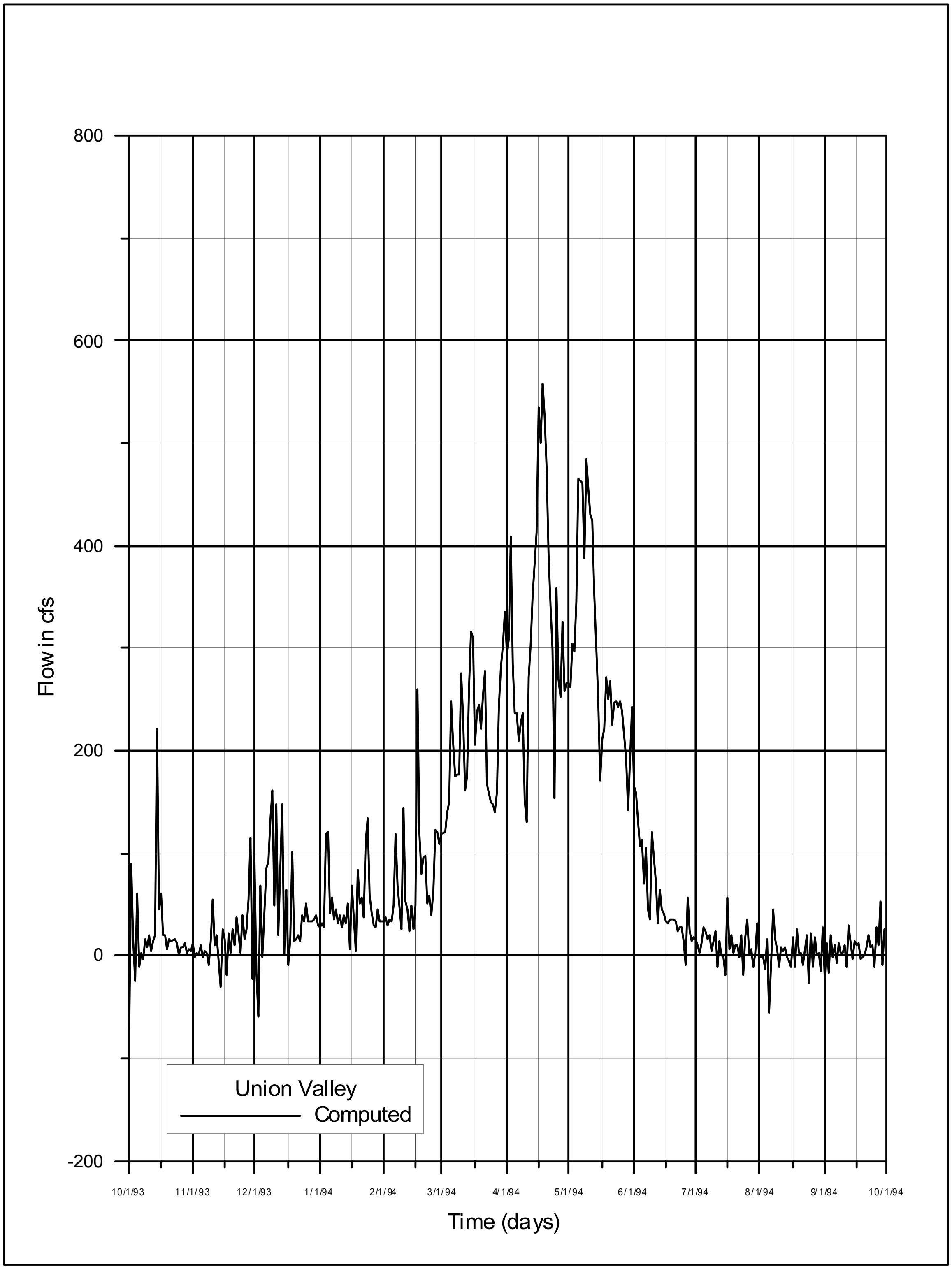


Figure 3.2.5-4. Unregulated Inflow to Union Valley Reservoir, WY 1994

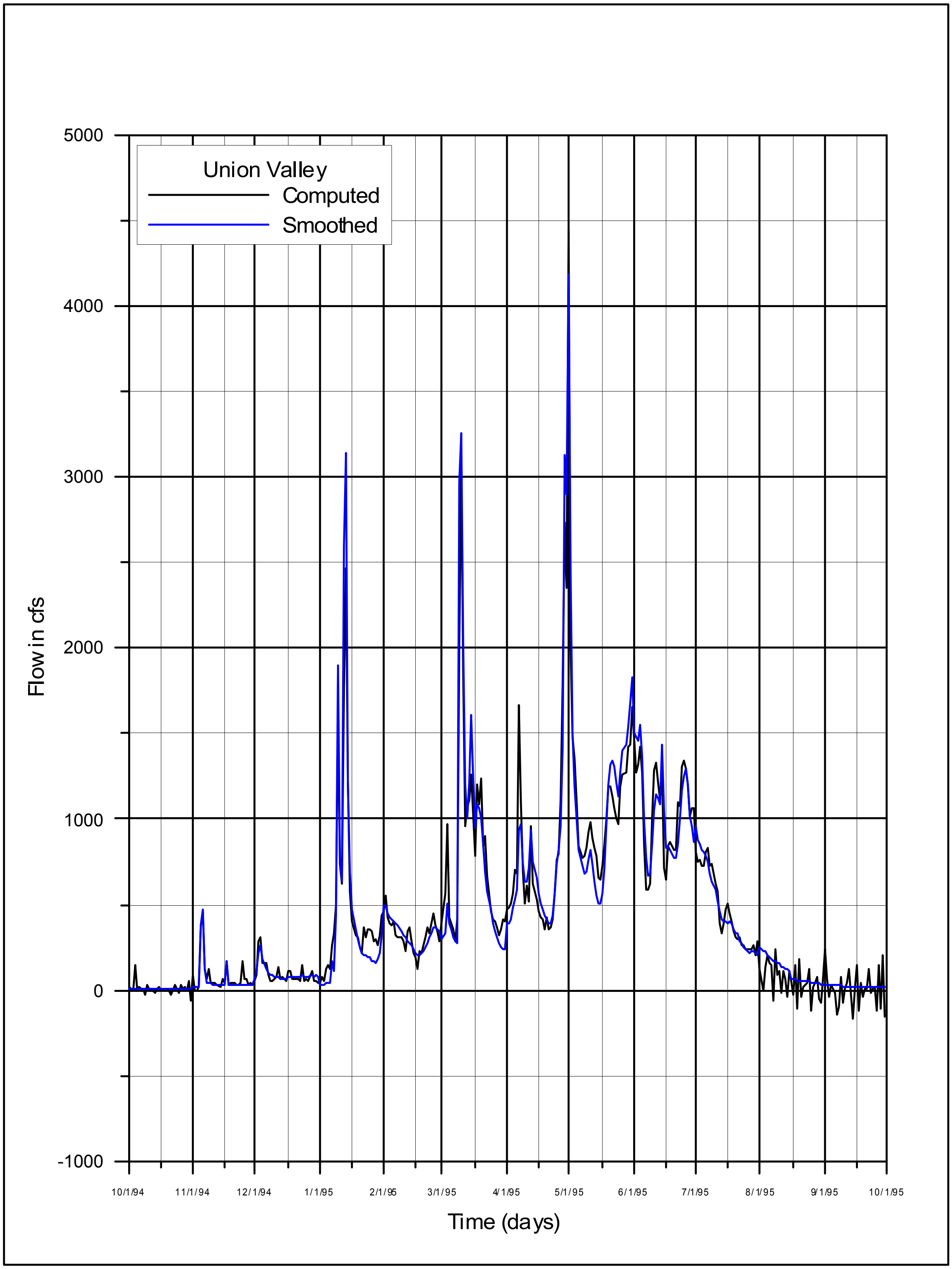


Figure 3.2.5-5. Unregulated Inflow to Union Valley Reservoir, WY 1995

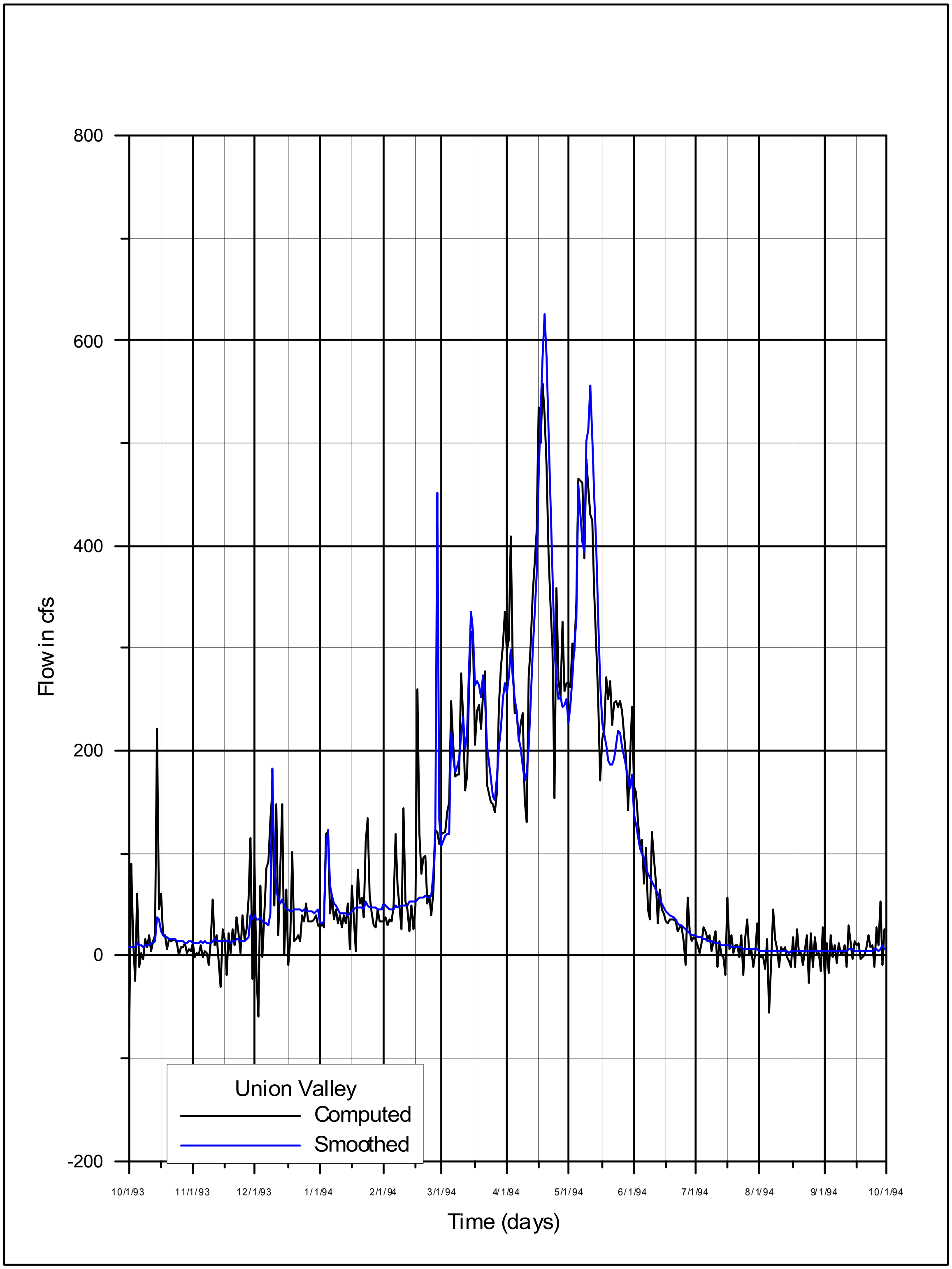


Figure 3.2.5-6. Unregulated Inflow to Union Valley Reservoir, WY 1975

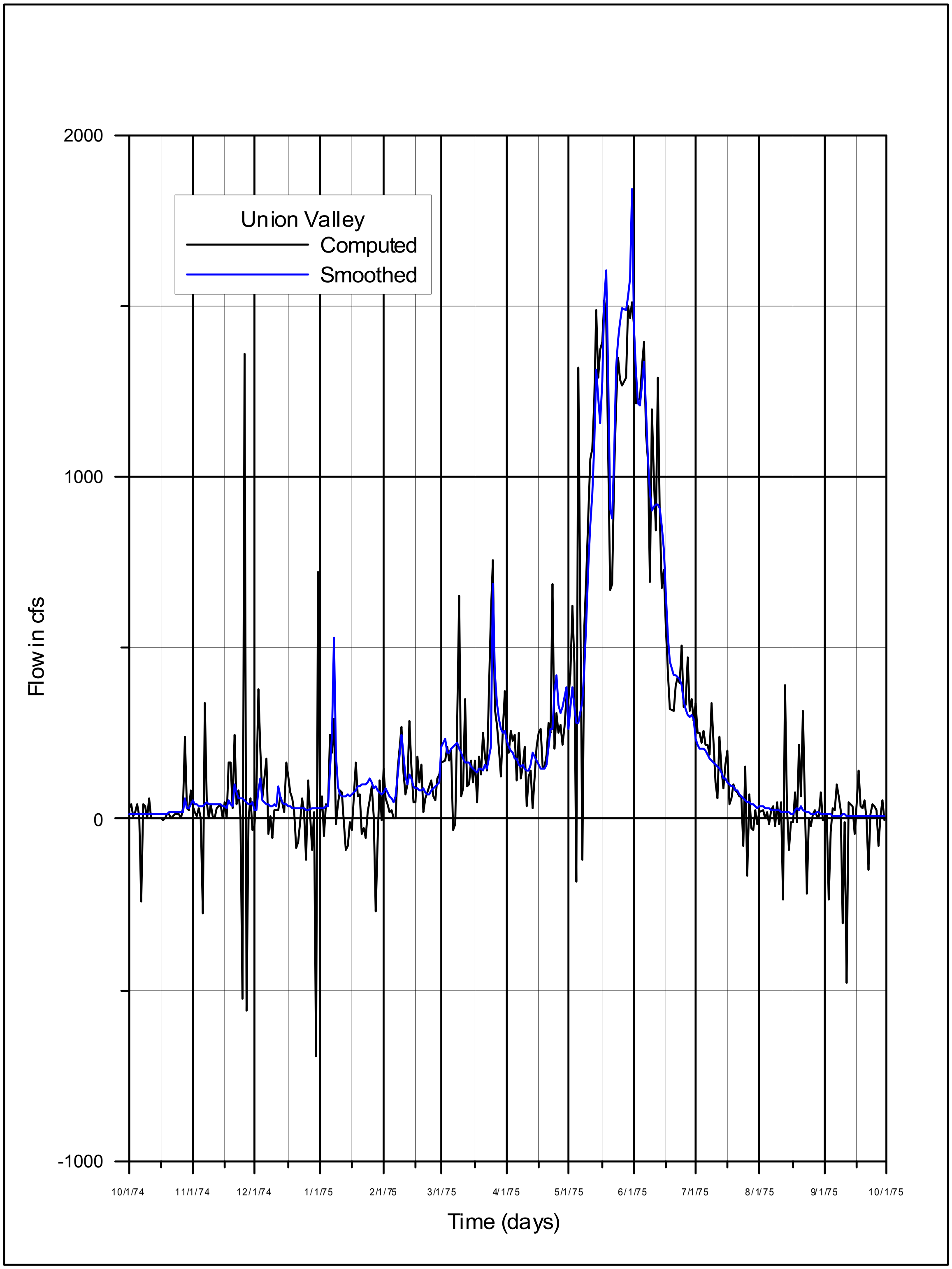


Figure 3.2.5-7. Unregulated Inflow to Union Valley Reservoir, WY 1994

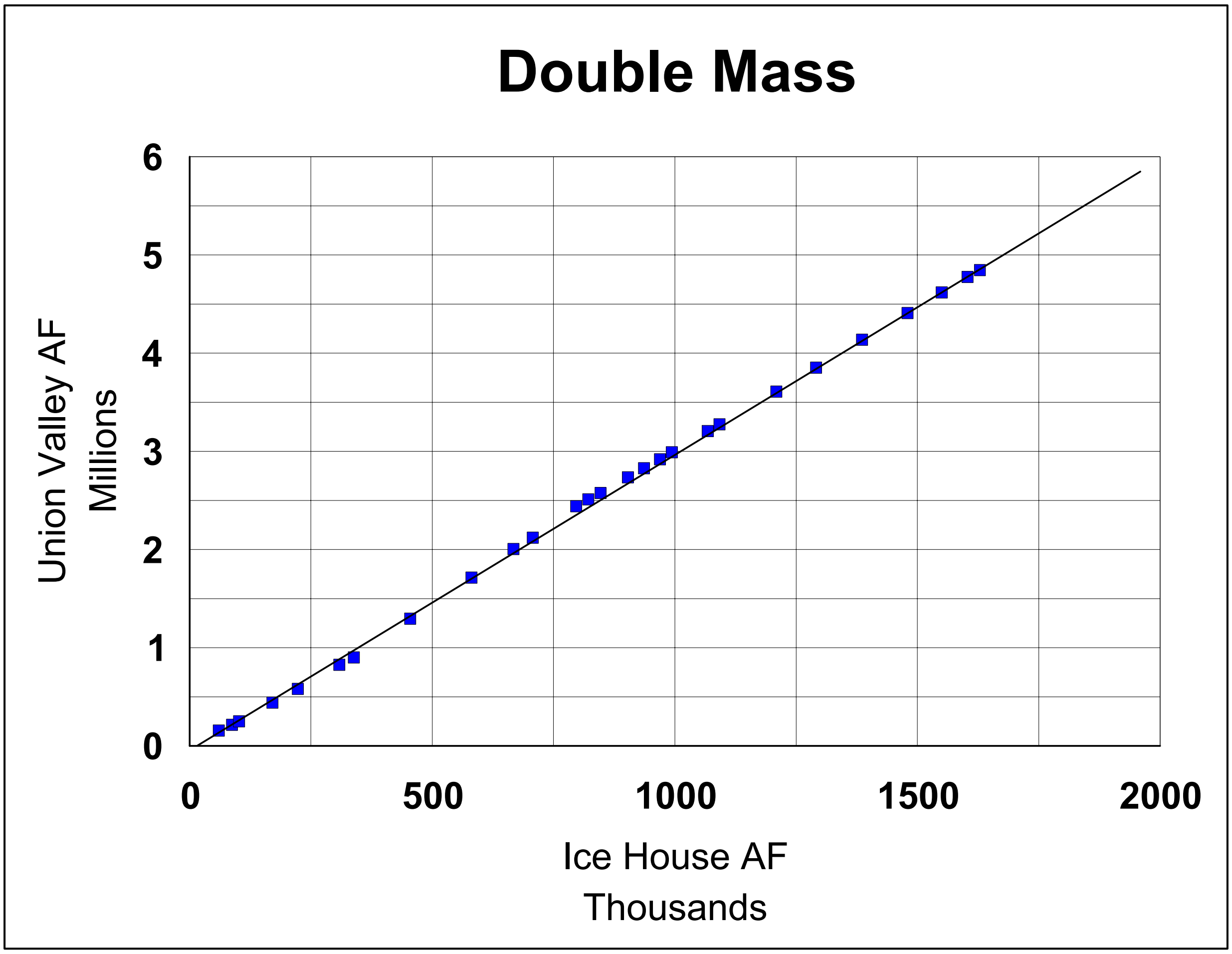


Figure 3.2.5-8. Double Mass - Unregulated Inflow to Union Valley Reservoir Versus Unregulated Inflow to Ice House Reservoir

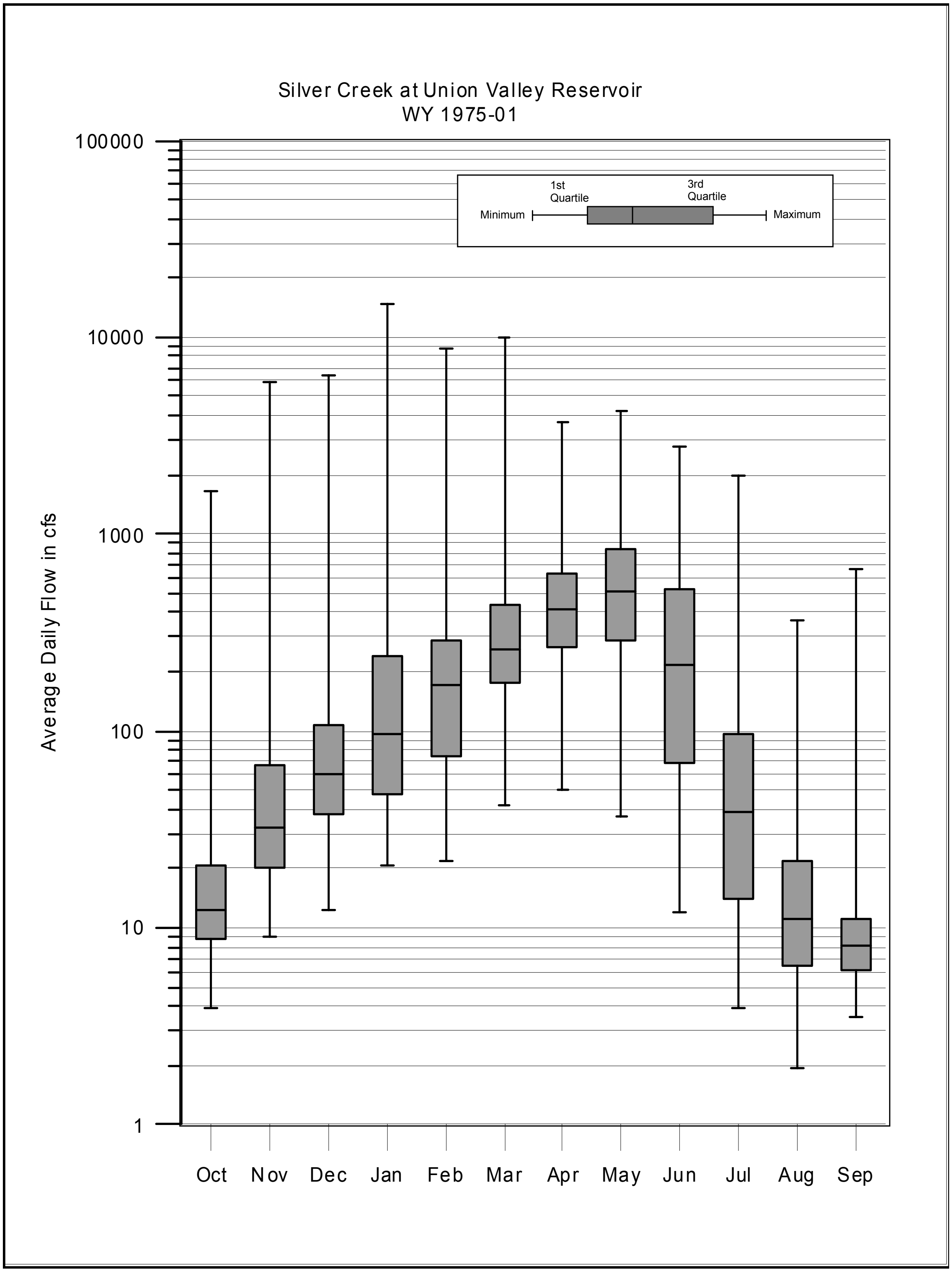


Figure 3.2.5-9. Silver Creek at Union Valley Reservoir, Unregulated Inflow, WY 1975-01, Monthly Box-whisker Diagram

3.2.6 Silver Creek at Camino Reservoir Including Brush Creek

The lower Silver Creek drainage, downstream of Union Valley Reservoir, contains three computation nodes with respect to the UARP (Figure 3.2.6-1):

- Silver Creek at Junction Reservoir
- Silver Creek at Camino Reservoir
- Brush Creek at Brush Creek Reservoir

The Silver Creek drainage area at Junction Reservoir Dam is 142.6 square miles and ranges in elevation from 4,450 to almost 10,000 feet. This drainage includes the South Fork Silver Creek, as well as the primary drainages upstream of Union Valley Reservoir. The watershed is a combination of granite and timber area with well developed soils. Construction of the dam was completed in 1962. SMUD has monitored or estimated all of the flow management components required to compute the unregulated inflow since 1993.

The Silver Creek drainage area at Camino Reservoir is 167.1 square miles and ranges in elevation from 2,920 to almost 10,000 feet. The watershed is a combination of granite and timber area with well developed soils. Construction of the dam was completed in 1961.

The Brush Creek drainage area at Brush Creek Reservoir is 8.0 square miles and ranges in elevation from 2,920 to almost 5,000 feet. The drainage area is covered with timber and has well developed soils. Construction of the dam was completed in 1961. Brush Creek Tunnel connects Brush Creek Reservoir with the lower end of Camino Tunnel. The Brush Creek Tunnel allows water to flow to and from the Camino Tunnel to Brush Creek Reservoir. The flow through the Brush Creek Tunnel is not monitored so it is only possible to compute the combined unregulated flow for the Silver Creek at Camino Reservoir and Brush Creek at Brush Creek Reservoir. Daily data have been monitored since 1993.

The process of computing unregulated flow at each of the three UARP nodes required a series of analytical steps that consist of combining drainages throughout the basin, then disaggregating them. The first step consisted of estimating the combined unregulated inflow at Camino Reservoir and Brush Creek Reservoir. This portion of the inflow estimate incorporates the total accretion that enters Silver Creek downstream of Union Valley Reservoir and Ice House Reservoir. Flows upstream of these reservoirs are not factored into this initial step of the analysis. Thus, this portion of the inflow estimate incorporates accretions from all sources including major tributaries below Ice House Reservoir (e.g., Big Hill Creek) as well as inflows downstream of Union Valley (e.g., Little Silver Creek, Onion Creek). The portion of the combined estimate dealing with Brush Creek consists of the total unregulated inflow to Brush Creek Reservoir. Once an estimate of the combined unregulated flow is derived, the second step of the process is to disaggregate the accretion values into the three separate drainages.

The combined unregulated inflow of Silver Creek at Camino Reservoir (excluding flow above Union Valley Reservoir and Ice House Reservoir) plus Brush Creek at Brush Creek Reservoir is computed from a mass balance procedure for the investigation period. Examples of the computed data are provided in figures 3.2.6-2 through 3.2.6-4. As seen from these figures, there are many computed negative flows and large daily fluctuations. Some of these anomalies are attributable to the combined unregulated inflow often being relatively small compared to the volume of water passing through both powerhouses (Union Valley and Camino). Errors in the measurement of these large powerhouse flows can easily be greater than the computed unregulated flow. Also, the investigation period has several years of missing storage records and extended periods of missing records for the draft through the Camino Powerhouse. To overcome the problems associated with the computed flow, a procedure was developed to synthesize the inflows for the investigation period in order to validate or adjust the computed inflows.

Because the Junction-Camino-Brush drainage basins do not have similar elevation characteristics, the flow synthesis procedure for the drainage area are analyzed as two components, each with their own elevation characteristics:

- Brush Creek at Brush Creek Reservoir
- Silver Creek at Camino Reservoir (excluding flow above Union Valley Reservoir and Ice House Reservoir)

The following describes the analysis performed for each of these drainage areas and the additional analysis required to disaggregate the second component into accretions to Junction Reservoir and accretions to Camino Reservoir.

As described previously, the Brush Creek drainage is relatively low in elevation and receives the majority of its annual precipitation in the form of rain. Several USGS low elevation sites were considered for use in the synthesis process, but only three were ultimately applied:

- Rock Creek near Placerville (adjusted for the Rock Creek Powerplant near Placerville), period of record 1986-present
- Pilot Creek above Stumpy Meadows, 1960-present
- Forest Creek near Wilseyville, 1960-present

The Rock Creek station was selected due to its proximity to the UARP and similar basin elevation characteristics. Despite the fact that the Rock Creek drainage is nearby the Brush Creek drainage, the runoff production per square mile is much less than Brush Creek. A more significant limitation with the Rock Creek data is the fact that the period of record does not cover the full investigation period. To overcome the period of record limitation, the Rock Creek data have been extended with the aid of the Pilot and Forest creek data.

Both the Pilot Creek and Forest Creek stations were evaluated as data sources for extending the Rock Creek data (figures 3.2.6-5 and 3.2.6-6). However, the Pilot Creek drainage is significantly higher in elevation, leading to poor correlation results when the data are compared on a daily basis, leading to the conclusion that Pilot Creek data are of limited value in extending the Rock Creek daily record.

Daily and monthly flow data of Rock Creek and Forest Creek are much more strongly correlated, resulting in the use of the Forest Creek data to extend the Rock Creek record. Then, using annual data (not the daily data) from Pilot Creek, a relationship was developed between Rock Creek and Pilot Creek to evaluate the extended data. If the annual sum of the daily extended flows varied significantly from the expected volume, the data were adjusted. Relationships used to extend the record are summarized in Appendix C.

Once the Rock Creek data were extended, the inflow into Brush Creek Reservoir was estimated. Based on estimates performed by SMUD, the average annual runoff into Brush Creek Reservoir is about 14,000 acre-feet. The daily inflow into Brush Creek is estimated as follows:

Inflow to Brush Creek Reservoir (cfs) =	Rock Creek daily flow times * 0.2684

Unregulated inflow data for the site were tested for consistency (or homogeneity) for the investigation period 1975 through 2001 through comparison with the unregulated inflow at the American River at Fair Oaks, and appears as Figure 3.2.6-7. The data appear homogenous.

The second component of the Junction-Camino-Brush drainages is the Silver Creek at Camino location (excluding flow above Union Valley Reservoir and Ice House Reservoir). The process of estimating the accretion in this drainage area began with use of the historical USGS gage record. Prior to the construction of the UARP, the USGS maintained a gage on Silver Creek just above the confluence of the South Fork American River (Silver Creek near Placerville). The drainage area was estimated to be 177 square miles, which is just 6 square miles downstream of the present Camino Reservoir. Also, there were USGS gages at the current approximate locations of Union Valley Reservoir Dam on Silver Creek and Ice House Reservoir on the South Fork Silver Creek. An estimate of accretion between the two upper gages and the mouth of Silver Creek was derived by subtracting the flow at the upstream gages from the downstream gage, explained as the following equation:

Silver Creek at Placerville = Excluding flow above Union Valley Reservoir and Ice House Reservoir (Adjusted Silver Creek near Placerville)	Silver Creek near Placerville minus South Fork Silver Creek near Ice House minus Silver Creek at Union Valley

Next, data from nearby gaging stations were used to develop monthly relationships with the computed Adjusted Silver Creek near Placerville. The two sites used were:

- Pilot Creek near Georgetown, and
- Silver Creek at Union Valley

Both sites were discontinued prior to the investigation period. However, Pilot Creek near Georgetown was replaced with Pilot Creek near Stumpy Meadows (located upstream of the Georgetown gage) and unregulated flow of Silver Creek at Union Valley was a computation node in this analysis (see Section "Silver Creek at Union Valley"). The Pilot Creek gage was used to synthesize the winter/spring period (figures 3.2.6-8 and 3.2.6-9) and the Silver Creek to synthesize the summer/fall period (Figure 3.2.6-10). Relationships were developed from the monthly values shown in the plots. Because the earlier gages have been relocated, the points used to develop the relationships were transformed to represent the current gage location Relationships used to extend the record are summarized in Appendix C.

Daily flows have been synthesized for the investigation period at the following two sites:

- Brush Creek at Brush Creek Reservoir
- Silver Creek at Camino (excluding flow above Union Valley Reservoir and Ice House Reservoir)

Data were summed for the two drainage areas and compared to the original computed data (figures 3.2.6-11 through 3.2.6-13). The black line represents the computed daily inflow based on a mass balance of gaged flows and computations. The red line represents the synthesized daily inflow. Synthesized data have been used for the period 1975-1992 (red line). For the period 1993-2001, the synthesized daily data have been used but have been proportionately adjusted on a daily basis to equal the monthly volume of computed inflow based on the USGS record. The results of an example of these adjustments are shown in figures 3.2.6-11 and 3.2.6-13. Upon further review of the data, additional modification was made to finalize the daily data while maintaining the monthly volumes (blue line). A double mass diagram using these data are provided in Figure 3.2.6-14, Double Mass Diagram.

After creating the final data set, “Silver Creek at Camino excluding flow above Union Valley Reservoir and Ice House Reservoir” was disaggregated into two components:

- Accretions to Junction Reservoir (referred to as Area A)
- Accretions to Camino Reservoir

As described previously, SMUD has computed the daily inflow to Area A and accretions to Camino Reservoir plus the Brush Creek inflow (Area B) since 1993. To disaggregate the synthesized “Silver Creek at Camino excluding flow above Union Valley Reservoir and Ice House Reservoir” into Area A and accretions to Camino Reservoir the following relationships were developed using the computed data:

- Area A plus Area B minus the synthesized Brush Creek Inflow (combined accretions to Junction and Camino only)
- Area A (accretions to Junction)

The synthesized flow was disaggregated and synthesized flows for Area A and Area B estimated. The results were compared to the computed flows for Area A and Area B for the 1993-2001 period. Relationships used to extend the record are summarized in Appendix C. Results for water years 1995, 2000 and 1994 are displayed for Area A and Area B in figures 3.2.6-15 through 3.2.6-20.

The computed accretions for the drainages above Union Valley Reservoir and Ice House Reservoir are then added to the components of accretion for the Junction and Camino locations. A box-whisker diagram describing the daily flow characteristics by month has been prepared for:

- Silver Creek at Junction Reservoir (Figure 3.2.6-21)
- Silver Creek at Camino Reservoir (Figure 3.2.6-22)
- Brush Creek inflow to Brush Creek Reservoir (Figure 3.2.6-23)

The average annual runoff is estimated as:

- Silver Creek at Junction Reservoir: 295,500 acre-feet
- Silver Creek at Camino Reservoir: 335,600 acre-feet
- Brush Creek inflow to Brush Creek Reservoir: 14,200 acre-feet

A table of monthly runoff at this site for the period 1975-2001 is included in Appendix B.

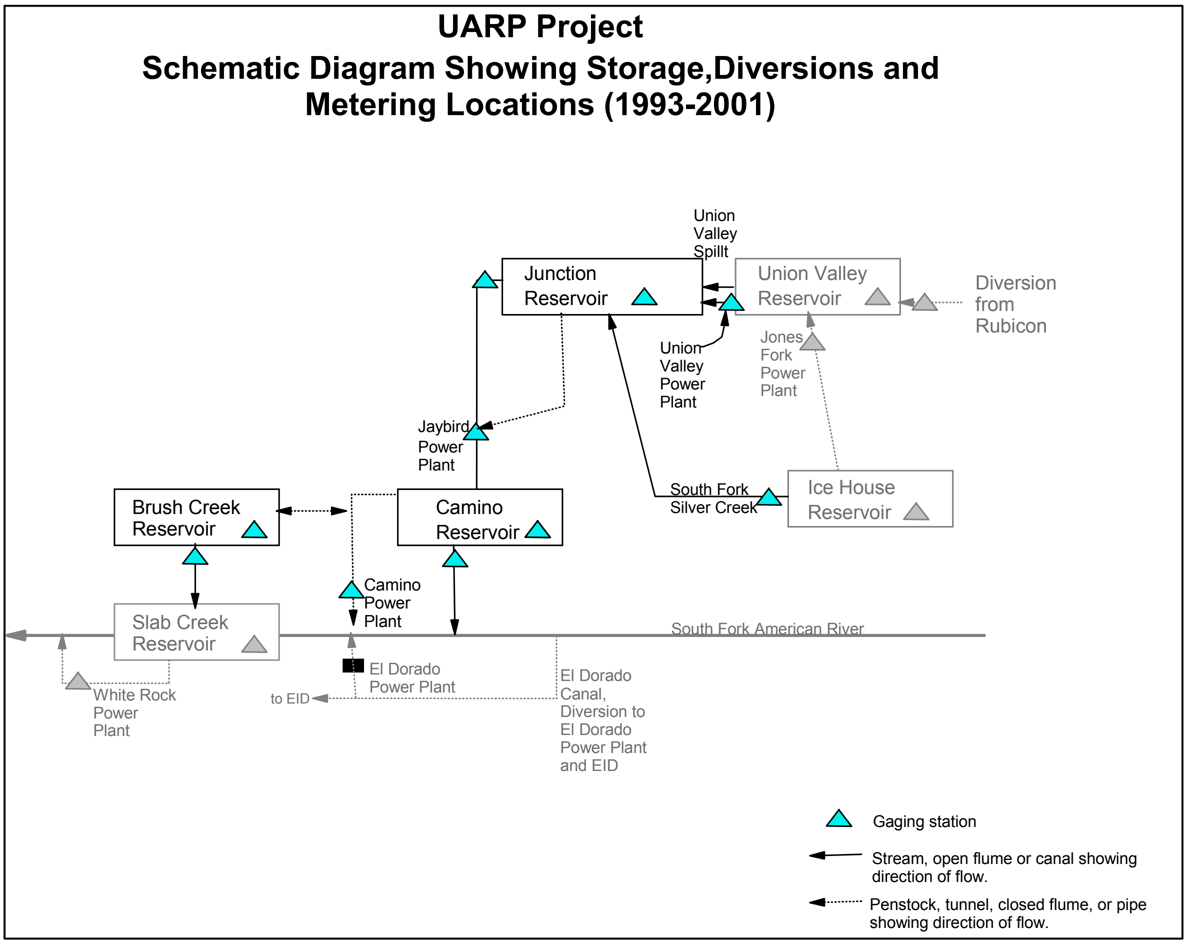


Figure 3.2.6-1. UARP – Schematic Diagram Showing Storage, Diversions and Metering Locations (1993-2001)

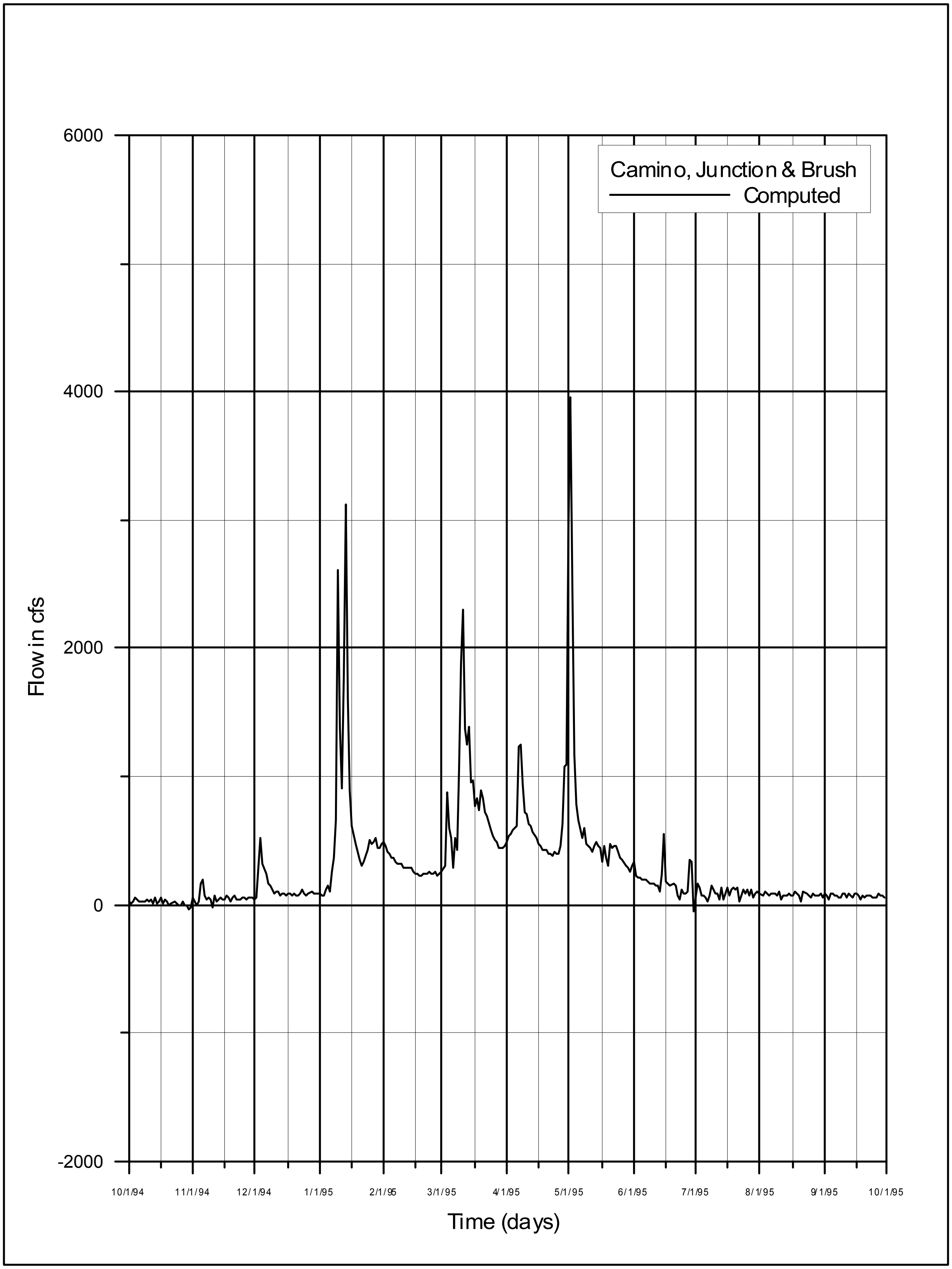


Figure 3.2.6-2. Unregulated Inflow to Camino, Junction and Brush, WY 1995

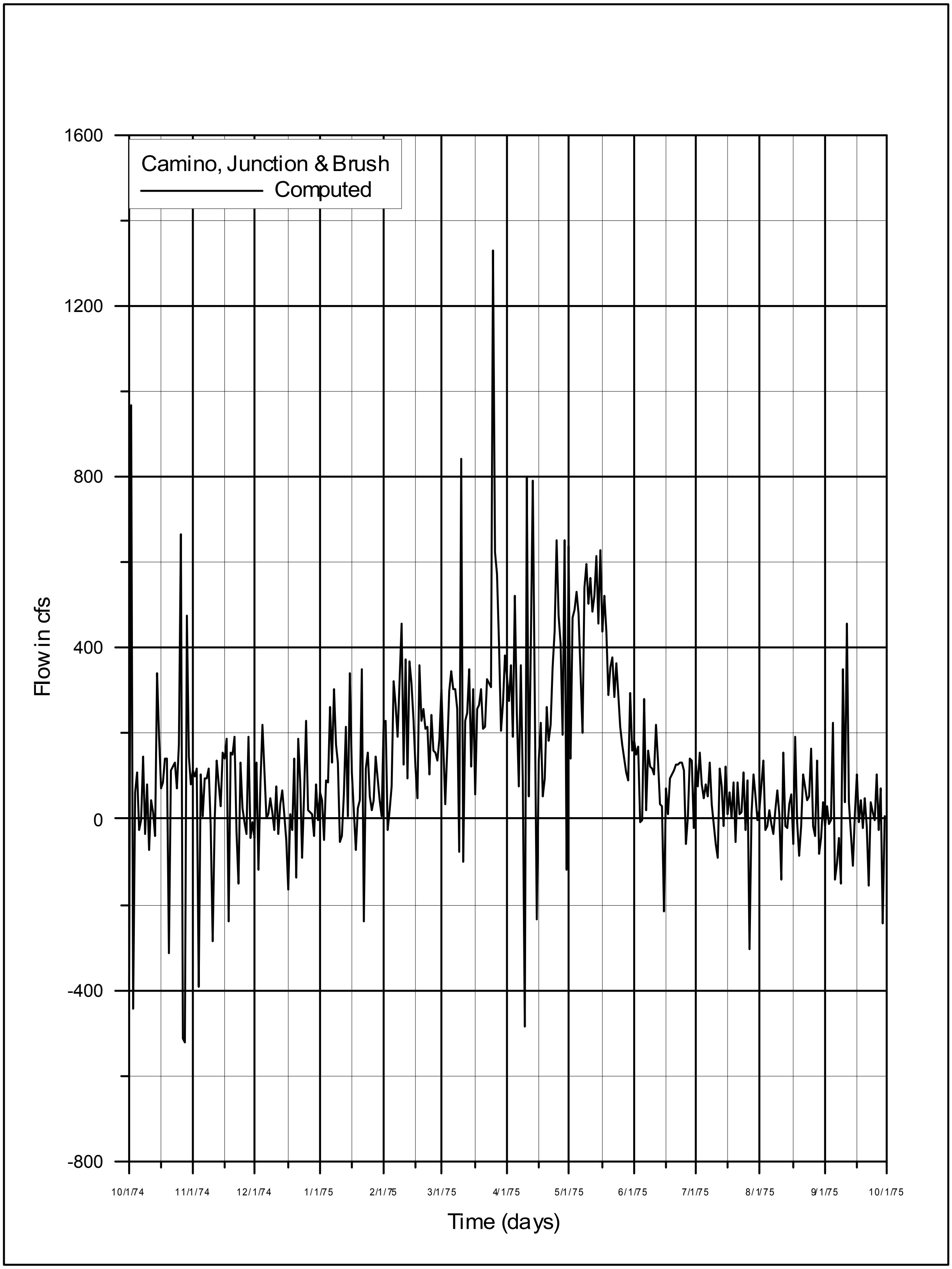


Figure 3.2.6-3. Unregulated Inflow to Camino, Junction and Brush, WY 1975

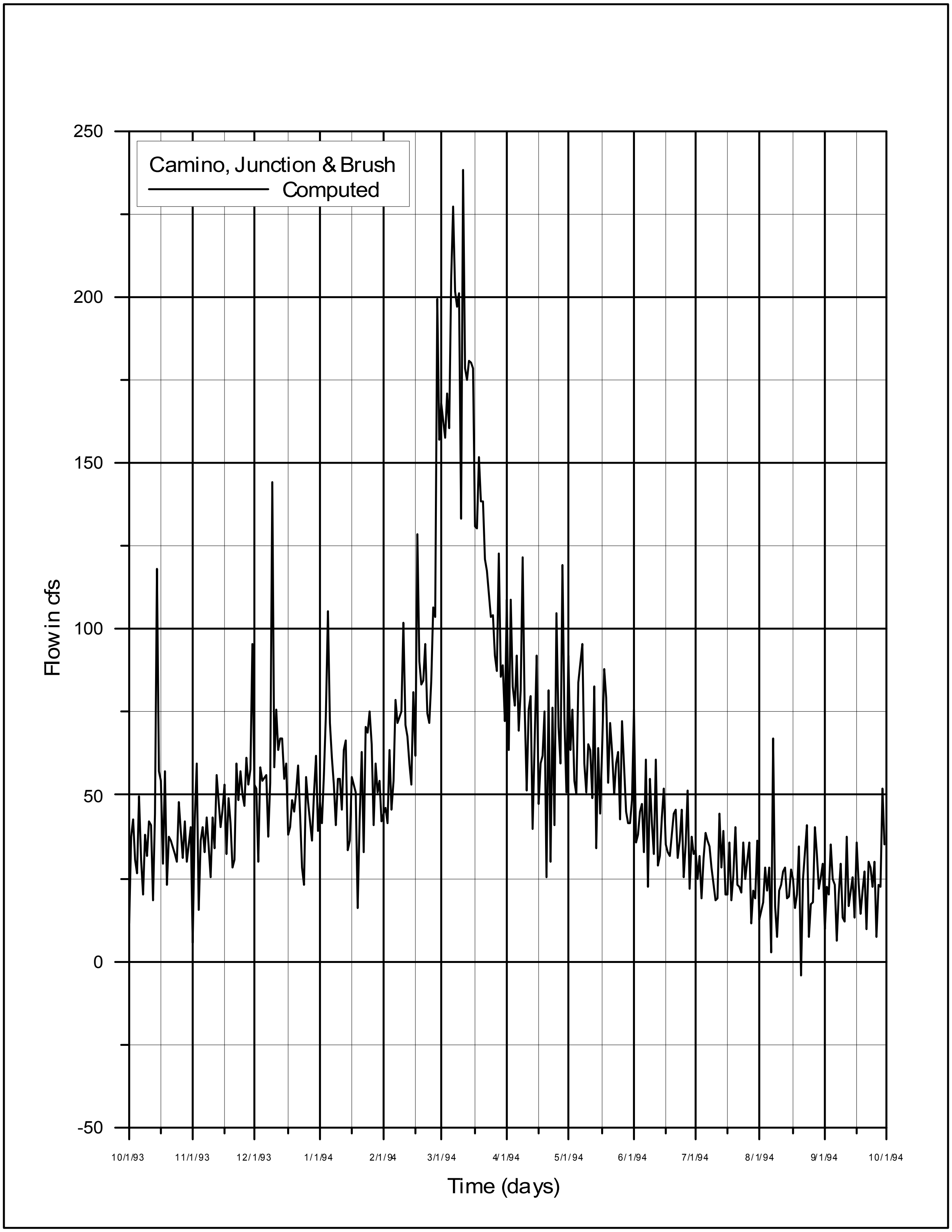


Figure 3.2.6-4. Unregulated Inflow to Camino, Junction and Brush, WY 1994

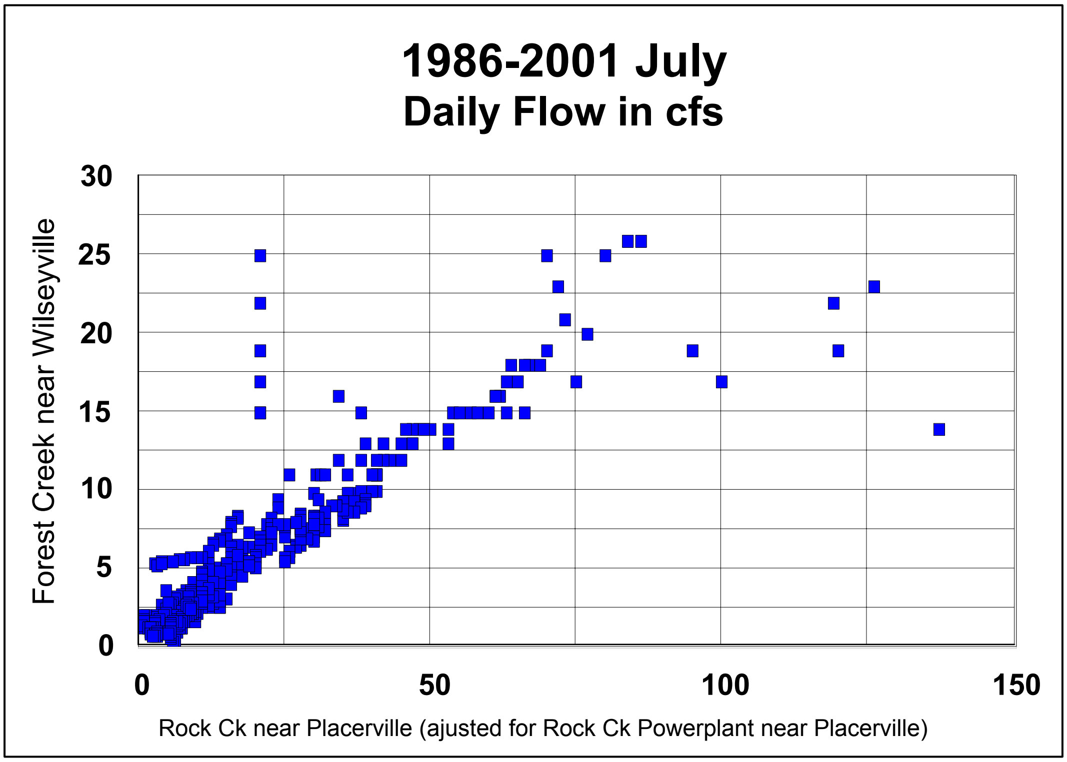


Figure 3.2.6-5 1986-2001 July – Daily Flow – Forest Creek Near Wilseyville Versus Rock Creek near Placerville (adjusted for Rock Creek Powerplant near Placerville)

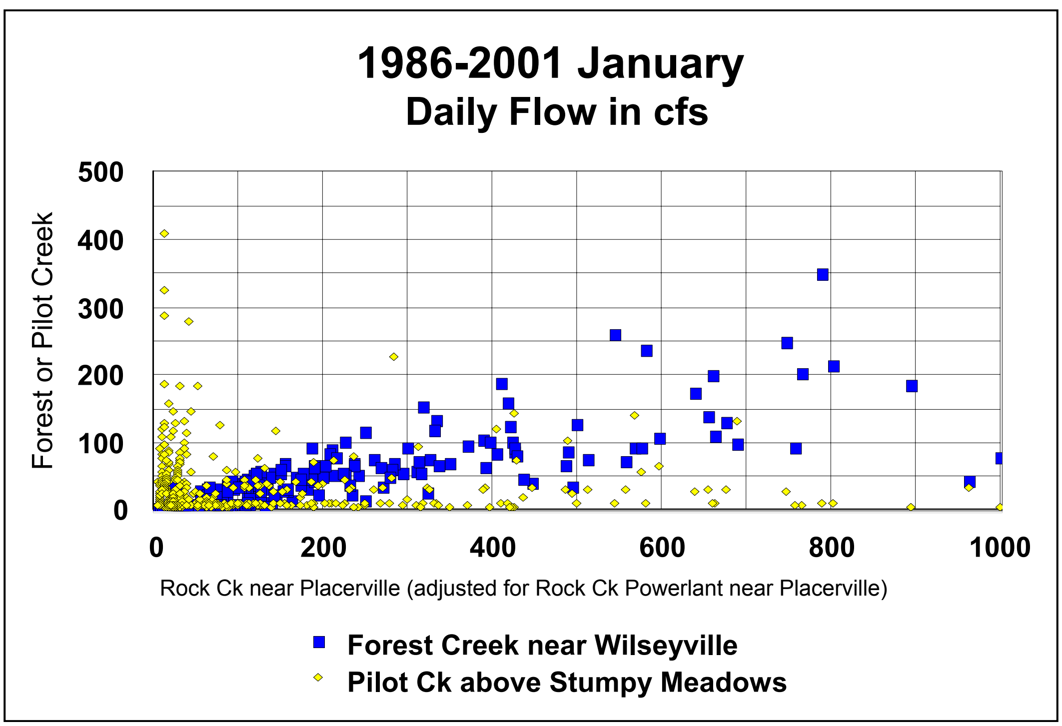


Figure 3.2.6-6. 1986-2001 January – Daily Flow – Forest Creek Near Wilseyville Versus Rock Creek near Placerville (adjusted for Rock Creek Powerplant near Placerville)

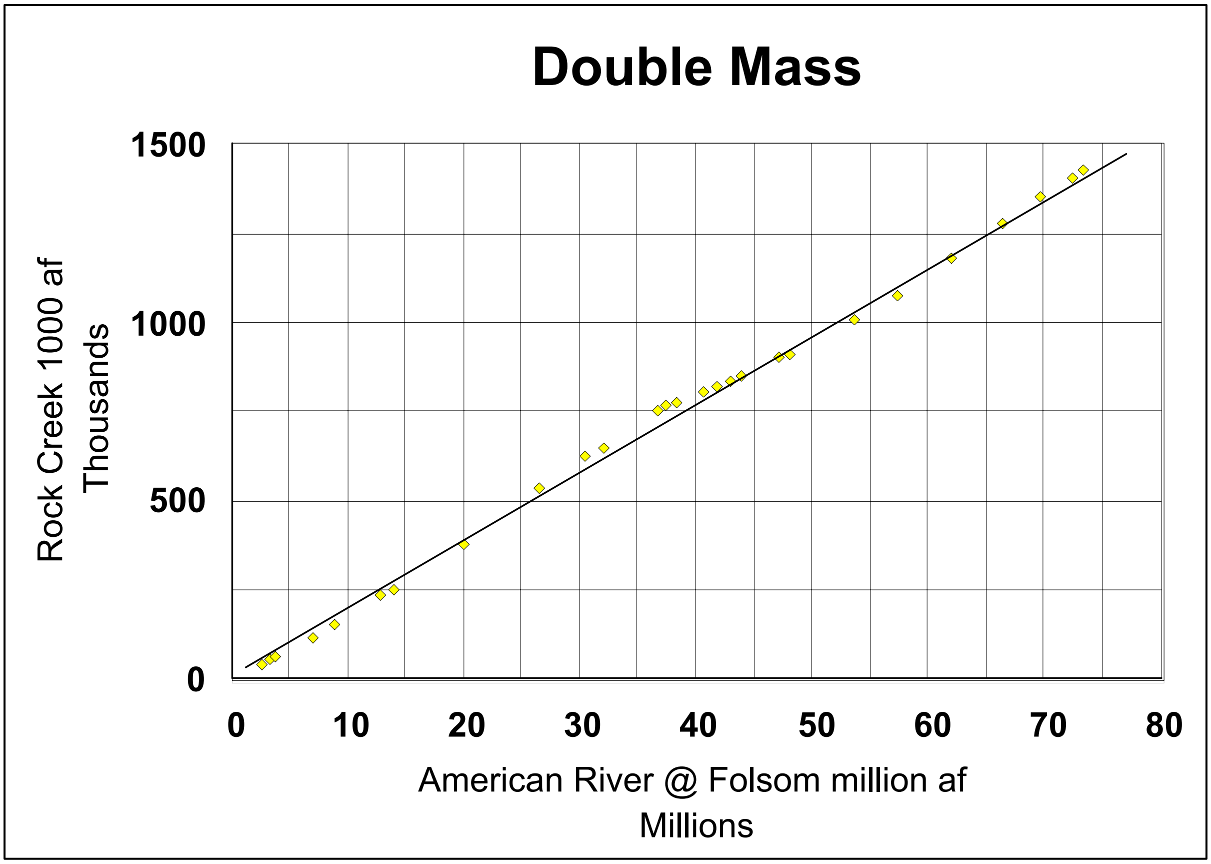
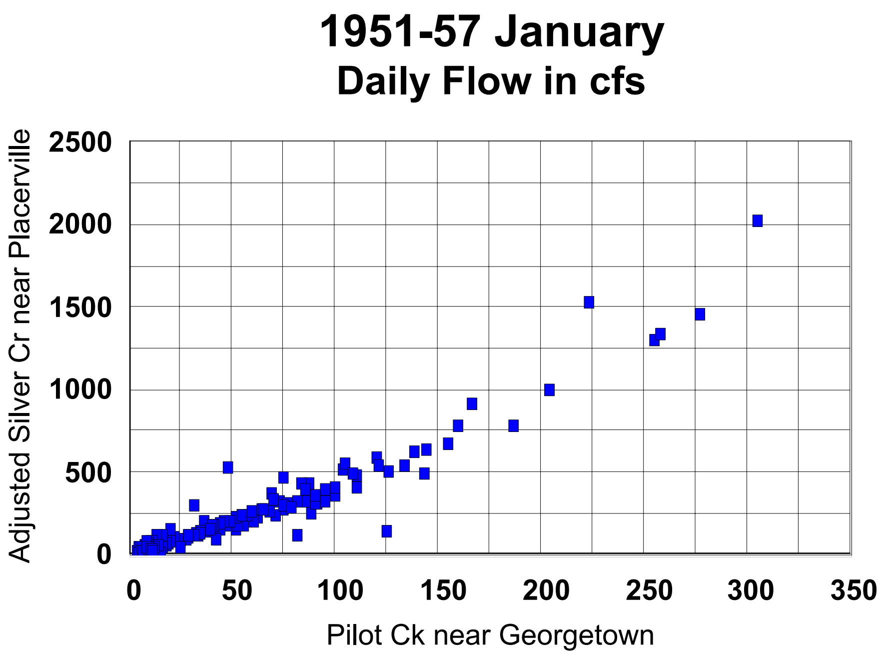


Figure 3.2.6-7. Double Mass – Unregulated Inflow at Rock Creek Versus Unregulated Inflow for the American River at Fair Oaks (Folsom)



Adjusted Silver Creek near Placerville: Silver Creek near Placerville minus South Fork Silver Creek near Ice House and Silver Creek at Union Valley

Figure 3.2.6-8. 1951-57 January - Daily Flow: Adjusted Silver Creek near Placerville Versus Pilot Creek Near Georgetown

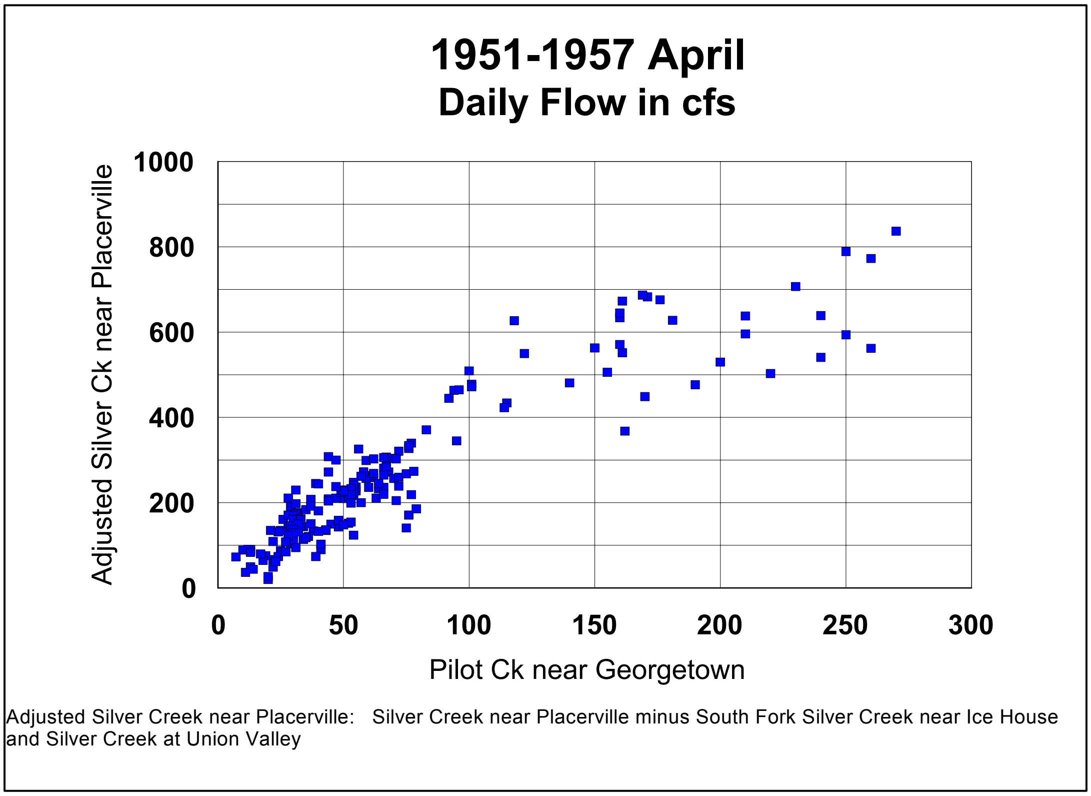
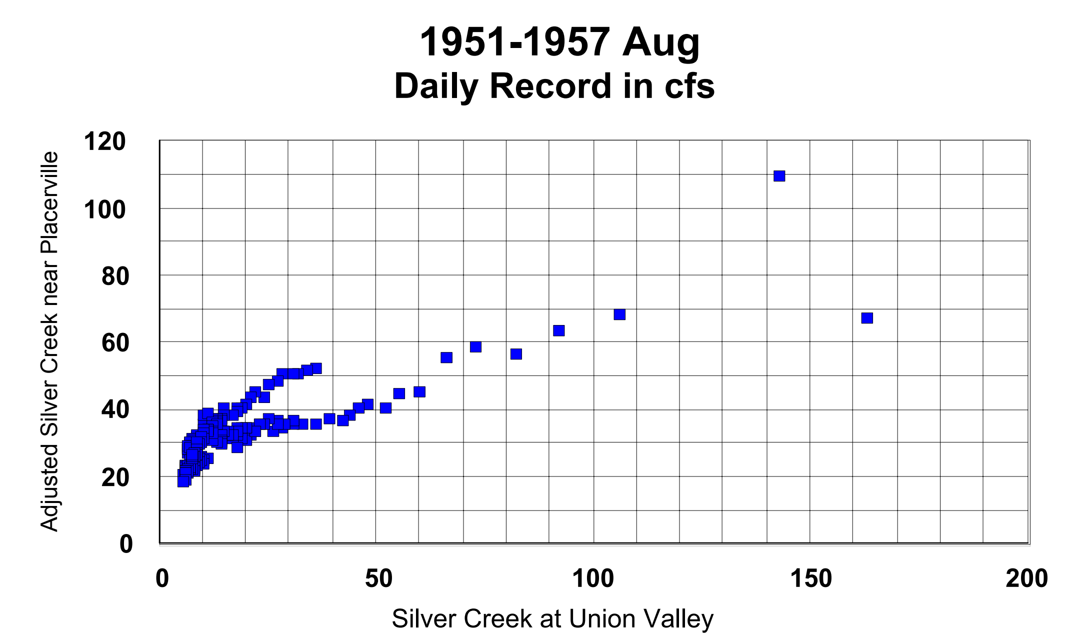


Figure 3.2.6-9. 1951-57 April - Daily Flow: Adjusted Silver Creek near Placerville Versus Pilot Creek Near Georgetown



Adjusted Silver Creek near Placerville: Silver Creek near Placerville minus South Fork Silver Creek near Ice House and Silver Creek at Union Valley

Figure 3.2.6-10. 1951-57 August - Daily Flow: Adjusted Silver Creek near Placerville Versus Pilot Creek Near Georgetown

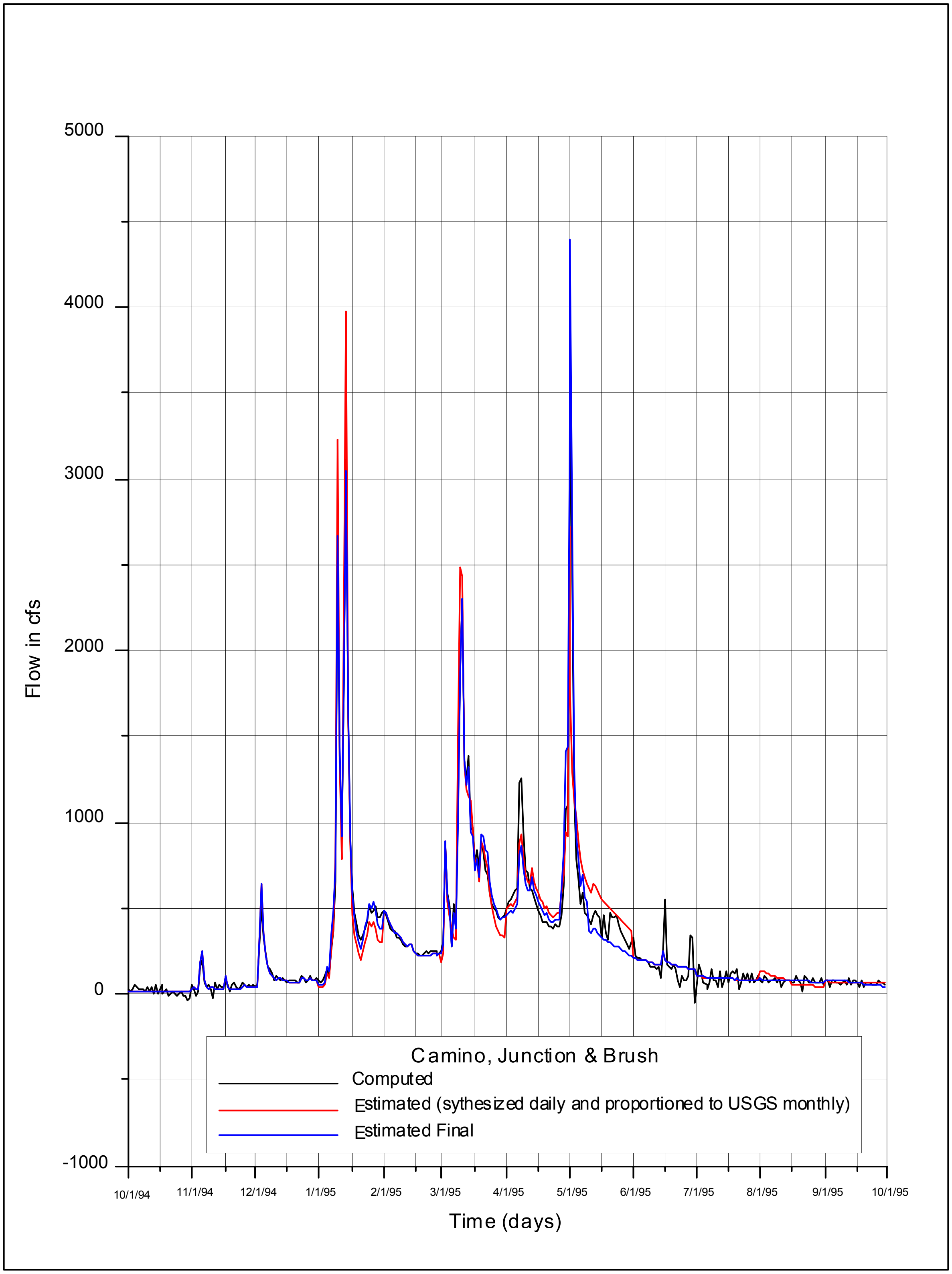


Figure 3.2.6-11. Unregulated Inflow to Camino, Junction and Brush, WY 1995

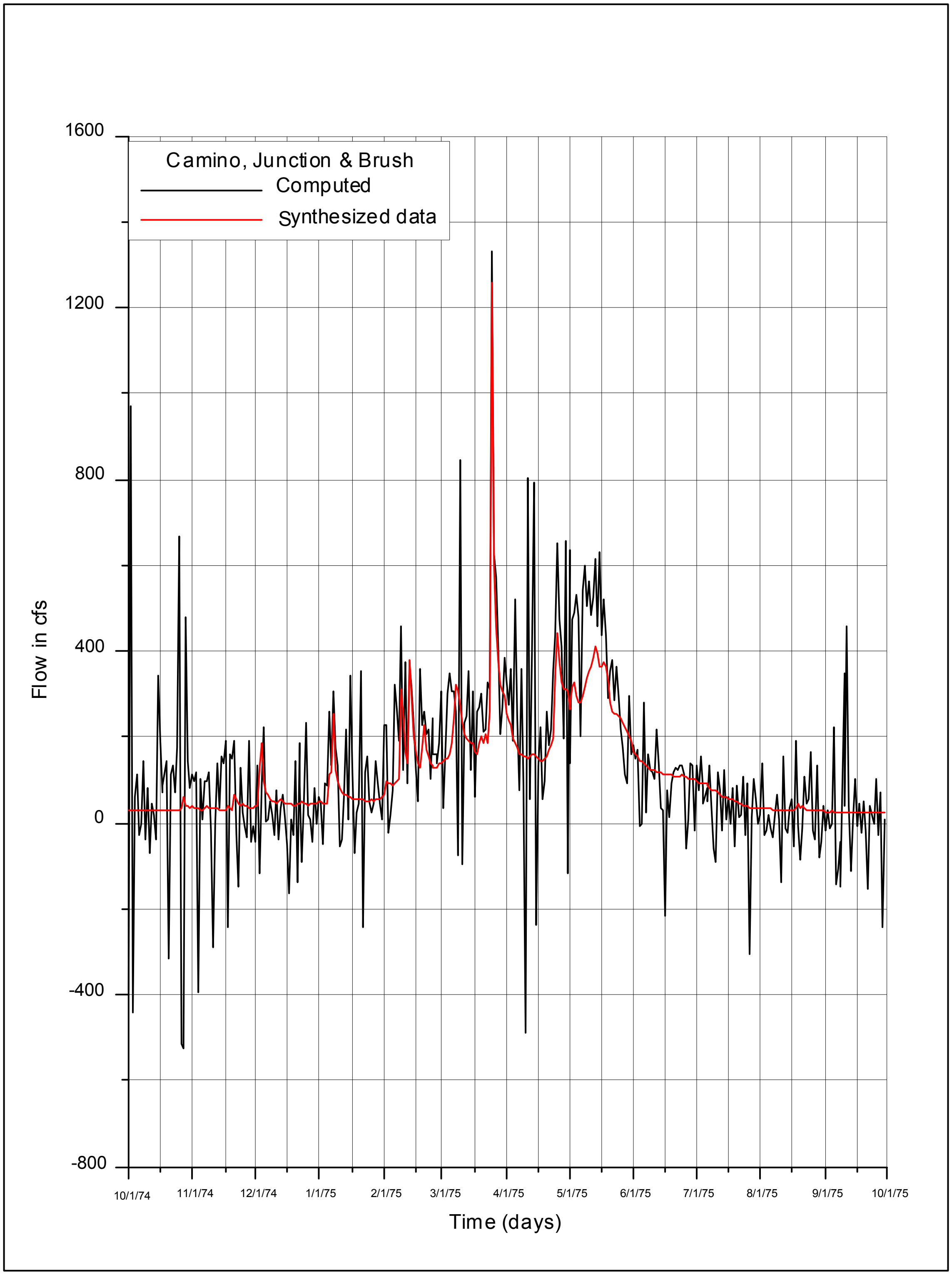


Figure 3.2.6-12. Unregulated Inflow to Camino, Junction and Brush, WY 1975

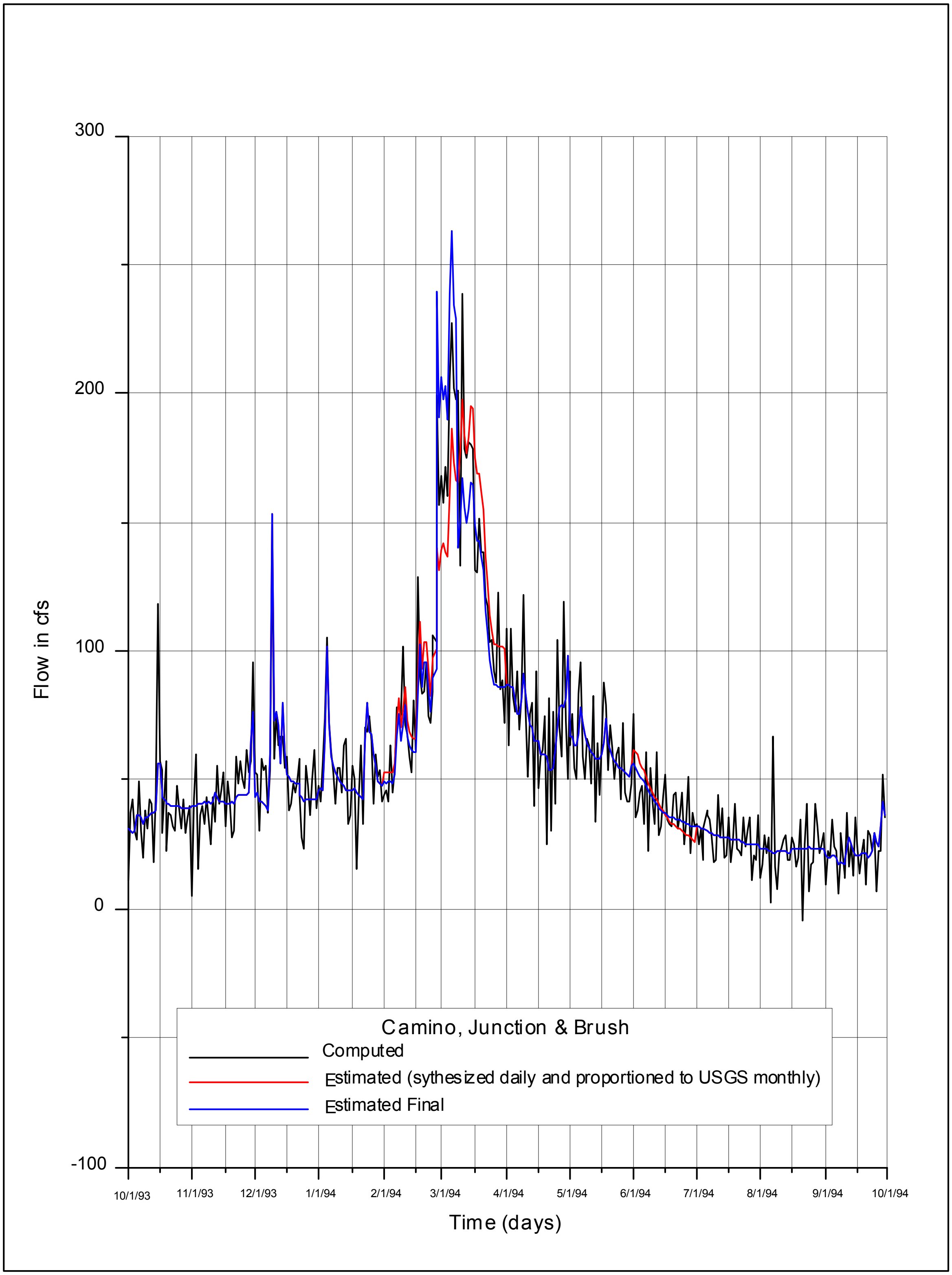


Figure 3.2.6-13. Unregulated Inflow to Camino, Junction and Brush, WY 1994

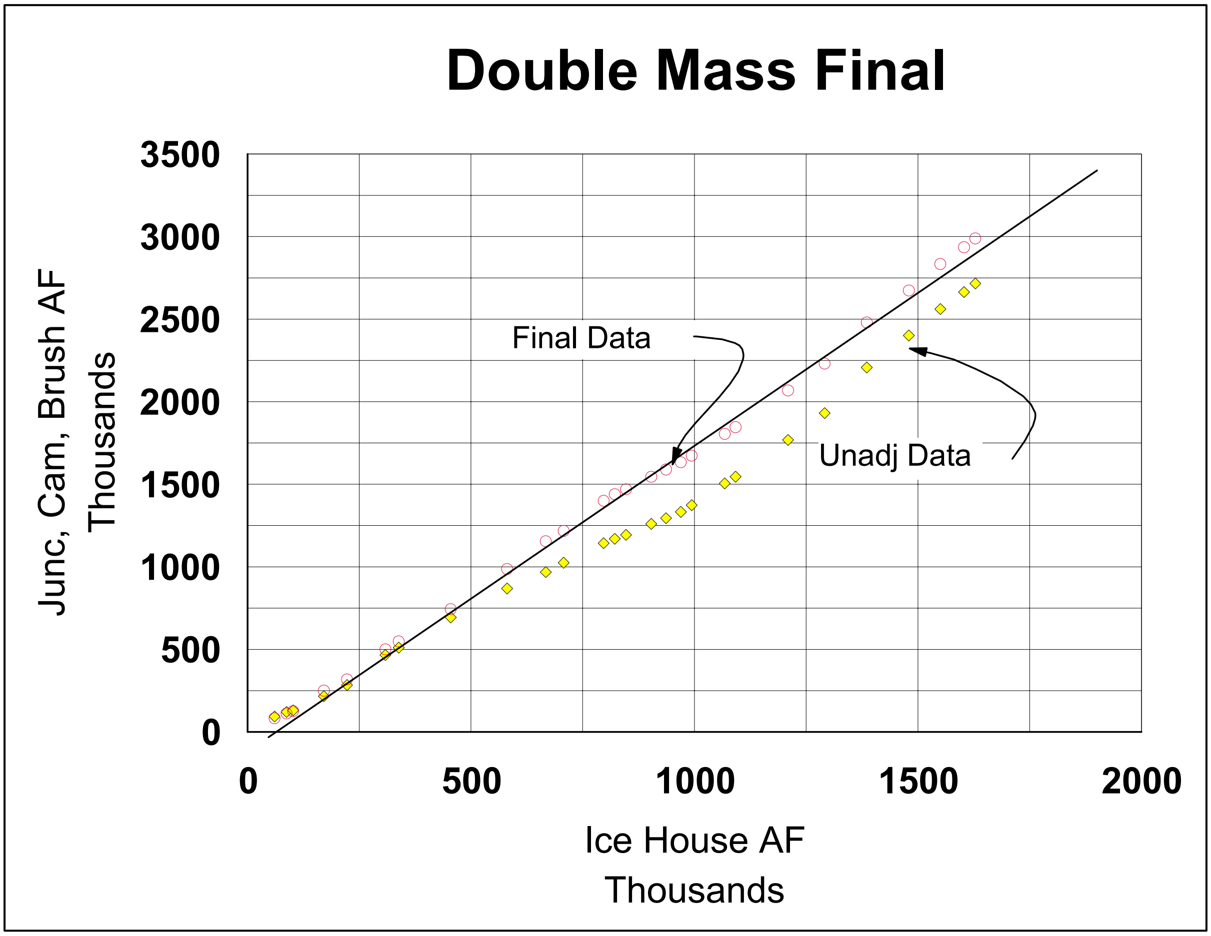


Figure 3.2.6-14. Double Mass – Unregulated Inflow to Junction, Camino, Brush Versus Unregulated Inflow to Ice House Reservoir

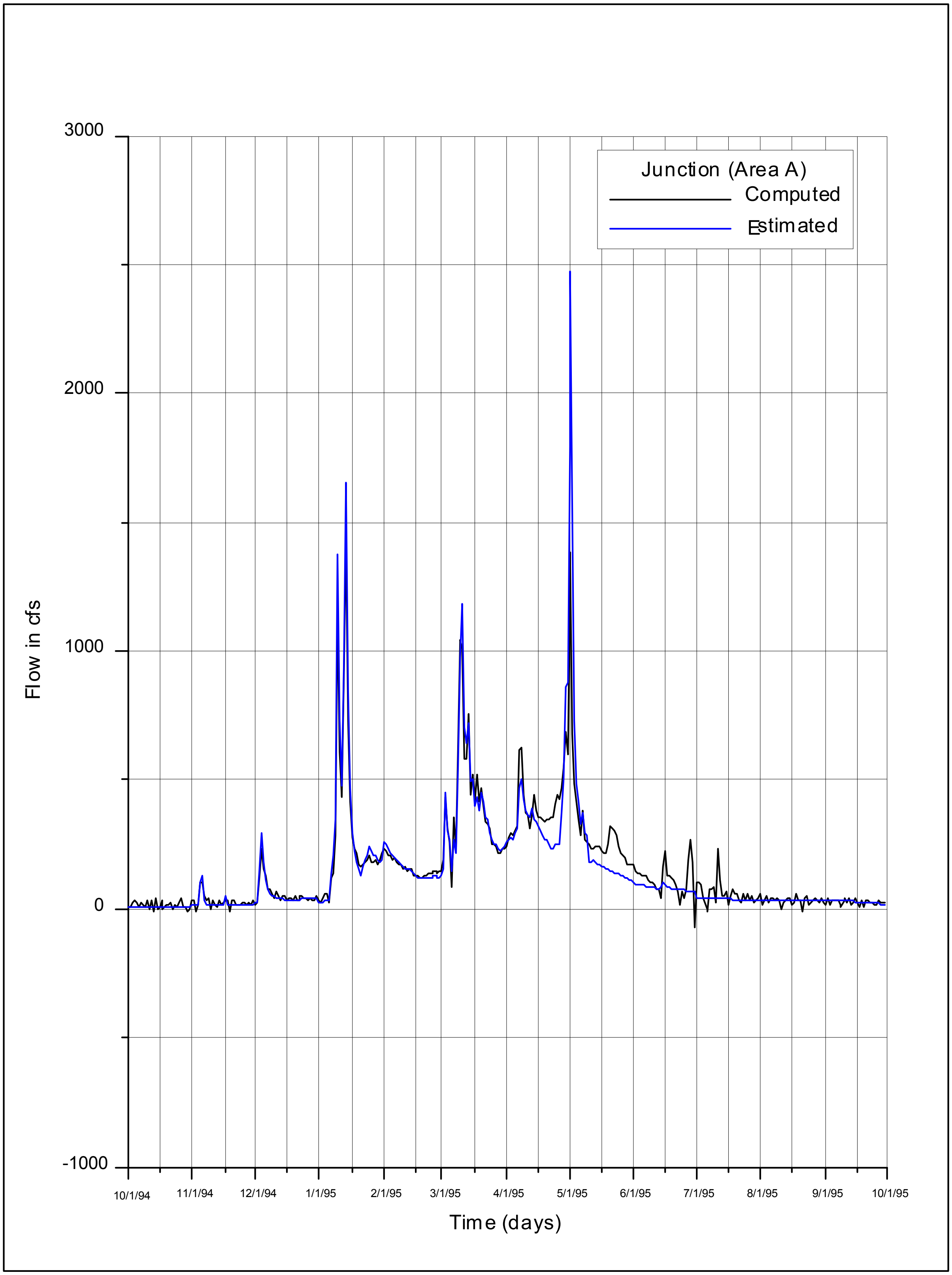


Figure 3.2.6-15. Unregulated Inflow to Junction (Area A), WY 1995

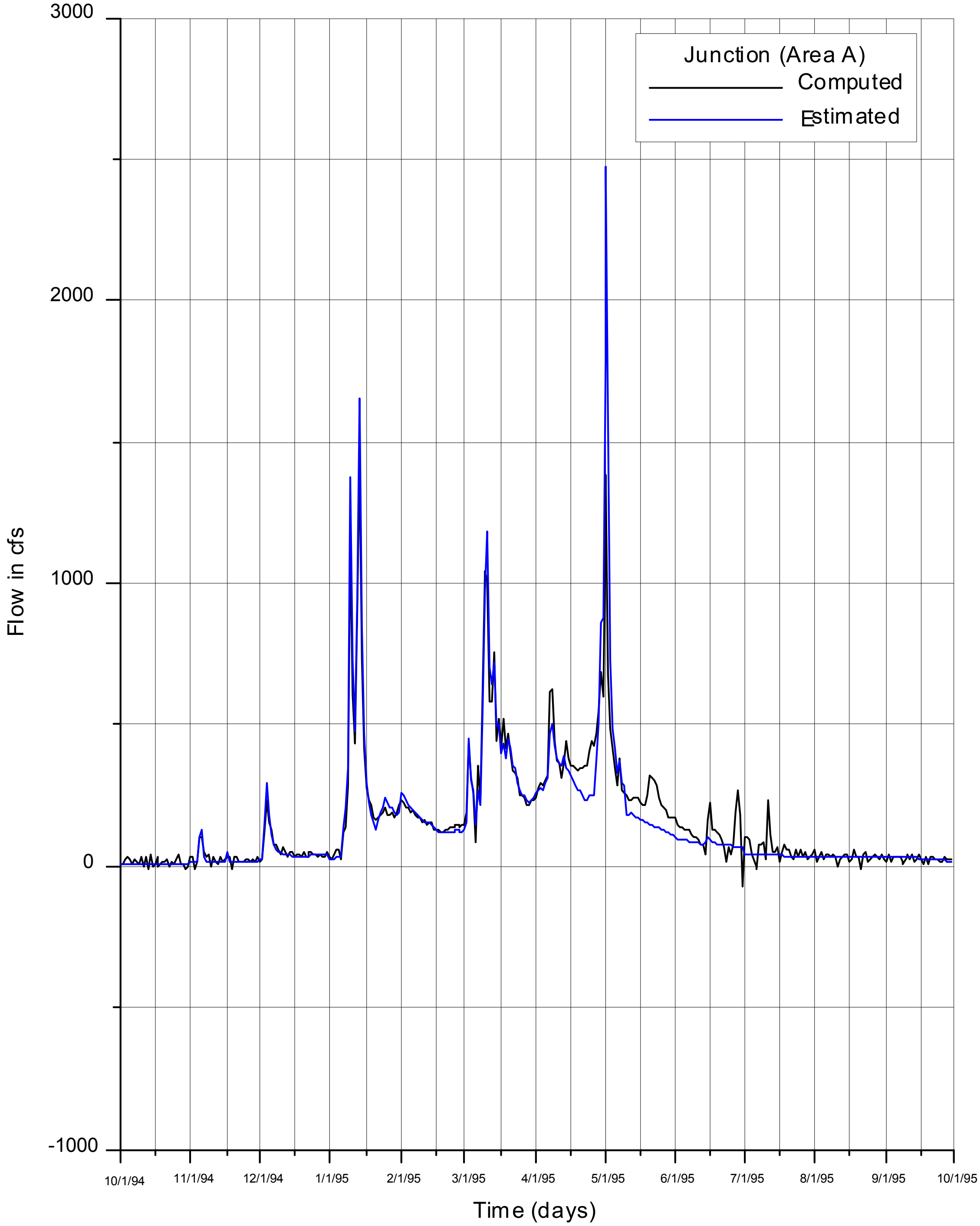


Figure 3.2.6-16. Unregulated Inflow to Junction (Area A), WY 2000

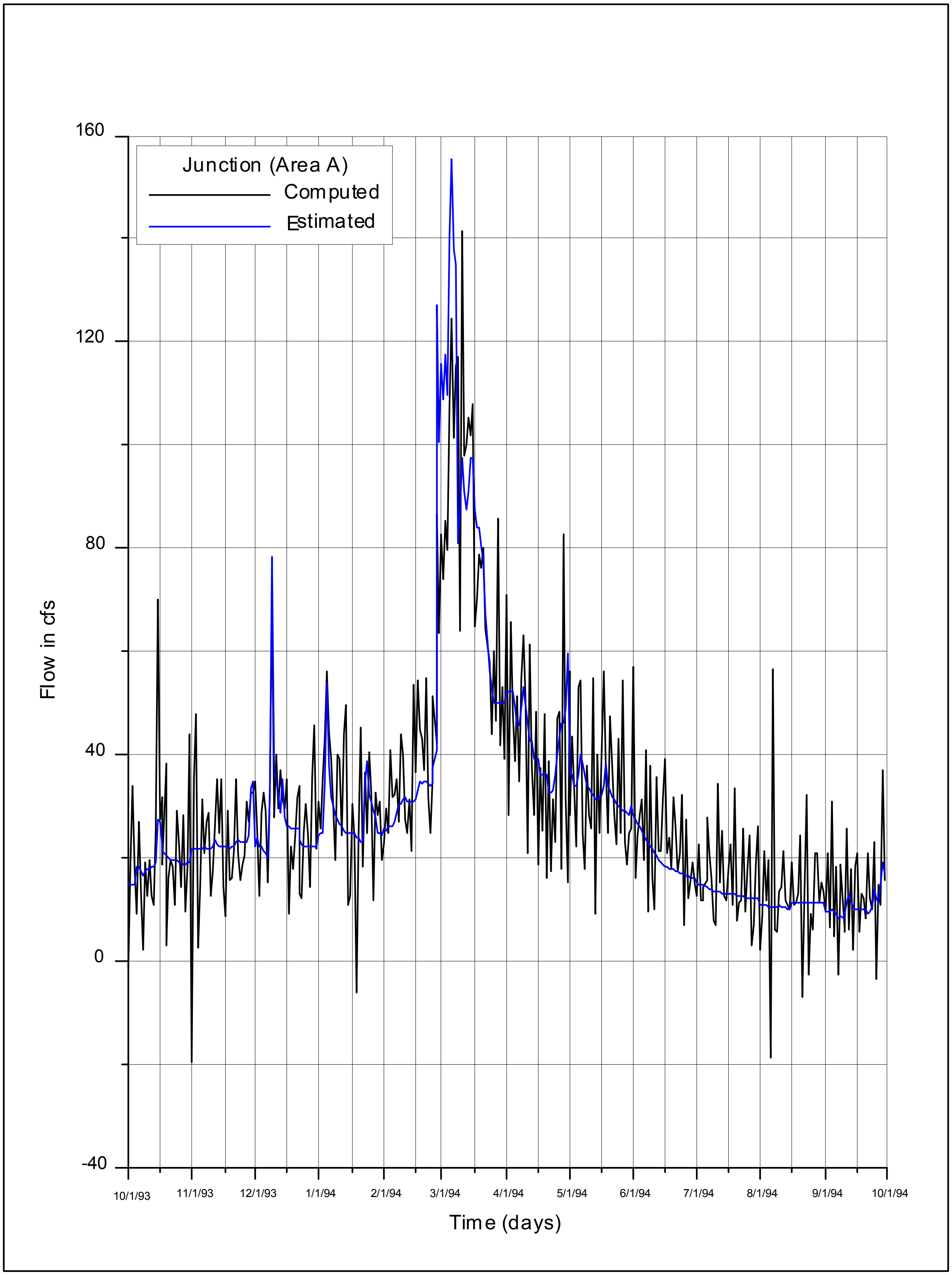


Figure 3.2.6-17. Unregulated Inflow to Junction (Area A), WY 1994

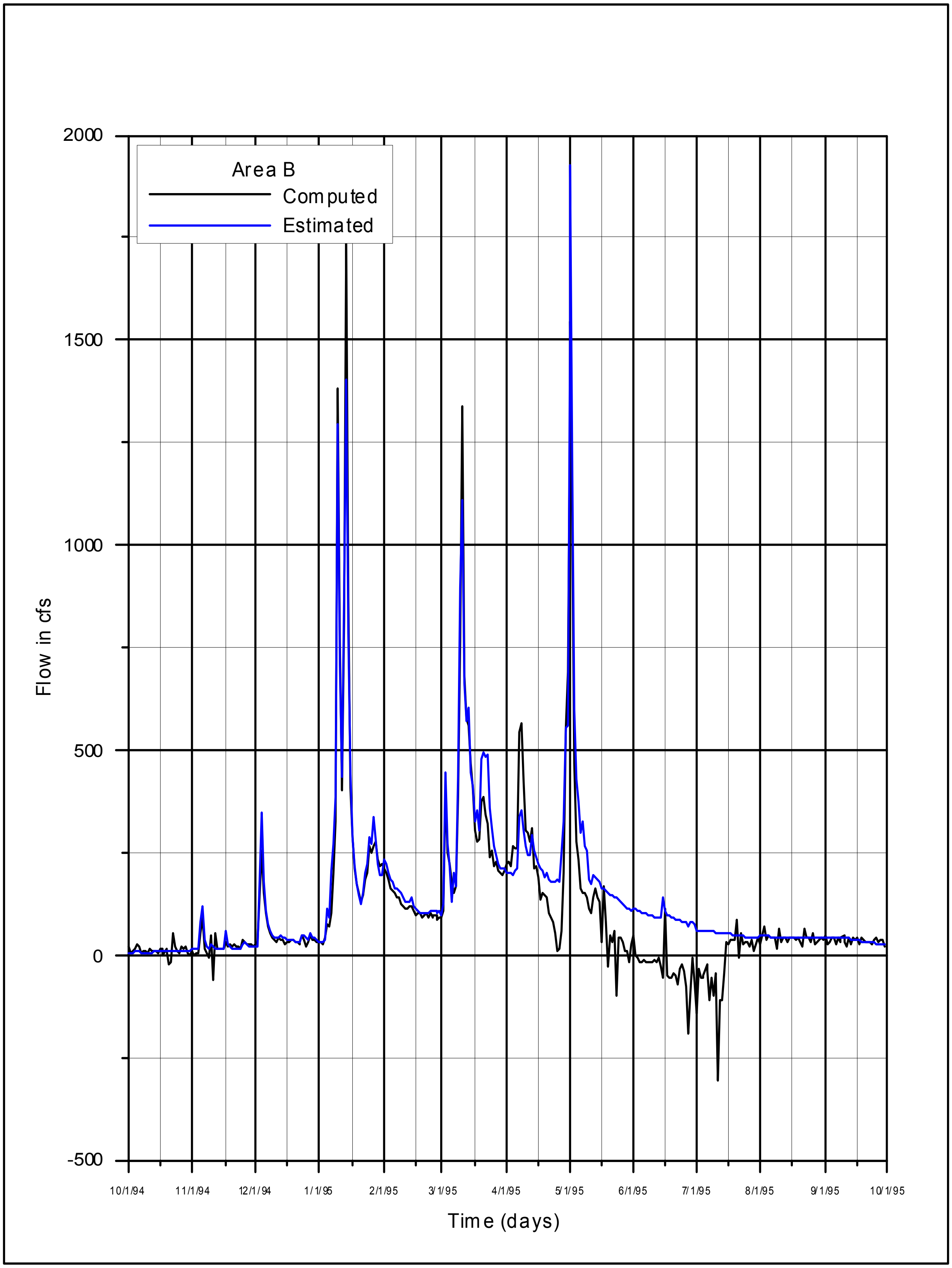


Figure 3.2.6-18. Unregulated Inflow to Area B, WY 1995

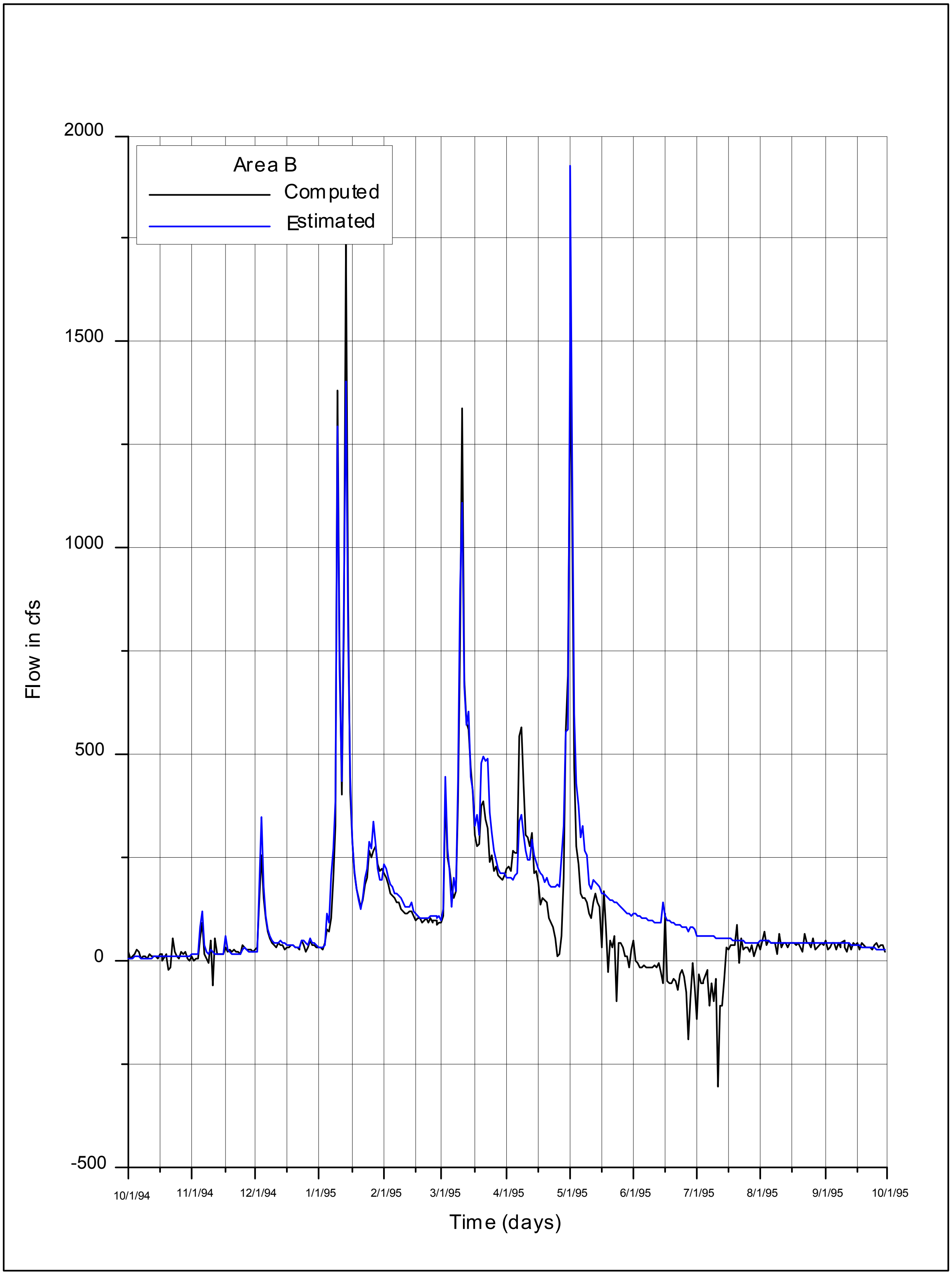


Figure 3.2.6-19. Unregulated Inflow to Area B, WY 2000

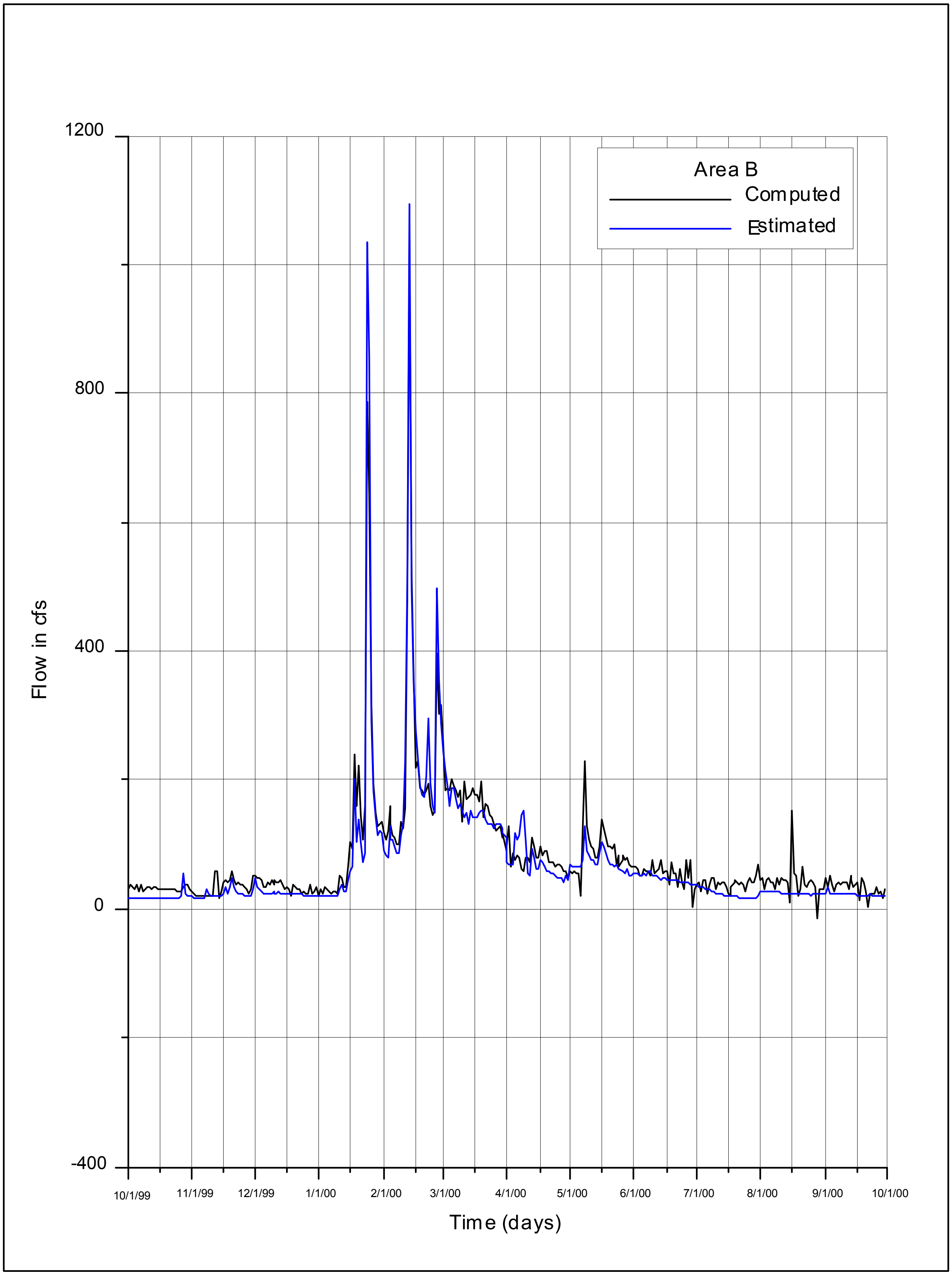


Figure 3.2.6-20. Unregulated Inflow to Area B, WY 1994

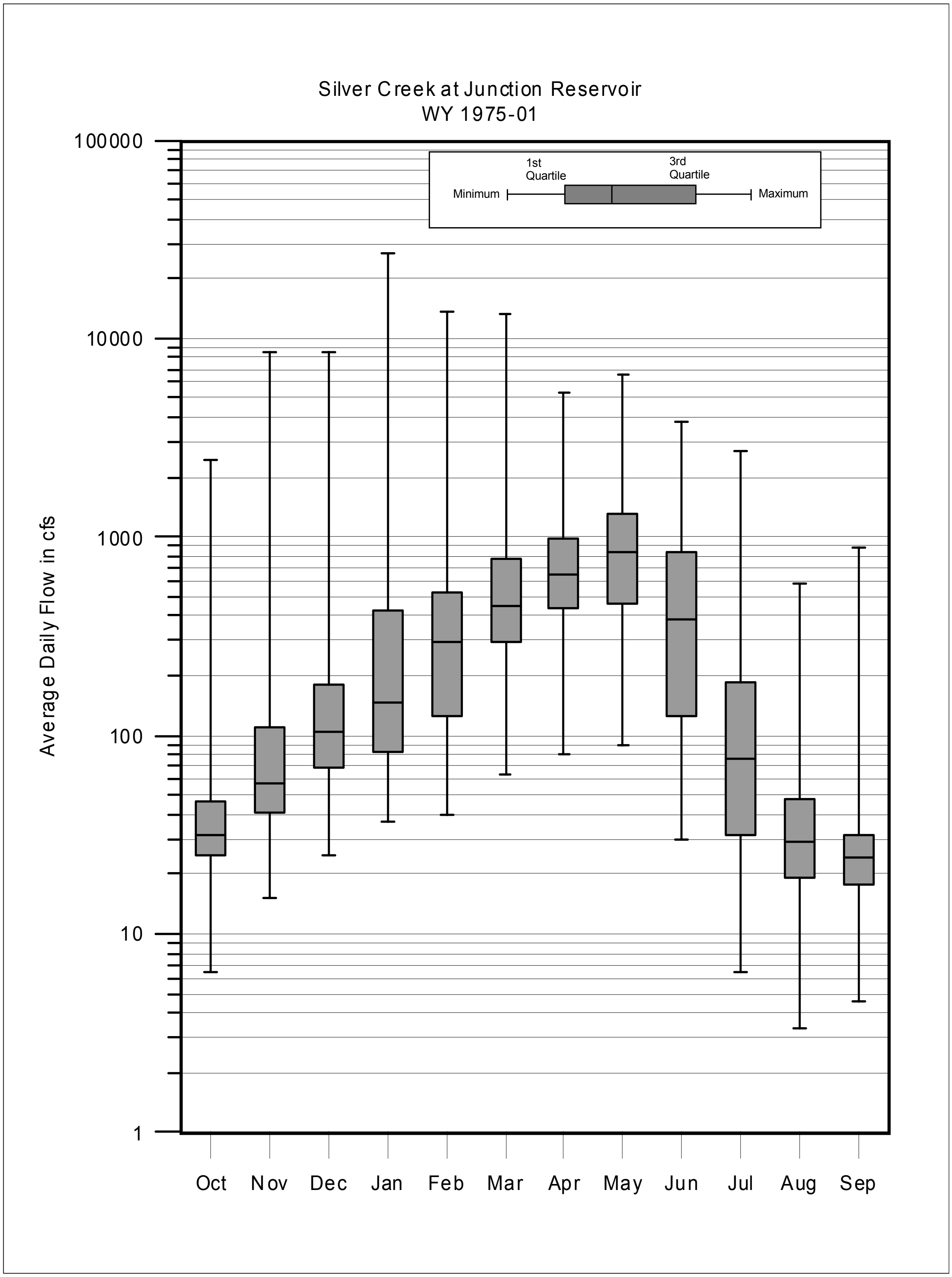


Figure 3.2.6-21. Silver Creek at Junction Reservoir, Unregulated Inflow WY 1975-01, Monthly Box-whisker Diagram

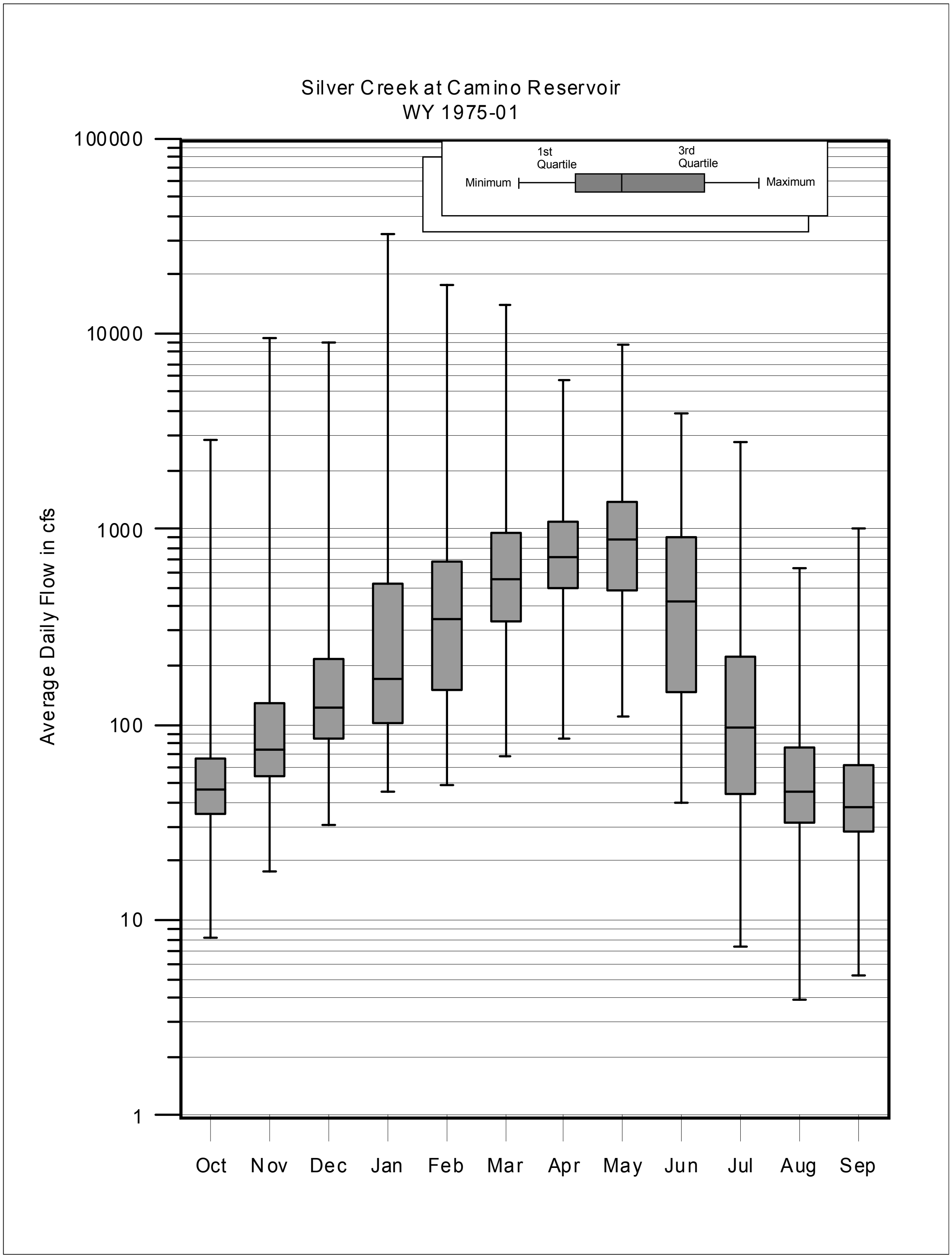


Figure 3.2.6-22. Silver Creek at Camino Reservoir, Unregulated Inflow, WY 1975-01, Monthly Box - Whisker Diagram

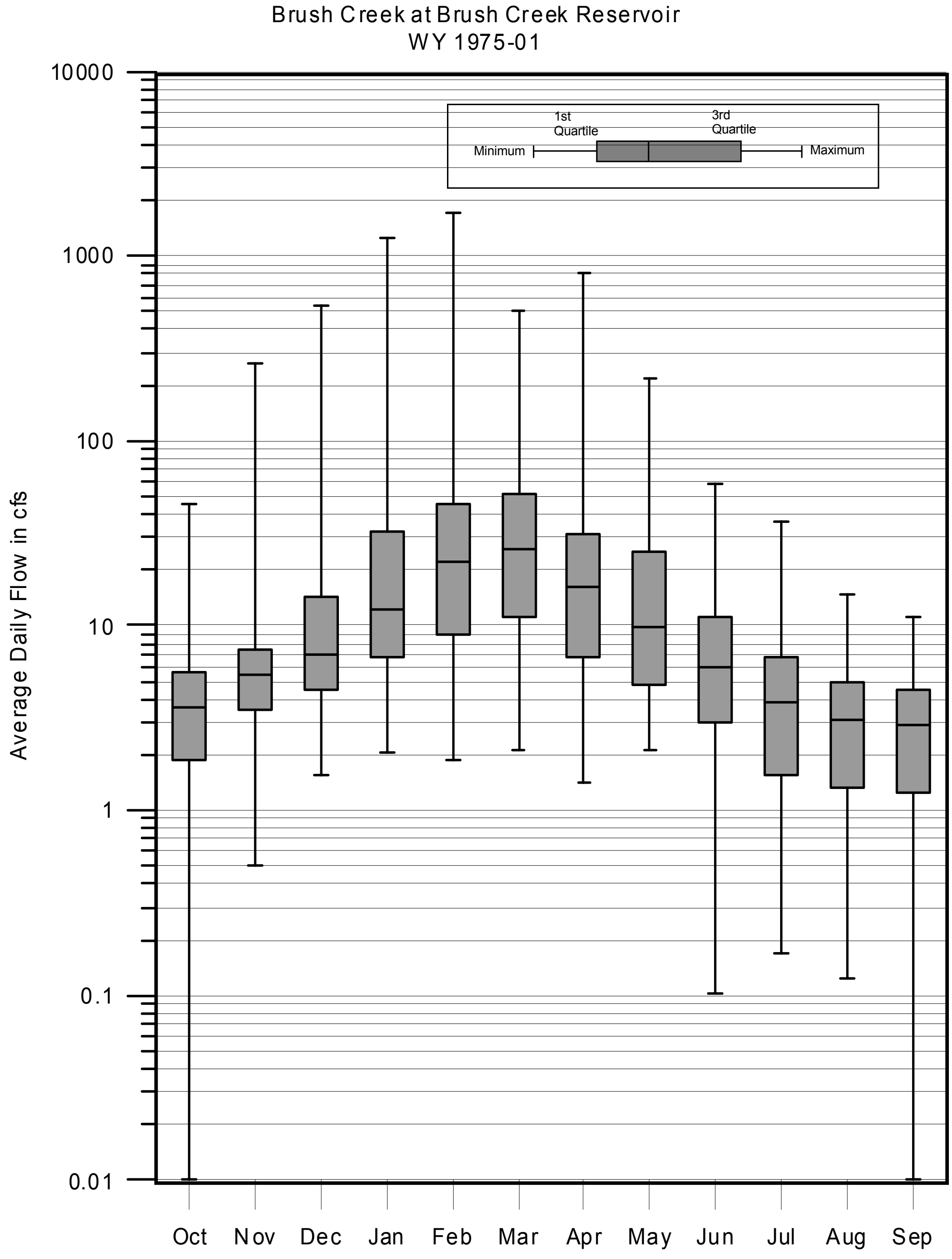


Figure 3.2.6-23. Brush Cr. at Brush Cr. Res., Unreg. Inflow, WY 1975-01, Monthly Box-whisker Diagram

3.2.7 South Fork American River at Slab Creek Reservoir

The drainage area of the South Fork American River at Slab Creek Reservoir is about 493 square miles and ranges in elevation from 1,850 to almost 10,000 feet. The watershed is a combination of granite and timber area with well developed soils. Construction of the dam was completed in 1967.

The "natural" SFAR inflow to Slab Creek Reservoir represents the unregulated inflow to Slab Creek Reservoir absent the effects of both Project 184 and the Upper American River Project (UARP). Daily flows for the SFAR below Akins Powerhouse, excluding Silver Creek, were prepared by Hydrologics as part of the relicensing effort of Project 184. Daily data were extended by ECORP to include the period of investigation in March 2004.

The unregulated inflow to Slab Creek Reservoir represents the inflow to the reservoir absent the effects the UARP only (SFAR is the proposed regulation of Project 184). EID has provided regulated flow data for the SFAR below Akins, excluding Silver Creek, for the proposed operation of Project 184. The regulated flow assumes that Project 184 will be operated under the terms identified in the EID April 30, 2003 relicensing settlement agreement. This includes an import to the South Fork American River of water from Echo Lake and consumptive water withdrawals from the El Dorado Forebay reservoir. The data were prepared by Hydrologics as part of the relicensing effort of Project 184. Daily data were extended by ECORP to include the period of investigation in March 2004.

The inflow to Slab Creek Reservoir is made up of three components:

- Silver Creek above Camino Diversion Dam (computed by SMUD and detailed in this report)
- South Fork American River (SFAR) below Akins Powerhouse (computed by ECORP)
- Accretions between Akins Powerhouse and Slab Creek Reservoir (estimated at 2.3 times the inflow to Brush Creek Reservoir)

A box-whisker diagram describing the daily flow characteristics by month is provided in Figure 3.2.7-1. The average annual runoff at Slab Creek Reservoir is 768,400 acre-feet (1975-2001). A table of monthly runoff at this site for the period 1975-2001 is included in Appendix B.

The "natural" SFAR inflow to Slab Creek Reservoir represents the unregulated inflow to Slab Creek Reservoir absent the effects of both Project 184 and the Upper American River Project (UARP). Daily flows for the SFAR at El Dorado Powerhouse, excluding Silver Creek, were prepared by Hydrologics as part of the relicensing effort of Project 184. Daily data are available for the water year period 1975 through 1996.

A box-whisker diagram describing the daily flow characteristics by month is provided in Figure 3.2.7-2. The average annual runoff at Slab Creek Reservoir is 783,100 acre-feet (1975-2001). A table of monthly runoff at this site for the period 1975-2001 is included in Appendix B.

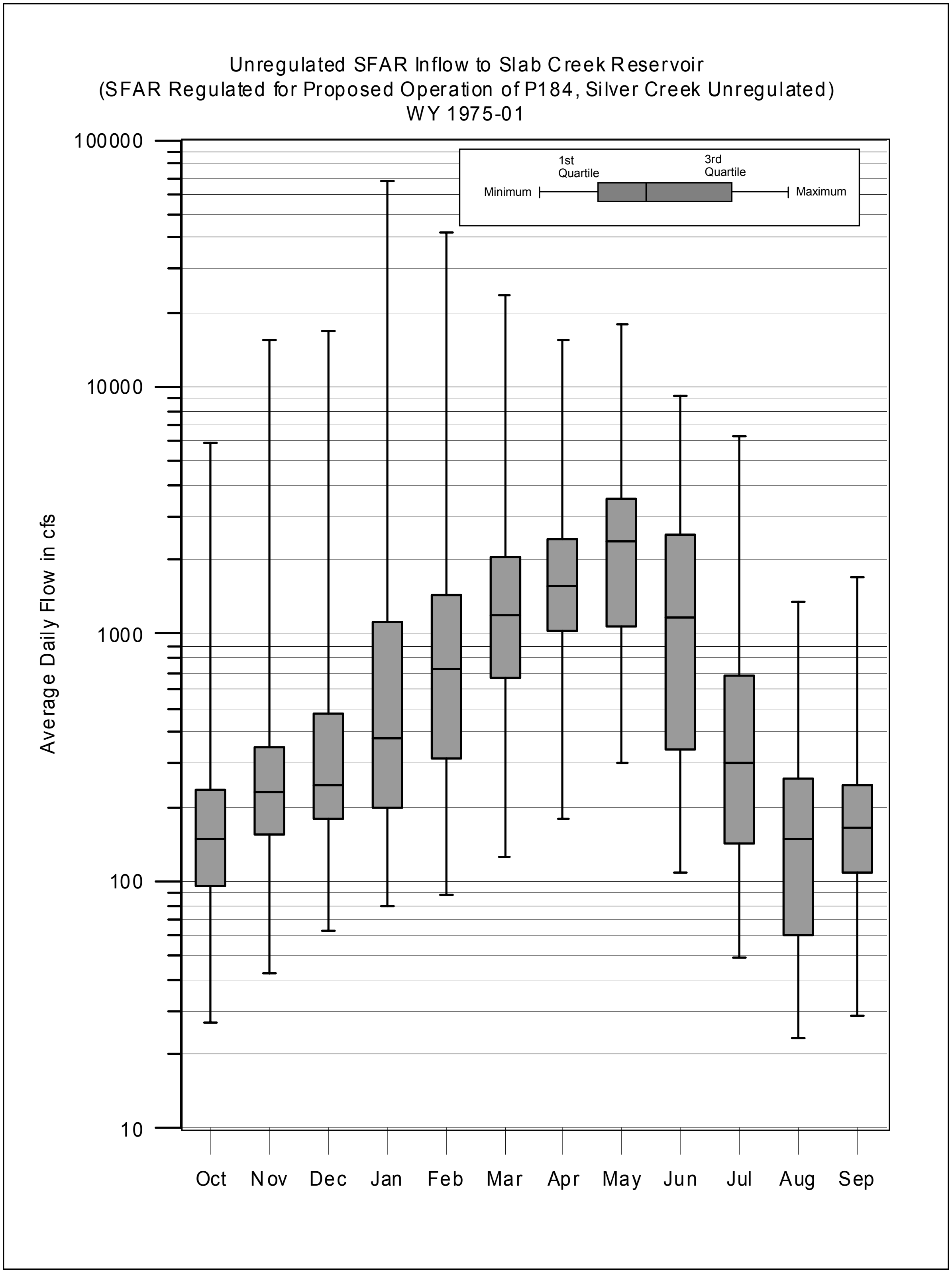


Figure 3.2.7-1. Unregulated SFAR Inflow to Slab Creek Reservoir (SFAR Regulated for P184, Silver Creek Unregulated) WY 1975-01, Monthly Box-whisker Diagram

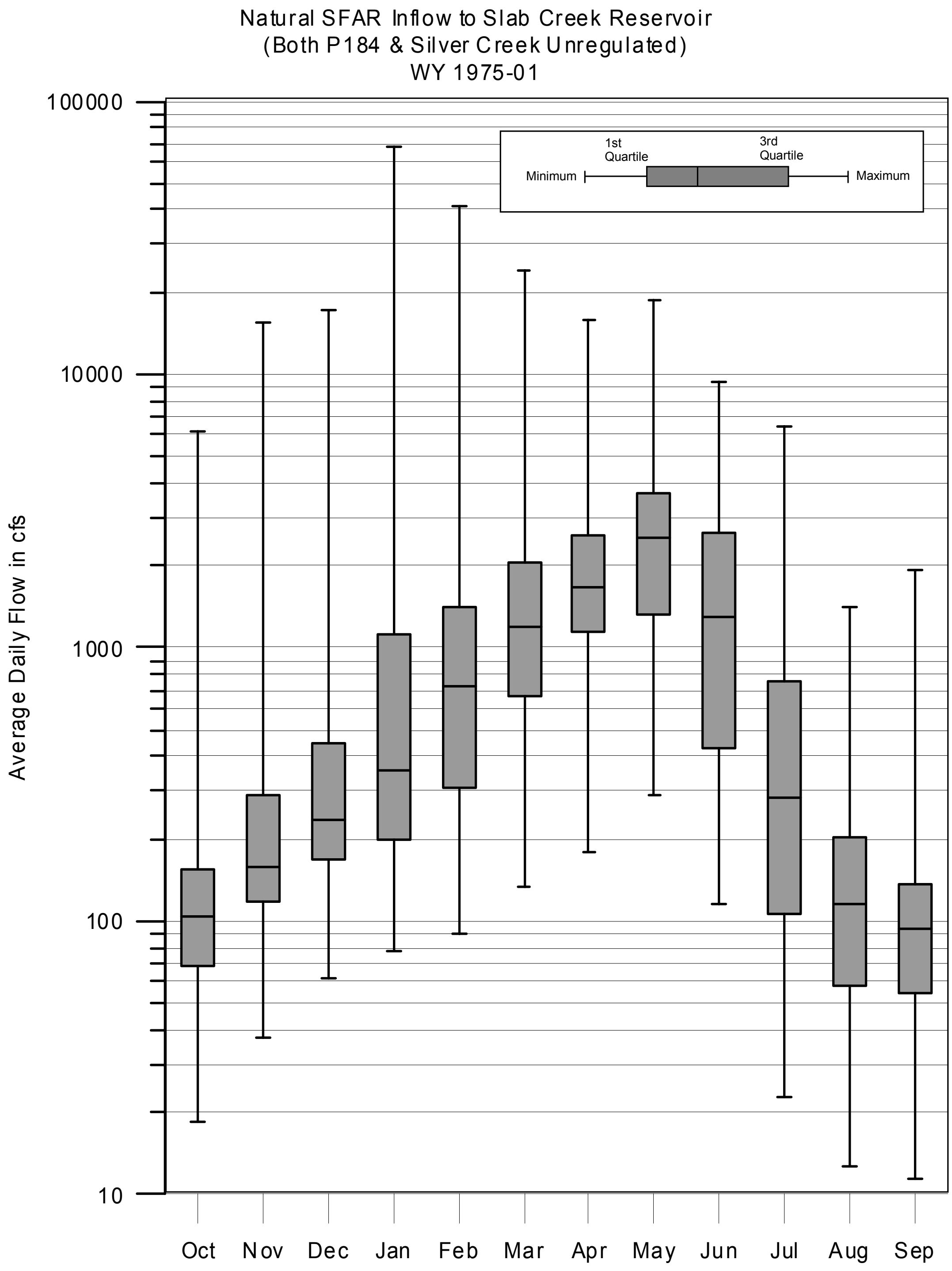


Figure 3.2.7-2. Natural SFAR Inflow to Slab Creek Reservoir (Both P184 & Silver Creek Unregulated) WY 1975-01, Monthly Box-whisker Diagram

3.2.8 South Fork American River at Chili Bar Reservoir

The inflow to Chili Bar Reservoir is made up of two components:

- SFAR inflow to Slab Creek Reservoir
- Accretions between Slab Creek Reservoir and Chili Bar Reservoir (Chili Bar accretions)

For the SFAR inflow to Slab Creek Reservoir, two estimates of inflow are computed:

- Unregulated SFAR inflow to Slab Creek Reservoir
- Natural SFAR inflow to Slab Creek Reservoir

The unregulated inflow to Slab Creek Reservoir represents the inflow to the reservoir absent the effects the UARP only (SFAR is the proposed regulation of Project 184). The "natural" SFAR inflow to Slab Creek Reservoir represents the unregulated inflow to Slab Creek Reservoir absent the effects of both Project 184 and the Upper American River Project (UARP).

The drainage area of the SFAR at Chili Bar Reservoir is about 598 square miles and ranges in elevation from 931 (at the stream gage below the reservoir) to almost 10,000 feet. The drainage area of the SFAR between Chili Bar Reservoir and Slab Creek Reservoir, as computed by SMUD consultant Vestra is 104 square miles. The total watershed is comprised a combination of granite and timber area with well developed soils.

Sufficient data are available to compute the unregulated Chili Bar accretions on a daily basis. The results for a wet, average and dry year are displayed in figures 3.2.8-1, 3.2.8-2 and 3.2.8-3, respectively. As seen from these figures, there are many computed negative flows and large daily fluctuations. Some of these apparent anomalies are attributable to the unregulated inflow often being relatively small compared to the volume of water reported as passing through both powerhouses (White Rock and Chili Bar). The errors in measurement of large flows through these powerhouses can easily be greater than the computed unregulated flow. To overcome the problems associated with the computed flow, a procedure was developed to synthesize the inflows for the investigation period in order to validate or refine the computed inflows. The data were checked for homogeneity (Figure 3.2.8-4). The data were not considered to be homogeneous for the entire period of record. It is hypothesized that this may be due to a change in flow determination methods over the duration of the evaluation period (installation of an Acoustical Velocity Meter (AVM) at White Rock Powerhouse in 1993).

Analyses were performed to make the flow estimates consistent. The first analysis performed was the evaluation of the flow data from White Rock Powerhouse (WRP). WRP was completed in 1968. The WRP draft is based on generation-discharge curves from 1968 through 1992. In August 1992, SMUD installed an AVM to measure the WRP draft. A daily analysis was created to evaluate the WRP measured efficiency before and after the AVM was installed. Daily generation data are only available for the period 1978 through 1991 (pre-AVM).

The results of the WRP generation analysis are illustrated in Figure 3.2.8.5. Unit efficiency for the pre-AVM period is displayed in red and the post-AVM period is displayed in black. As seen in the figure, the efficiency “dropped” after the AVM was installed. This circumstance is likely an indication the flow through the unit was underestimated prior to installation of the AVM. After reviewing the results provided in Figure 3.2.8-5, an adjustment was made to the generation data for the pre-AVM period. Volume adjustments varied between 0% and 18% of the annual draft.

Data for the period 1978 through 1991 were adjusted and the accretions to Chili Bar Reservoir recomputed. Representative examples of the impact to the computation of unregulated accretions are provided in figures 3.2.8-6 and 3.2.8-7. The results of this first procedure are displayed in red (WR draft) and the previously computed inflow is displayed in black (computed). As seen in these figures, there still remained computed negative flows and large daily fluctuations. However, the annual and monthly volumes had been adjusted.

A second procedure was performed to simulate daily flows through a method that included the use of the unregulated daily record from a gaging station within the drainage basin (Rock Creek near Placerville). The gage at Rock Creek near Placerville has existed since water year 1987. Rock Creek enters the SFAR between Slab Creek and Chili Bar reservoirs. The drainage area at the Rock Creek gage is estimated to be 73 square miles. This drainage area is approximately 70 percent of the total drainage area between Slab Creek Reservoir and Chili Bar Reservoir.

The major limitation with the Rock Creek data was that the period of record did not cover the full investigation period. To overcome the period of record limitation, the Rock Creek data were extended with the aid of the Pilot and Forest creek data. The extension of the Rock Creek data is discussed in section “Silver Creek at Camino Reservoir Including Brush Creek”.

Assuming the observed average annual Chili Bar accretions for the period 1993 to 2001 are representative, the Rock Creek data were multiplied by a factor to compute the same average for the 1993 to 2001 period. The daily Chili Bar accretions were estimated as follows:

Estimated Chili Bar Accretions (cfs) = Rock Creek daily flow times
Chili Bar Accretions 1993-01 annual average (108,805 AF) divided by
Rock Creek 1993-01 annual flow average (64,203 AF)

Representative results of the procedures are displayed in figures 3.2.8-8 and 3.2.8-9 (estimate Chili Bar accretions in blue). A double mass diagram is displayed in Figure 3.2.8-10.

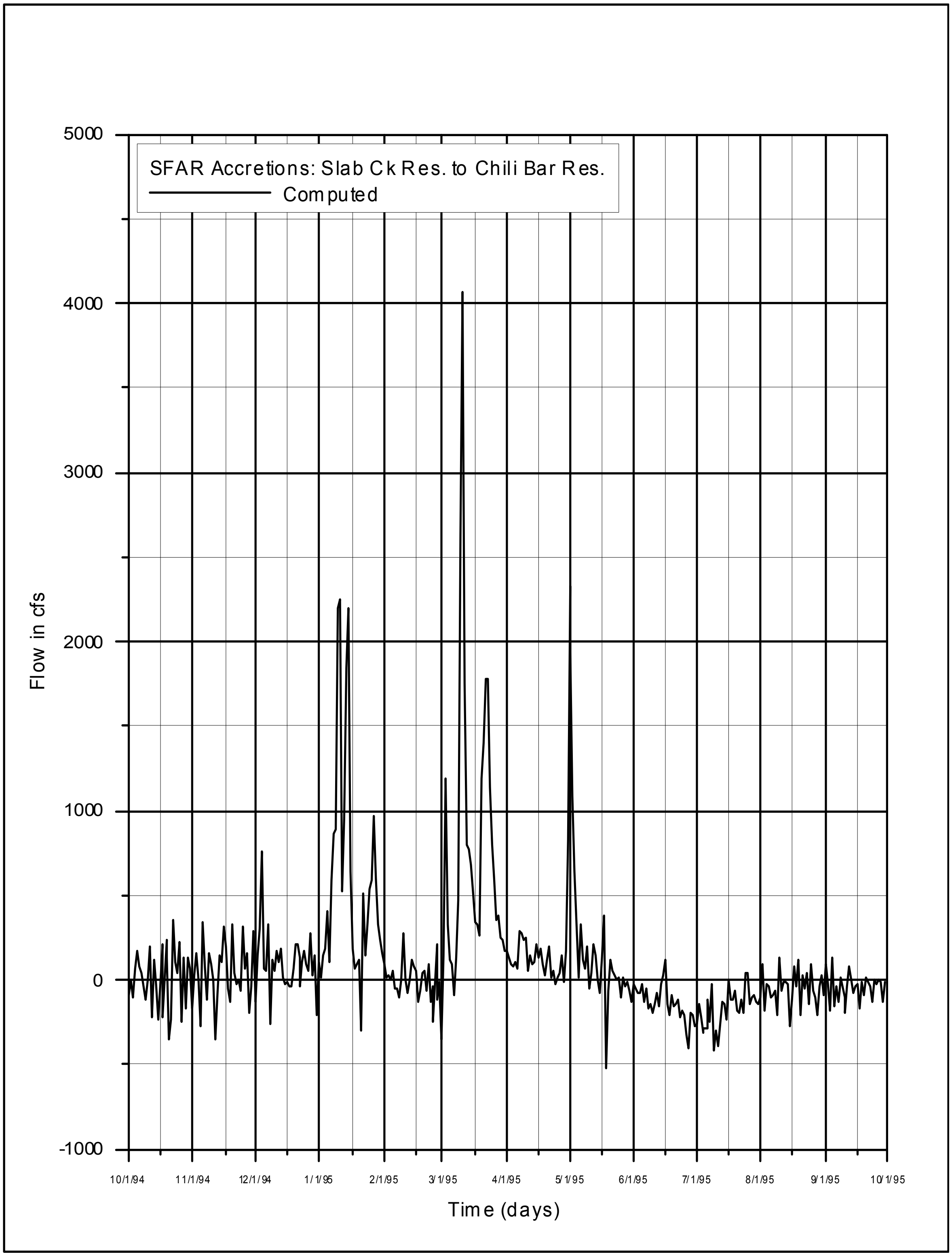


Figure 3.2.8-1. SFAR Accretions: Slab Creek Reservoir to Chili Bar Reservoir, WY 1995

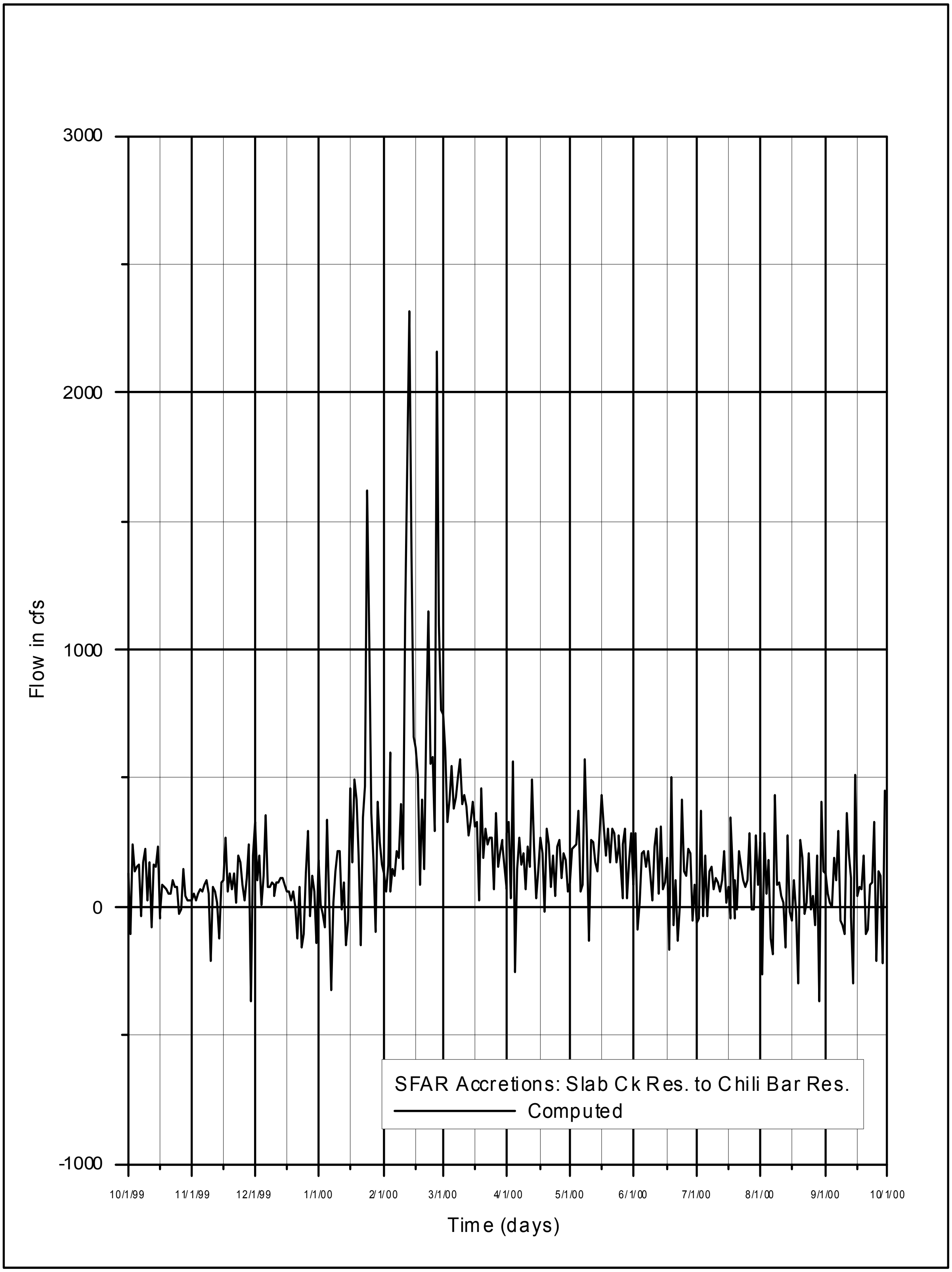


Figure 3.2.8-2. SFAR Accretions: Slab Creek Reservoir to Chili Bar Reservoir, WY 2000

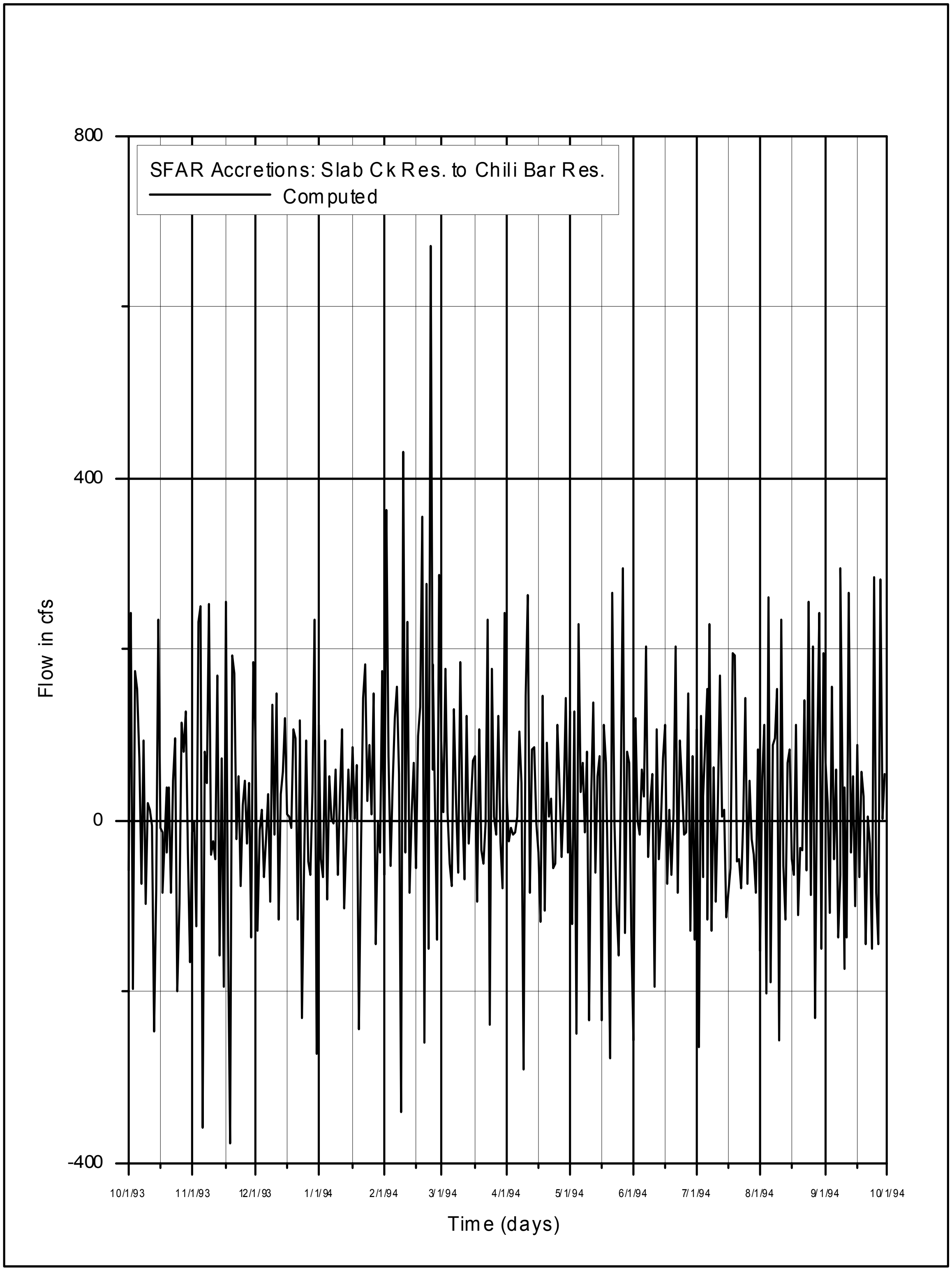


Figure 3.2.8-3. SFAR Accretions: Slab Creek Reservoir to Chili Bar Reservoir, WY 1994

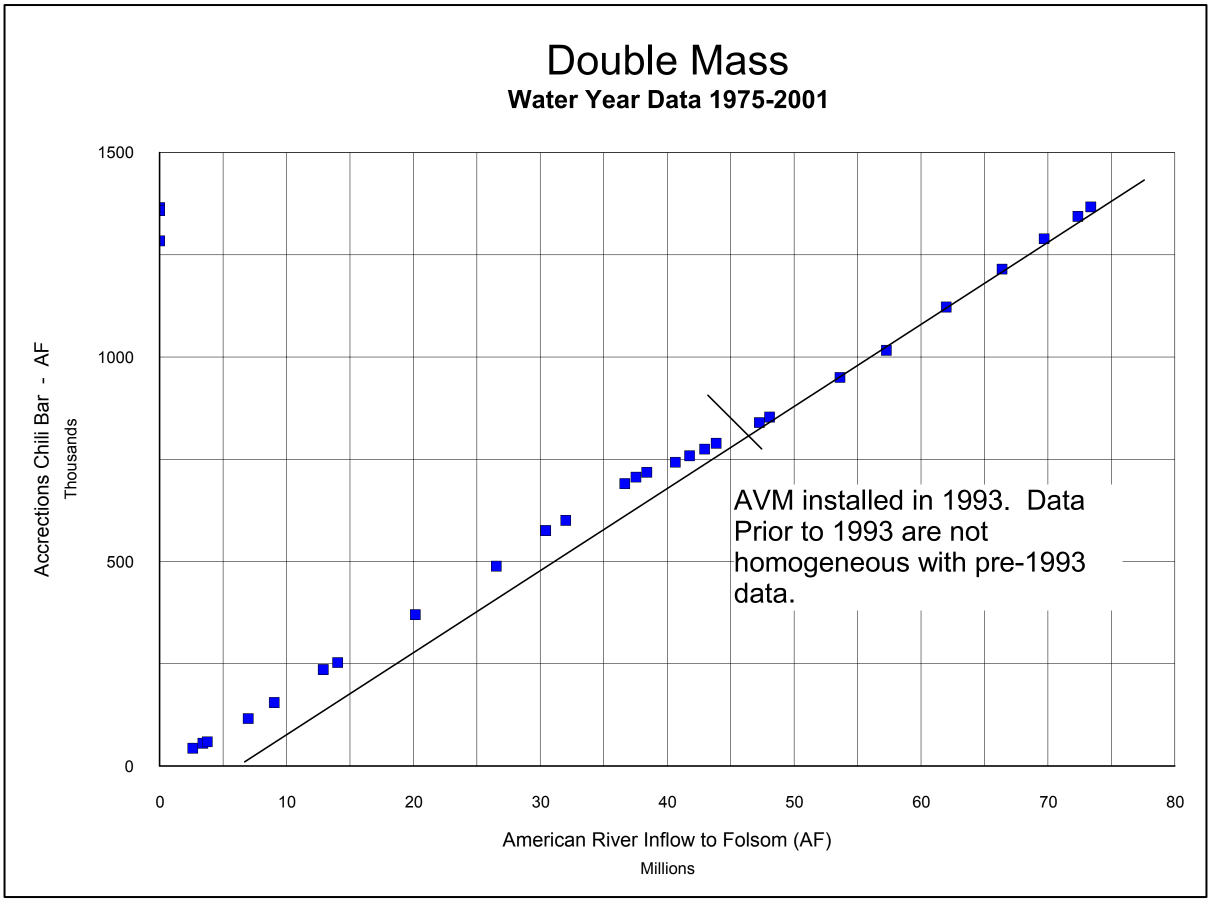


Figure 3.2.8-4. Double Mass – Water Year Data 1975-2001 – Accretions to Chili Bar Reservoir Versus Unregulated Inflow for the American River to Fair Oaks (Folsom)

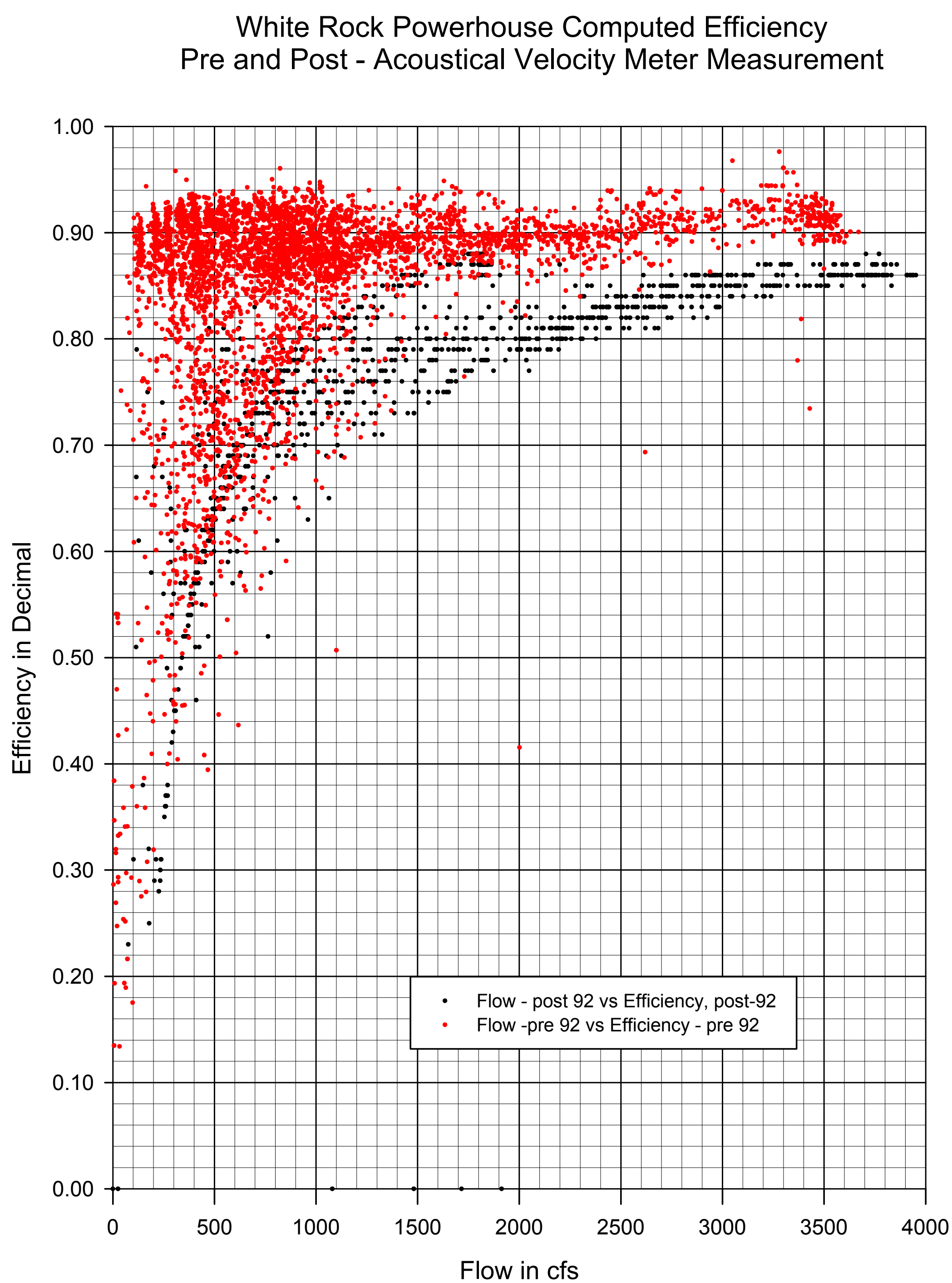


Figure 3.2.8-5. White Rock Powerhouse Computed Efficiency Pre and Post- Acoustical Velocity Meter Measurement

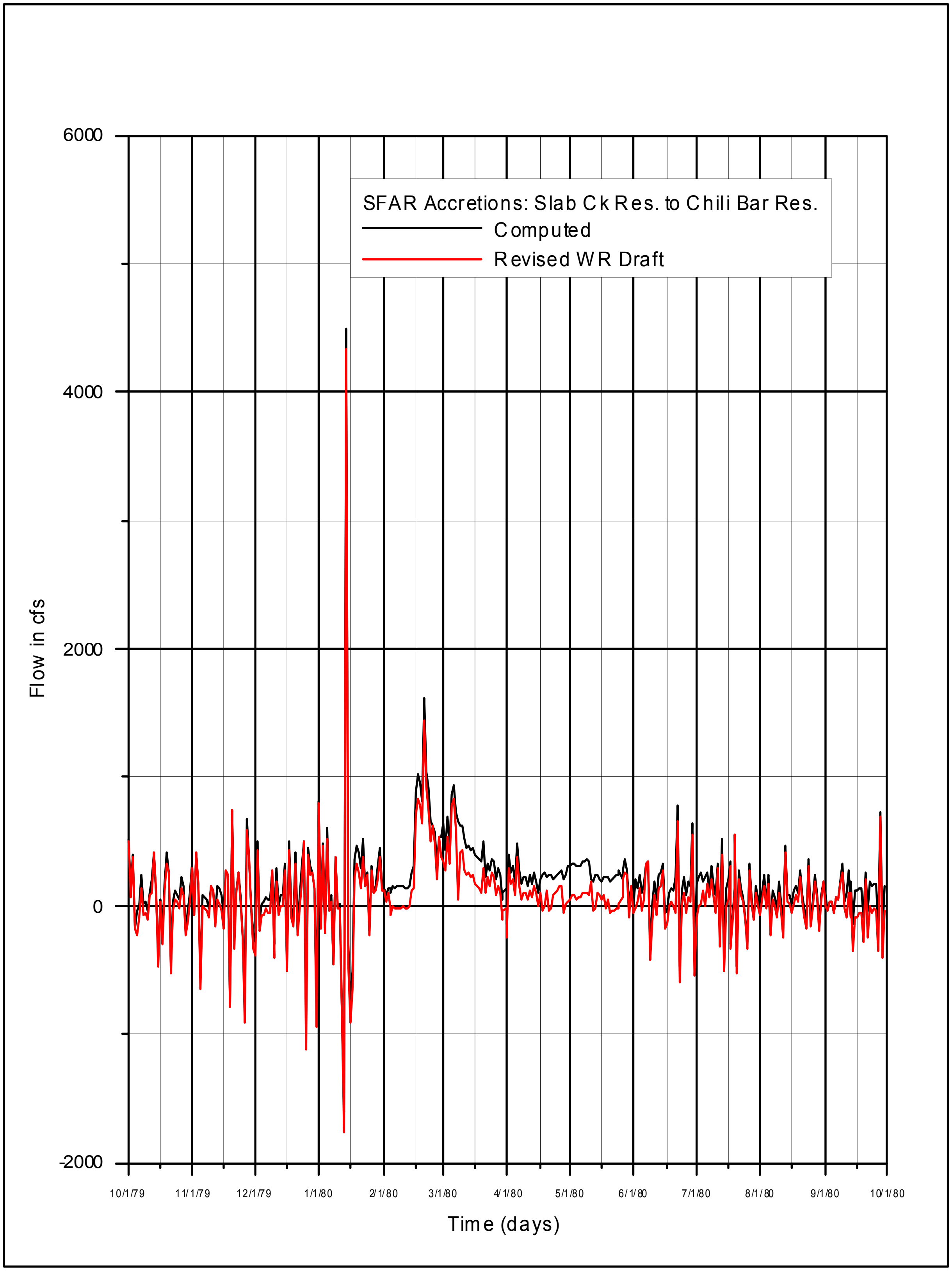


Figure 3.2.8-6. SFAR Accretions: Slab Creek Reservoir to Chili Bar Reservoir, WY 1980

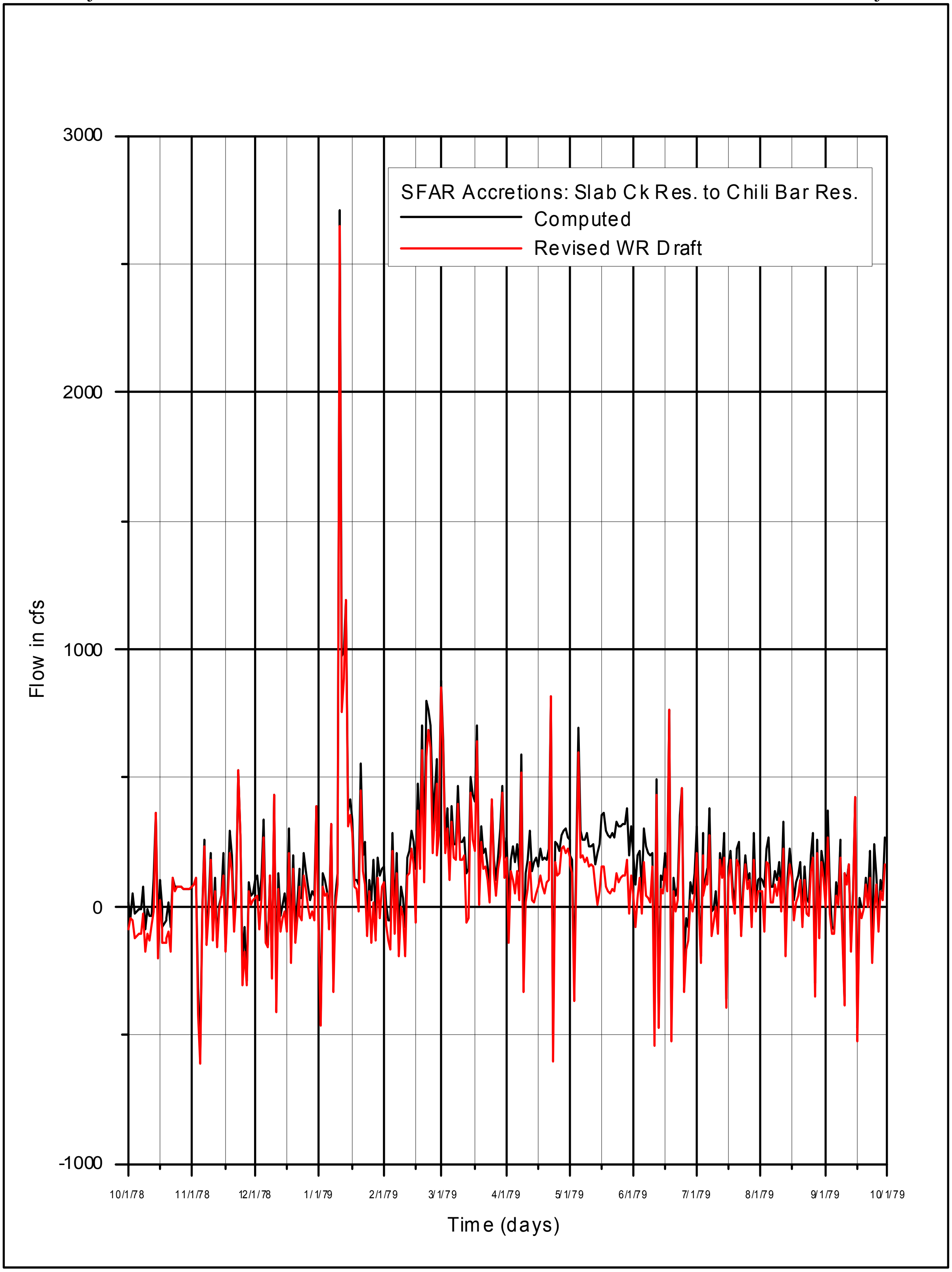


Figure 3.2.8-7. SFAR Accretions: Slab Creek Reservoir to Chili Bar Reservoir, WY 1979

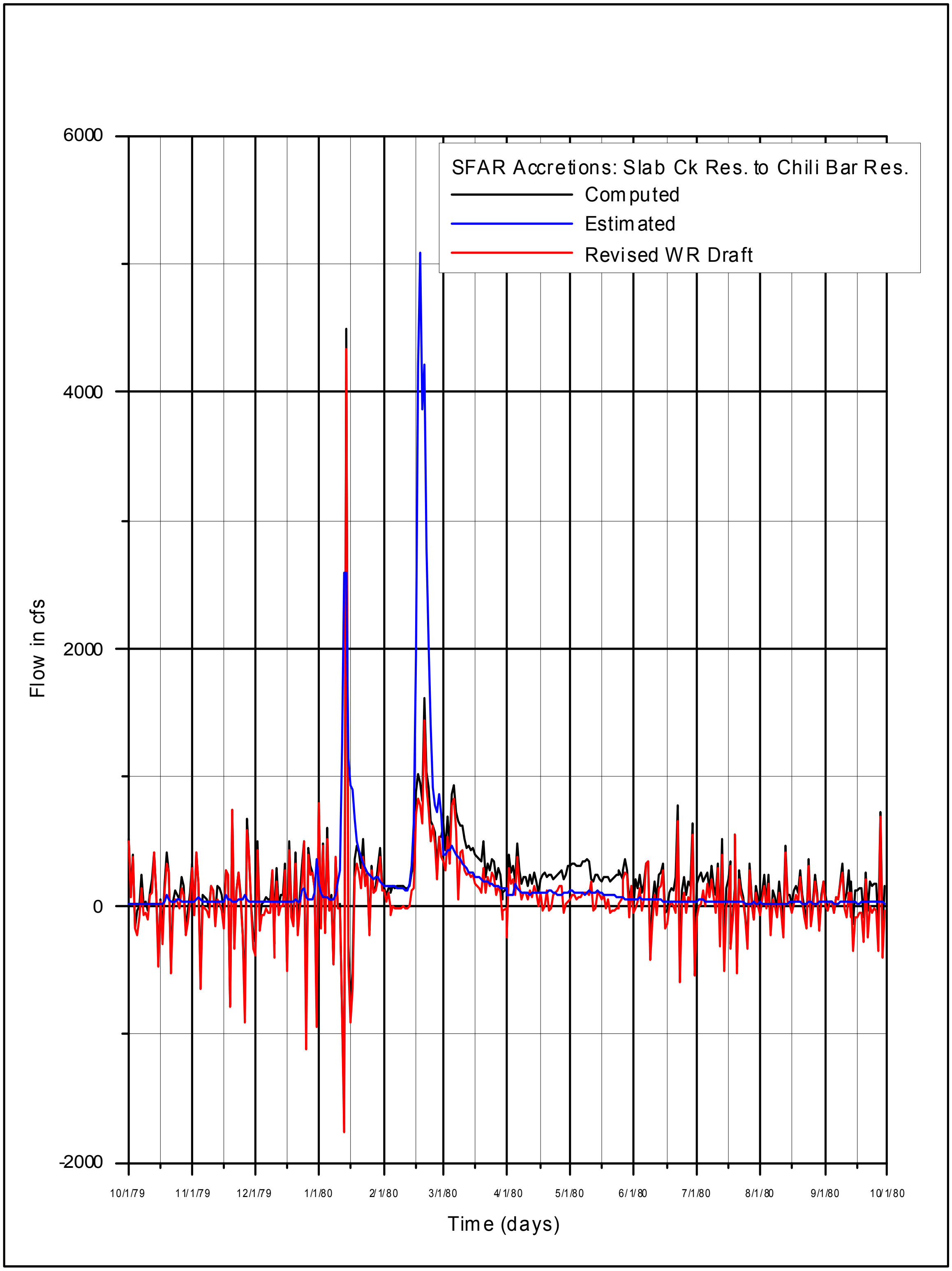


Figure 3.2.8-8. SFAR Accretions: Slab Creek Reservoir to Chili Bar Reservoir, WY 1980

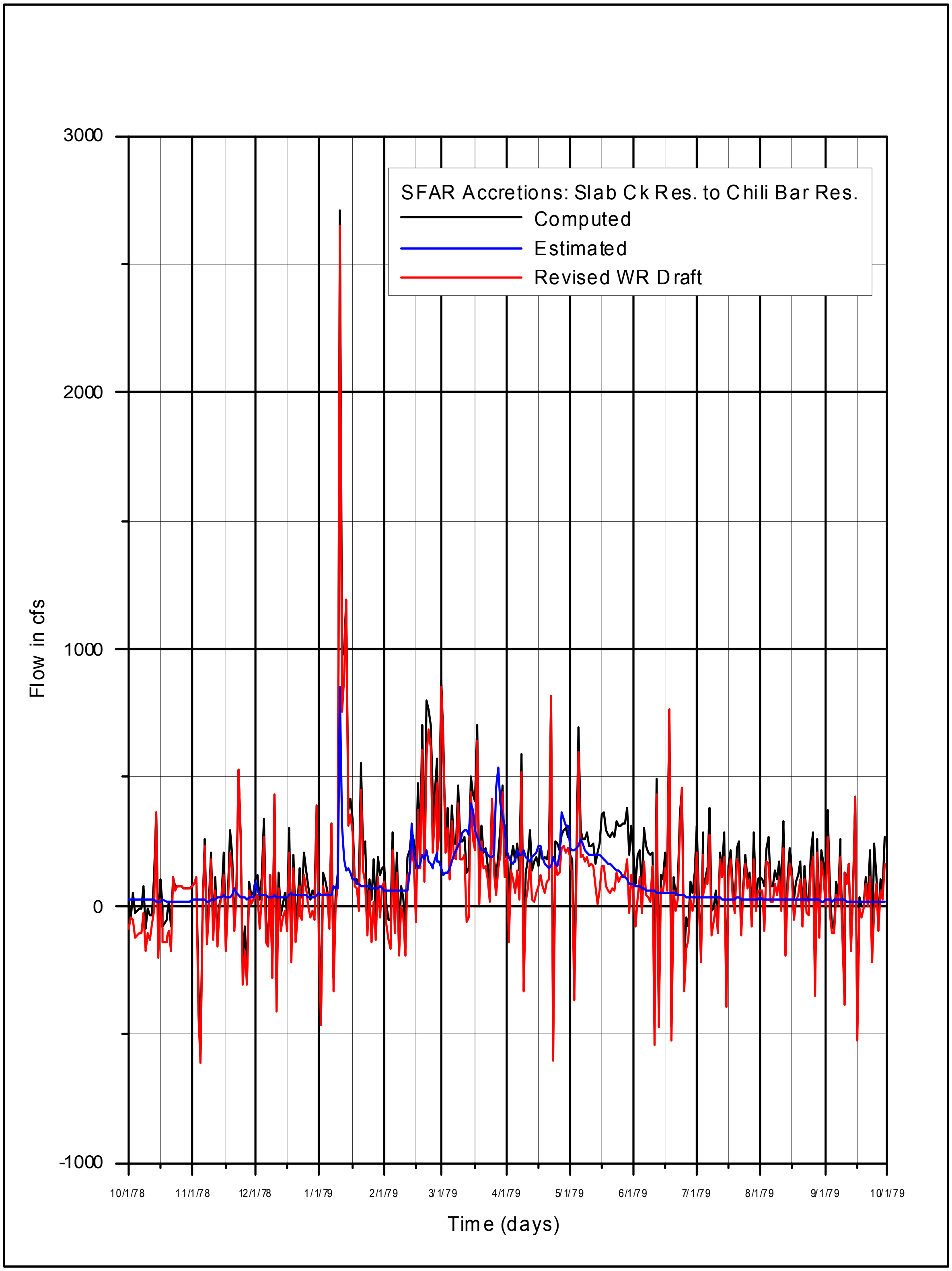


Figure 3.2.8-9. SFAR Accretions: Slab Creek Reservoir to Chili Bar Reservoir, WY 1979

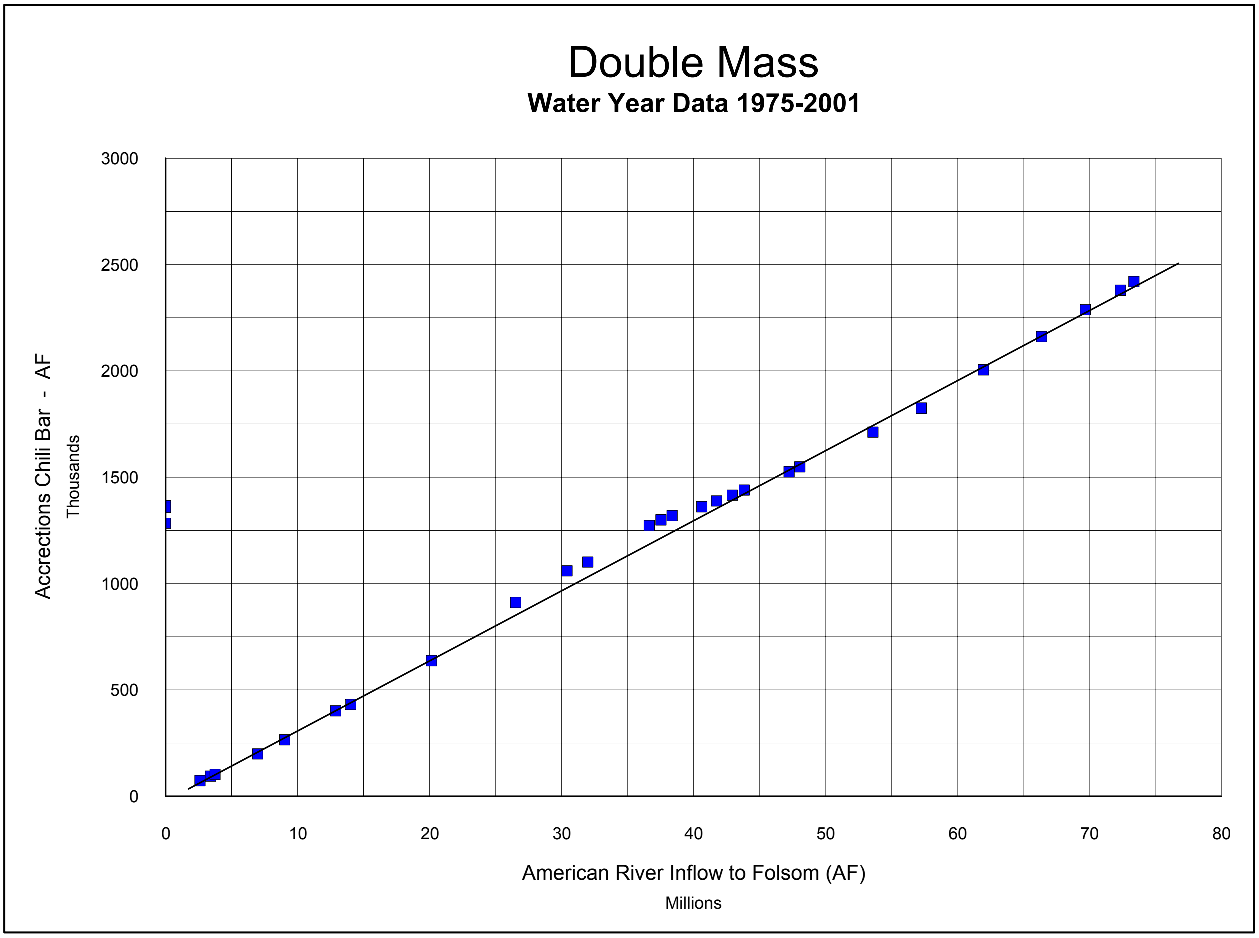


Figure 3.2.8-10. Double Mass – Water Year Data 1975-2001 – Accretions to Chili Bar Reservoir Versus Unregulated Inflow for the American River to Fair Oaks (Folsom)

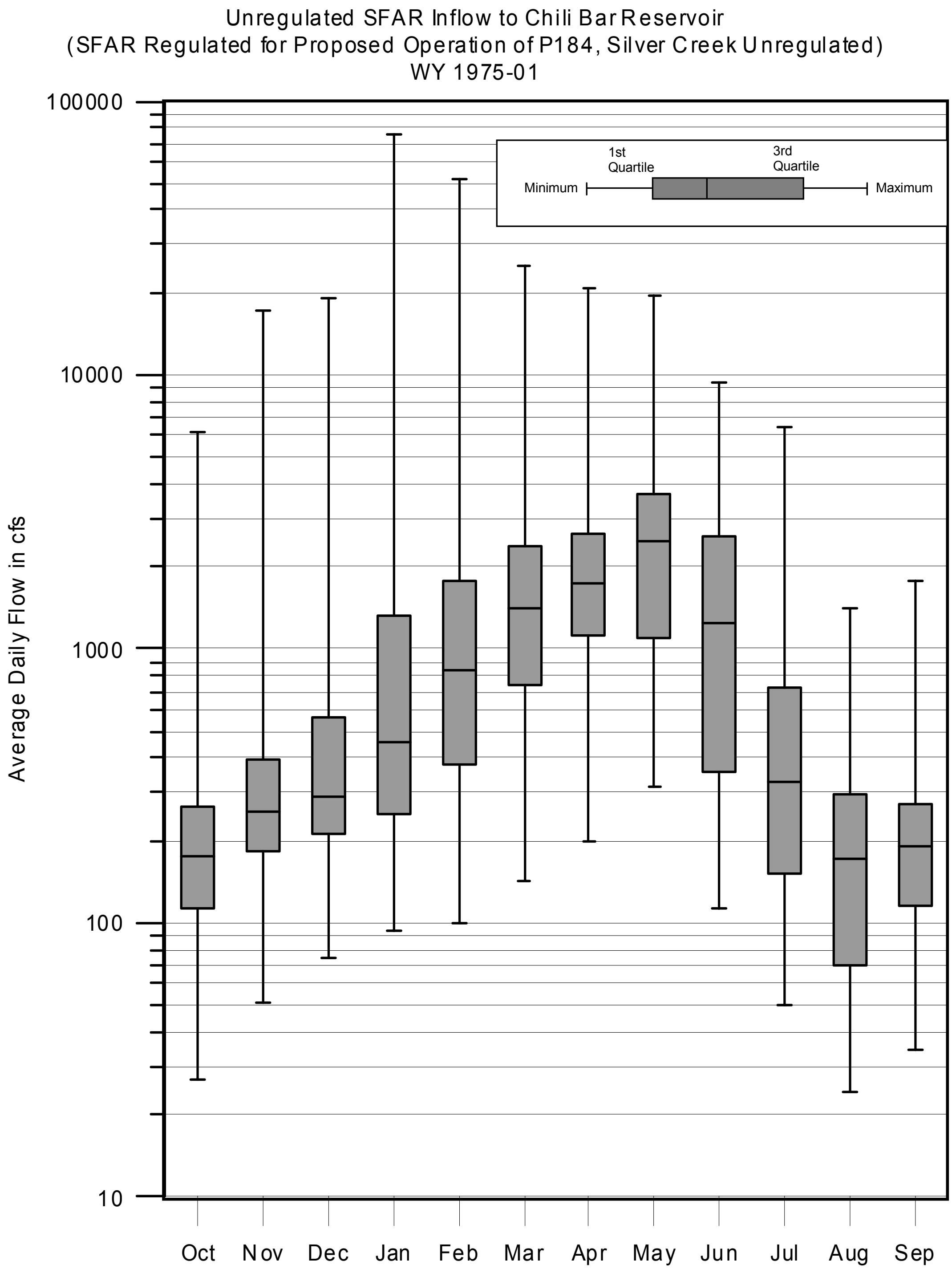


Figure 3.2.8-11. Unregulated SFAR Inflow to Chili Bar Reservoir (SFAR Regulated for P184, Silver Creek Unregulated) WY 1975-01, Monthly Box-whisker Diagram

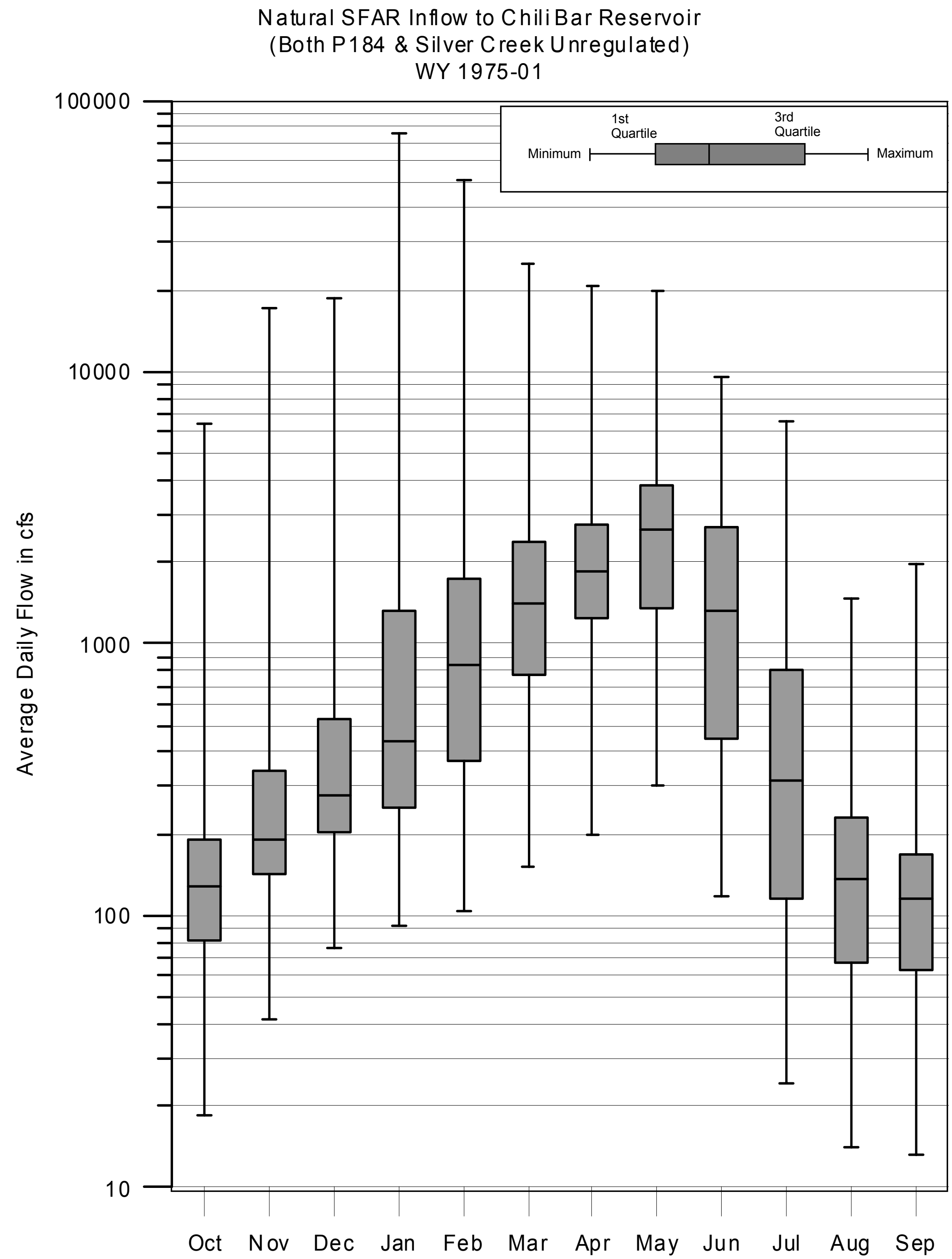


Figure 3.2.8-12. Natural SFAR Inflow to Chili Bar Reservoir (Both P184 & Silver Creek Unregulated) WY 1975-01, Monthly Box-whisker Diagram

These data were added to the two estimates for the SFAR inflow to Slab Creek Reservoir. Total flow was computed for the two conditions:

- Unregulated SFAR inflow to Chili Bar Reservoir
- Natural SFAR inflow to Chili Bar Reservoir

A box-whisker diagram describing the daily flow characteristics by month is provided in Figure 3.2.8-11. The average annual "unregulated" runoff at Chili Bar Reservoir is 857,900 acre-feet (1975-2001). A table of monthly runoff at this site for the period 1975-2001 is included in Appendix B.

A box-whisker diagram describing the daily flow characteristics by month is provided in Figure 3.2.8-12. The average annual runoff "natural" at Chili Bar Reservoir is 872,700 acre-feet (1975-2001). A table of monthly runoff at this site for the period 1975-2001 is included in Appendix B.

4.0 ACCRETIONS

Points where accretions are computed were selected by the Water Balance Subcommittee on October 8, 2003. The locations and the procedures to compute the accretions are summarized in Appendix D. Accretions data are provided on the attached disk.

4.1 Computation of Daily Accretions

Flow at forty-one locations was computed on a daily basis. This group of forty-one locations was further segregated into regulated and unregulated locations. A location existing below a reservoir would be considered regulated. A location above a reservoir, which is not impacted by diversions into the basin or regulated inflow from an upstream facility, would be considered to be unregulated. Regulated locations are described in Table 4.1-1. Unregulated locations are described in Table 4.1-2.

To compute the daily accretions for sub-areas, the computed unregulated flows described in Section 3.0 of this report were proportionately distributed by drainage sub-area and precipitation. Procedures to compute these daily accretions are summarized in Appendix D. The computed daily accretions at the 41 locations are provided on the attached disk.

Table 4.1-1. Daily Accretions: Regulated Location Points

Node Identification on October 8, 2003 Memo	Description
Rubicon River	
Rubicon 4	Rubicon River at Rubicon Springs
Rubicon 5	Rubicon River below Miller Creek
Rubicon 6	Rubicon River below Little Rubicon River
Gerle Creek	
Rockbound 1	Rockbound Lake release to Buck Island Reservoir
Loon 4	Gerle Creek below Jerrett Creek
Loon 5	Gerle Creek below Barts and Dellar Creek
Loon 6	Gerle Creek Inflow Above Rocky Basin Creek

Table 4.1-1. Daily Accretions: Regulated Location Points

Node Identification on October 8, 2003 Memo	Description
Loon 7	Gerle Creek below Rocky Basin Creek
Loon 8	Gerle Creek Inflow to Gerle Reservoir
Gerle 4	Gerle Creek above Confluence with SF Rubicon River
South Fork Rubicon River	
Gerle 5	SF Rubicon above Confluence with Rubicon River
Gerle Other (additional point added by SMUD after October 8, 2003)	SF Rubicon River below Gerle Creek near Georgetown (USGS Gage, 1143000)
South Fork Silver Creek	
Ice House 4	SF Silver Creek below Peavine Creek
Ice House 5	SF Silver Creek below Windmiller Ravine
Ice House 6	SF Silver Creek below Big Hill Canyon
Ice House 7	SF Silver Creek at Junction Reservoir
Silver Creek	
Junction 4	Silver Creek below Grey Horse Creek
Junction 5	Silver Creek below Onion Creek
Junction 6	Silver Creek below Sugar Pine Creek
Junction 7	Silver Creek at Camino Reservoir
Camino 3	Silver Creek below Round Tent Canyon
Camino 4	Silver Creek Halfway, no name creek
Camino 5	Mouth of Silver Creek
Brush Creek	
Brush 4	Brush Creek Inflow to Slab Creek Reservoir
South Fork American River	
Slab 4	SF American River below Iowa Canyon Creek
Slab 5	SF American River above Mosquito Road Bridge
Slab 6	SF American River below Rock Creek
Slab 7	SF American River Above Chili Bar Reservoir
Chili Bar 4	SF American River below Dutch Creek
Chili Bar 5	SF American River below Greenwood
Chili Bar 6	SF American River below Weber Creek

Table 4.1-2. Daily Accretions: Unregulated Location Points

Node Identification on October 8, 2003 Memo	Description
1	Rubicon River Inflow to Rubicon Reservoir
2	Highland Creek Inflow to Rockbound Reservoir
3	Ellis Creek Inflow to Loon Lake
4	SF Rubicon Inflow to Robbs Peak Reservoir
5	SF Silver Creek Inflow to Ice House Reservoir
6	Tells Creek Inflow to Union Valley Reservoir
7	Big Silver Creek Inflow to Union Valley Reservoir
8	Jones Fork Silver Creek Inflow to Union Valley Reservoir
9	Little Silver Creek Inflow to Junction Reservoir
10	Slab Creek Inflow to Slab Creek
11	Iowa Canyon above SF American River
12	Rock Creek above SF American River

5.0 FLOW STATISTICS

To illustrate the difference between unregulated flow at a location and project regulated flow, comparison tables were prepared for the regulated and unregulated flow condition. The Indicators of Hydrologic Alteration (IHAs) methodology, as described by Richter et al. (1996), was applied. Richter suggests that the hydrologic attributes of a stream can be described by five fundamental groups of statistics. These five groups are:

- Group #1: Magnitude of monthly water conditions
- Group #2: Magnitude and duration of annual extreme water conditions
- Group #3: Timing of annual extreme water conditions
- Group #4: Frequency and duration of high and low pulses
- Group #5: Rate and frequency of change in water conditions

IHA values were computed in accordance with Richter et al. (1991) and the Nature Conservancy (2001). As recommended by Richter, all data are presented as non-parametric (percentile) statistics due to the highly skewed nature of hydrologic data sets. In general, the median flow (that flow for which 50 percent of the recorded flows are less than it and 50 percent are greater than it) is used as a measure of central tendency for the IHA value. The spread between the 25th percentiles (that flow for which 25 percent of the recorded flows are less than it and 75 percent are greater than it) and the 75th percentile (that flow for which 75 percent of the recorded flows are less than it and 25 percent are greater than it) divided by the median is a measure of dispersion called the coefficient of dispersion (CD). The median and CD would correspond to the mean and standard deviation in parametric statistics, which is used for data sets that are not so highly skewed. To express the difference between regulated and unregulated statistics, Richter's deviation factor (unregulated value minus the regulated value divided by the unregulated value) was calculated for both medians and CDs. For medians, the deviation factor may range from a negative value (which indicates that regulated flows are greater than unregulated flows), to zero (which indicates no difference between the regulated and unregulated flows) to a value of one (which indicates regulated flow is approaching zero). For CDs, the deviation factor may range from a negative number (which indicates that regulated flows have a broader dispersion than unregulated flows), to zero (which indicates no difference between the regulated and unregulated flows) to a positive number that may exceed one (which indicates that regulated flows have a narrower dispersion than unregulated flows).

As also recommended by Richter, IHA statistics should normally be calculated at locations where measured hydrology data are available for about 30 years from both the pre-project and project period. This analysis differed from this approach in two ways. First, the period of record for this relicensing effort is the 26-year period from October 1974 through September 2000, rather than 30 years. Second, pre-project data are only available for a limited number of project points. Therefore, computed unregulated data will be utilized instead.

The analysis was performed at the locations described in Table 5.0-1. The following provides a summary of the parameters evaluated.

Table 5.0-1. IHA Analysis: Locations Analyzed

Unregulated	Regulated
Gerle Creek below Loon Lake Reservoir	4295 Gerle Ck below Loon Lake Dam
South Fork Rubicon Below Gerle Creek	4300 South Fork Rubicon Below Gerle Creek
South Fork Silver Creek below Ice House Reservoir	4415 South Fork Silver Creek below Ice House Reservoir
Silver Creek at Camino Diversion Dam	4419 Silver Creek below Camino Diversion Dam
South Fork American River at Slab Creek Reservoir , (unregulated flow, WY75-01)	4435 South Fork American River Near Camino
South Fork American River at Slab Creek Reservoir (natural flow, WY75-01)	4435 South Fork American River Near Camino
South Fork American River at Chili Bar Reservoir (unregulated flow, WY75-01)	4445 South Fork American River Near Placerville
South Fork American River at Chili Bar Reservoir (natural flow, WY75-01)	4445 South Fork American River Near Placerville

5.1 Magnitude of Monthly Water Conditions (IHA Group 1)

Regulated and unregulated monthly flows for the 26-year period are provided by location and with their comparisons summarized in Appendix E. The 12 parameters include monthly median flow values and associated statistics based on the 26-year period of record. Associated CDs and deviation factors were also calculated.

5.2 Magnitude and Duration of Annual Extreme Water Conditions (IHA Group 2)

Regulated and unregulated extreme flow conditions have been computed, and their comparisons are summarized in Appendix E. The 11 parameters based on the 26-year long record measure the magnitude of extreme (minimum and maximum) annual water conditions or various duration periods ranging from one-day to seasonal. The five duration periods for which statistics are calculated include 1-day, 3-day, 7-day (week), 30-day (month), and 90-day (season) for each year. The number of zero-flow days was also computed. The median, CDs and deviation factors for each value was calculated. For any given year, the 1-day maximum (or minimum) value is represented by the highest (or lowest) single median daily value occurring during that year. For any given year, the multi-day maximum (or minimum) value is represented by the highest (or lowest) average of median daily values over that multi-day period occurring in that year. There were no zero-flow days in either the regulated record or the unregulated record.

5.3 Timing of Annual Extreme Water Conditions (IHA Group 3)

Regulated and unregulated extreme flow conditions have been computed, and their comparisons are summarized in Appendix E. The two parameters include the median of the Julian date of the 26 Julian dates when the 1-day minimum water condition occurred in the 26-year record, and the median of the Julian date of the 26 Julian dates when the 1-day maximum water condition occurred. Associated CDs and deviation factors were also calculated.

5.4 Frequency and Duration of High and Low Pulses (IHA Group 4)

The frequency of high and low flow pulses as well as the duration of each for regulated and unregulated conditions is summarized in Appendix E. Four parameters are measured in this group for each of the 26 years in the record. Two parameters measure the number of annual occurrences (frequency) during which the magnitude of the water condition exceeded an upper threshold or remained below a lower threshold, respectively. Two additional parameters measure the number of days (duration) of such high and low pulses. Pulses were defined as those periods within a year in which the daily median water condition rose above the 75^{th} percentile (high pulse) or dropped below the 25^{th} percentile of all daily values for the unregulated hydrology.

5.5 Rate and Frequency of Change in Water Conditions (IHA Group 5)

The rate and frequency of annual hydrograph changes for the unregulated monthly flows are provided in Appendix E. Three parameters were measured in this group for each of the 26 years in the record. Two parameters measured the median of positive and negative differences between consecutive daily values (rate). An additional parameter measured the median number of hydrologic reversals (frequency) based on median daily flows. Associated CDs and deviation factors were also calculated.

6.0 DIURNAL DAILY FLUCTUATION

The purpose of this analysis was to investigate the relationship between mean daily flow and the maximum daily flow during the snowmelt period. This type of analysis provides insight into the diurnal fluctuation of the unregulated snowmelt. The two basins of interest were the South Fork Silver Creek near Ice House (27.3 square miles) and the South Fork American River near Slab Creek Reservoir (493 square miles). Hourly unregulated data are not available for these locations. Instead, data from other drainage basins were utilized in the analysis. Flow data from basins with similar drainage area/elevation characteristics were selected; three small drainage basins and three large drainage basins (Table 6.0-1). Fifteen minute streamflow data were provided by the USGS for the period 1990 through 2001.

Table 6.0-1. Diurnal Daily Fluctuation Analysis, USGS Sites

Gage Location	Drainage Area
Blackwood Creek near Tahoe City	11.2
Ward Creek at Hwy 89 near Tahoe Pines [1/]	9.7
Trout Creek near Tahoe Valley[1/]	36.7
Merced River at Happy Isle [1/]	181
Merced River at Pohono Bridge[1/]	321
North Fork American River at North Fork Dam [2/]	342

[1/] Minor diversions upstream.
[2/] Minor regulation by Lake Clementine, 12,800 acre-feet. However, the impact of regulation on hourly data may be more significant.

The following discussion summarizes the analysis that was performed. The maximum to average day flow ratio (maximum flow ratio) was computed for each day, for the months April through July for each location. Because one plot would be used for all year types, the data was "normalized" so that wet, dry and normal years could be plotted on the same graph. To normalize the data, the volumetric values of flow representing the remaining April-July flow were expressed as a percentage of the total April-July flow. These computed values were plotted against the maximum flow ratio. The results of this analysis are provided in Appendix F.

After reviewing the results, and data, it was discovered that many spikes in the data were the result of single rain events. To dampen out the impact of these events, the maximum flow ratio was averaged over a four day period (the current day and the previous three days) and again plotted against the remaining April-July flow, as a percentage of the total April-July flow. The results of this refined analysis are also provided in Appendix F. This refinement created a relationship with less variability.

This was an investigative analysis. No conclusions will be drawn from the analysis performed.

7.0 FLOOD PEAK FREQUENCY

A flood peak frequency analysis was performed at several sites within the UARP. The sites are described in Table 7.0-1. The methodology applied to analyze these data was developed by the U.S. Army Corps of Engineers, 1962, and described below.

Table 7.0-1. Flood Peak Frequency Analysis Points
Rubicon River
Rubicon River at Rubicon Spring near Meeks Bay
Gerle Creek
Gerle Creek below Loon Lake Dam
South Fork Rubicon River
South Fork Rubicon River below Gerle Creek near Georgetown
South Fork Silver Creek
South Fork Silver Creek at Ice House Reservoir
Silver Creek
Silver Creek at Union Valley Reservoir
Silver Creek at Camino Diversion Dam
South Fork American River
South Fork American River near Camino
South Fork American River near Placerville

Instantaneous annual maximum events were downloaded from the USGS website. Data were broken down by period, i.e., regulated events versus unregulated events. Hydrologic plotting points were computed as follows:

$$1 - P_1 = (0.5)^{1/N}$$

Where:
P_1 is the plotting position for the largest event
N is the number of years of record

The plotting position for the smallest event is the complement of this value and all the other plotting positions are interpolated linearly between the two (U.S. Army Corps of Engineers, Statistical Methods in Hydrology, 1962). Results of the analysis are summarized in Appendix G (Appendix G, figures 1-1 through 1-8 and figures 2-1 through 2-4).

The purpose of this analysis is to evaluate the 2-year event. Additional analysis is required if recurrence intervals greater than 10 years are of interest.

The available data associated with sites described in Table 7.0-1 span varying hydrological periods. In attempt to capture the potential impact of differing hydrological periods, flood peak frequency curves were prepared for gages outside the American River basin and for the unregulated daily flow into Ice House Reservoir. These plots can be used to aid the user in evaluating results from this analysis. Results of the analysis are summarized in Appendix G (Appendix G, figures 3-1 through 3-5 and figures 4-1 through 4-16).

8.0 LITERATURE CITED

Richter's et al. 1999

SMUD 2002. SMUD Upper American River Project, Hydrology Study Plan. Plenary Approval August 5, 2002.

U.S. Army Engineer District Corps of Engineers. Statistical Methods in Hydrology. January 1962.

APPENDIX A

A COMPUTATION OF SIMULATED DATA INFLOW TO ICE HOUSE RESERVOIR

Computation of Simulated Data
Inflow to Ice House Reservoir

The simulated inflow to Ice House Reservoir was derived by computer. The relationship was derived using data at the gages listed in Table 1-1.

Table 1-1: Streamflow Gages Adjacent to or Nearby the UARP

USGS Number	USGS Description	Gage Elevation (feet)	Drainage Area (sq-mi)	Coefficient Applied
10336660	Blackwood Creek near Tahoe City (Blackwood)	6,240	11.2	.72
10336780	Trout Creek near Tahoe Valley (Trout)	6,250	36.7	.24[1/]
11427700	Duncan Creek near French Meadows (Duncan)	5,270	9.9	1.19
11431800	Pilot Creek above Stumpy Meadows (Pilot)	4,280	11.7	.13[1/]
	Constant			0

[1/] Applied to flow above estimated base flow.

There was an adjustment to the flow at Trout and Pilot prior to computing the inflow to Ice House Reservoir. Preliminary results from the Ice House daily multiple regression analysis indicated a poor correlation with the gaged flow at Trout and Pilot. Monthly plots were prepared comparing Ice House with Trout and Pilot. The monthly data indicated a strong relationship with Ice House, however, the monthly relationship varied by season. Further investigation suggested that the variation was due to a higher base flow at Trout and Pilot as compared to Ice House. The base flow was removed from Trout and Pilot and the daily data reanalyzed. The correlation between Ice House and Trout/Pilot adjusted inflow improved. Samples of the base flow adjustment procedure at Trout and Pilot are plotted in figures 4-1 and 4-2. The inflow to Ice House Reservoir is computed as:

Inflow to Ice House Reservoir = Blackwood times 0.72 plus
Trout adjusted flow times 0.24 plus
Duncan times 1.19 plus
Pilot adjusted flow times 0.13

Where:
All flows are in cfs

The daily inflow to Ice House Reservoir are simulated using the equation above than the data were prorated so the monthly volumes equaled the computed monthly volumes based on the USGS computation at Ice House Reservoir.

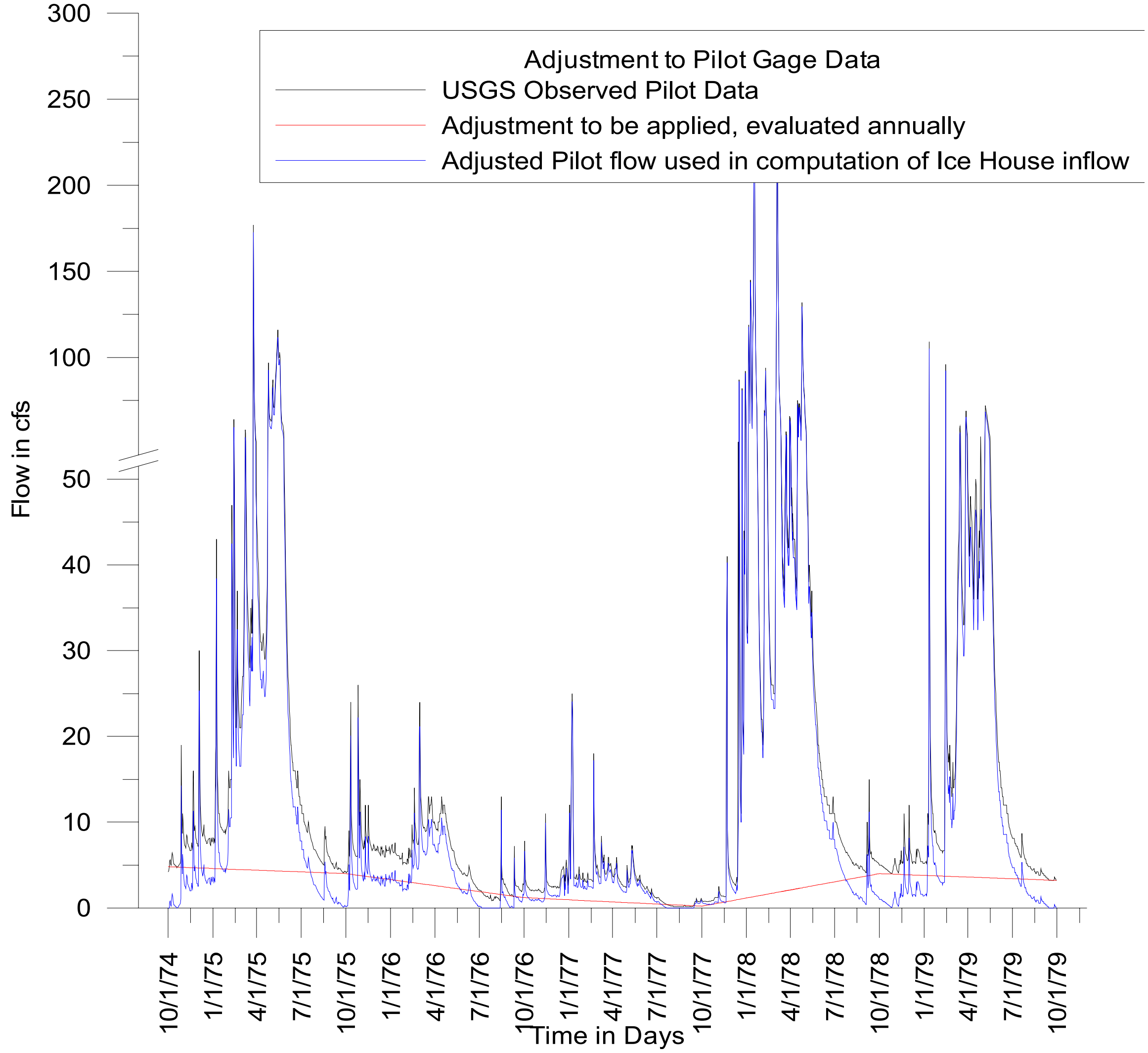

Adjustment to Pilot Gage Data
USGS Observed Pilot Data
Adjustment to be applied, evaluated annually
Adjusted Pilot flow used in computation of Ice House inflow
Flow in cfs
300
250
200
150
100
50
40
30
20
10
0
10/1/74
1/1/75
4/1/75
7/1/75
10/1/75
1/1/76
4/1/76
7/1/76
10/1/76
1/1/77
4/1/77
7/1/77
10/1/77
1/1/78
4/1/78
7/1/78
10/1/78
1/1/79
4/1/79
7/1/79
10/1/79
Time in Days

Figure 4-1

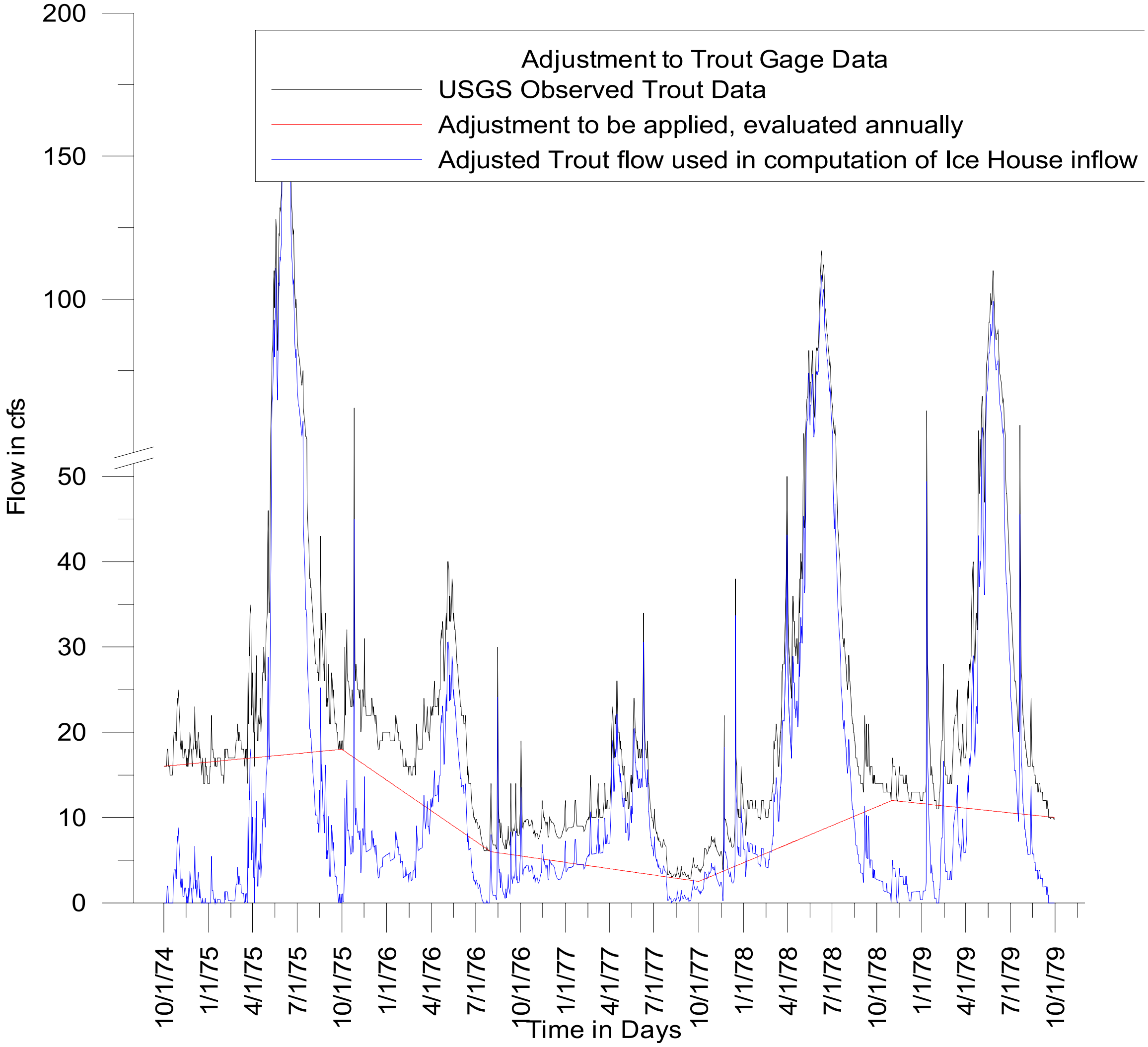

Adjustment to Trout Gage Data
USGS Observed Trout Data
Adjustment to be applied, evaluated annually
Adjusted Trout flow used in computation of Ice House inflow
Flow in cfs
200
150
100
50
40
30
20
10
0
10/1/74
1/1/75
4/1/75
7/1/75
10/1/75
1/1/76
4/1/76
7/1/76
10/1/76
1/1/77
4/1/77
7/1/77
10/1/77
1/1/78
4/1/78
7/1/78
10/1/78
1/1/79
4/1/79
7/1/79
10/1/79
Time in Days

Figure 4-2

APPENDIX B

MONTHLY UNIMPAIRED INFLOW

(Daily Data Provided as Raw Data on CD by Request)

Rubicon River at Rubicon Reservoir
Average Monthly Flow - Acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	163	634	981	1,017	1,054	2,217	2,238	27,773	30,093	8,698	1,388	456	76,711
1976	6,095	3,864	1,345	813	1,229	2,669	5,897	12,504	2,432	395	1,580	349	39,170
1977	306	198	169	182	670	1,109	6,651	6,615	6,317	173	25	39	22,453
1978	16	432	4,380	2,818	1,831	6,402	8,206	25,310	26,982	10,007	1,308	2,102	89,796
1979	123	335	1,036	6,395	1,705	3,891	9,473	28,238	13,567	3,099	183	15	68,061
1980	2,653	3,061	2,123	21,609	5,155	2,558	12,967	22,437	22,308	13,463	1,514	183	110,032
1981	86	465	1,237	1,019	4,412	2,907	12,355	14,955	5,273	259	28	122	43,117
1982	1,799	20,751	20,632	2,669	16,369	4,258	17,937	34,173	28,330	14,277	2,743	5,766	169,705
1983	11,731	3,710	2,945	2,122	2,131	5,460	3,914	27,266	48,124	29,800	9,435	4,523	151,162
1984	2,513	18,816	10,695	3,009	2,128	5,273	7,898	30,063	19,481	6,883	933	512	108,203
1985	1,656	5,386	1,617	1,166	1,535	2,457	14,751	17,013	7,389	612	86	753	54,421
1986	1,289	1,361	3,548	7,888	15,540	16,082	13,844	27,089	23,492	5,999	1,138	905	118,174
1987	1,921	303	221	221	1,697	2,493	14,305	12,538	3,369	370	73	23	37,535
1988	5	534	2,459	1,685	1,793	4,701	7,990	9,840	5,276	355	30	1	34,670
1989	86	2,867	1,675	1,354	2,651	12,065	17,864	20,946	17,613	3,338	264	908	81,632
1990	2,216	2,053	1,395	2,523	1,297	4,796	13,351	11,314	8,437	1,267	27	27	48,704
1991	78	139	157	216	514	5,183	5,941	16,115	15,745	2,436	129	30	46,682
1992	806	2,582	898	707	3,247	3,426	13,372	9,174	2,831	1,135	156	89	38,422
1993	372	980	1,202	2,917	1,448	6,875	10,325	33,856	24,301	10,459	1,813	200	94,747
1994	662	257	438	803	712	3,917	9,784	13,358	4,221	251	14	8	34,423
1995	186	1,893	1,274	4,993	3,437	9,697	8,659	24,650	42,935	32,001	8,424	1,723	139,873
1996	286	50	10,012	3,620	13,752	4,769	12,317	35,987	21,629	7,016	769	227	110,435
1997	217	10,545	12,240	28,683	2,202	6,886	16,683	26,230	16,075	3,246	371	79	123,457
1998	468	1,221	1,162	5,098	2,276	8,301	8,403	14,767	40,615	22,170	3,488	1,335	109,304
1999	434	2,780	2,739	2,528	1,988	2,762	7,252	29,905	29,317	8,941	1,034	271	89,951
2000	542	1,207	804	3,609	3,541	4,589	13,808	26,225	13,275	2,247	270	471	70,589
2001	226	801	809	627	860	5,128	7,597	16,894	1,632	172	38	39	34,823
Maximum	11,731	20,751	20,632	28,683	16,369	16,082	17,937	35,987	48,124	32,001	9,435	5,766	169,705
Minimum	5	50	157	182	514	1,109	2,238	6,615	1,632	172	14	1	22,453
Average	1,368	3,231	3,266	4,085	3,525	5,217	10,510	21,305	17,817	7,003	1,380	784	79,491
Median	434	1,221	1,345	2,523	1,988	4,701	9,784	22,437	16,075	3,246	371	227	76,711

Little Rubicon River at Buck Island Reservoir
Average Monthly Flow - Acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	32	178	440	391	628	929	871	7,940	12,320	1,939	94	90	25,851
1976	1,899	1,093	469	296	361	869	1,738	3,833	188	78	312	69	11,205
1977	60	39	33	36	229	431	2,275	2,346	1,602	47	5	8	7,110
1978	4	99	2,123	1,157	740	1,823	2,487	8,227	8,744	2,326	287	419	28,436
1979	28	77	211	1,439	682	1,173	2,988	9,333	3,782	1,052	42	3	20,811
1980	853	918	583	5,259	1,560	731	3,808	7,492	6,641	2,631	150	37	30,661
1981	20	93	492	539	1,623	925	4,654	5,279	1,198	33	6	24	14,887
1982	843	5,860	5,091	1,079	4,132	1,631	3,637	7,319	4,858	3,650	664	1,692	40,455
1983	2,810	1,289	1,104	644	760	1,838	1,286	6,816	13,238	7,087	1,588	1,143	39,603
1984	853	8,418	3,769	817	636	1,582	2,439	10,211	5,238	1,569	157	118	35,808
1985	532	2,205	531	328	380	702	4,384	5,731	2,035	146	20	149	17,144
1986	254	442	1,364	3,214	4,823	3,204	2,895	7,606	7,771	1,492	174	249	33,487
1987	727	89	53	53	678	660	4,227	2,686	311	82	17	6	9,589
1988	4	116	1,128	641	385	1,429	2,095	2,464	1,052	69	7	0	9,390
1989	19	1,178	503	341	631	3,368	3,658	3,776	2,187	295	57	185	16,198
1990	913	684	452	902	329	884	3,154	1,922	1,014	111	6	6	10,378
1991	16	28	32	44	113	2,034	1,395	4,355	2,865	200	26	6	11,114
1992	318	922	251	173	1,463	1,418	3,972	1,622	480	235	36	20	10,910
1993	116	462	652	1,614	617	2,243	2,871	10,371	5,216	1,353	136	28	25,679
1994	221	52	207	326	375	1,552	3,295	3,936	780	32	3	2	10,781
1995	38	737	498	2,285	960	3,496	3,619	8,256	10,826	7,519	1,614	211	40,059
1996	65	10	3,137	1,190	3,412	1,573	4,277	11,261	4,992	547	128	46	30,638
1997	44	2,828	5,221	7,506	294	2,205	4,779	7,179	2,926	209	69	16	33,277
1998	95	412	353	1,890	651	1,709	2,400	4,483	10,076	4,095	457	207	26,829
1999	88	1,128	833	821	629	581	2,310	9,287	8,906	2,820	206	55	27,664
2000	45	395	309	2,140	1,393	870	4,851	6,666	2,280	250	56	96	19,352
2001	46	163	165	127	234	2,304	3,174	5,556	332	35	8	8	12,150
Maximum	2,810	8,418	5,221	7,506	4,823	3,496	4,851	11,261	13,238	7,519	1,614	1,692	40,455
Minimum	4	10	32	36	113	431	871	1,622	188	32	3	0	7,110
Average	405	1,108	1,111	1,306	1,064	1,562	3,094	6,146	4,513	1,478	234	181	22,202
Median	88	442	498	817	636	1,552	3,154	6,666	2,926	295	69	46	20,811

Gerle Creek at Loon Lake Reservoir
Average Monthly Flow - Acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	54	191	220	561	1,492	2,297	2,037	9,284	2,476	561	117	71	19,361
1976	593	999	551	608	629	1,448	1,758	973	137	63	116	39	7,912
1977	45	42	68	121	289	612	1,086	1,216	289	27	9	13	3,817
1978	11	115	2,086	2,384	1,639	4,164	4,330	5,671	1,797	354	78	87	22,716
1979	53	91	193	1,351	1,257	2,046	4,414	4,715	993	166	41	13	15,335
1980	275	903	803	8,297	3,643	1,923	4,697	4,788	1,351	470	112	34	27,295
1981	25	101	362	585	1,404	1,953	3,782	2,033	315	40	16	20	10,636
1982	107	4,633	6,258	1,644	5,982	3,958	6,181	7,580	2,854	612	154	347	40,311
1983	1,601	2,481	2,390	1,742	2,356	4,462	2,722	9,969	8,696	2,474	458	141	39,492
1984	285	7,145	6,414	1,754	1,987	3,447	3,378	2,420	763	226	62	38	27,920
1985	129	1,633	1,098	551	850	1,643	4,555	2,185	502	72	35	64	13,318
1986	74	259	1,354	3,580	10,417	7,571	4,615	2,924	586	213	61	119	31,773
1987	263	112	139	220	1,301	2,079	2,994	1,209	180	57	27	25	8,606
1988	43	112	712	1,007	930	1,288	1,409	712	368	65	19	17	6,682
1989	18	965	510	406	873	7,218	6,752	4,324	894	133	51	68	22,213
1990	299	495	428	957	799	2,555	3,712	2,071	856	119	24	16	12,331
1991	28	45	59	88	162	2,497	3,682	3,973	1,094	206	36	15	11,885
1992	86	188	181	209	1,401	2,640	2,746	592	150	125	25	21	8,365
1993	101	156	618	2,660	1,779	5,648	6,470	7,190	3,501	452	102	34	28,711
1994	60	59	204	316	747	2,017	2,568	1,781	259	43	10	11	8,074
1995	39	652	1,008	4,893	2,295	7,642	5,948	9,615	5,515	1,582	295	81	39,564
1996	54	43	2,352	2,153	5,720	3,479	5,512	8,974	837	192	69	45	29,429
1997	58	1,317	7,518	9,226	1,358	3,418	3,819	2,112	749	193	56	24	29,848
1998	89	330	478	3,377	2,240	4,329	4,013	6,904	7,151	1,329	148	91	30,479
1999	95	909	1,172	2,608	2,605	2,426	4,180	7,340	2,197	331	99	49	24,010
2000	61	183	271	2,829	3,096	2,720	5,013	3,788	650	145	37	49	18,842
2001	52	173	271	344	581	2,403	3,017	2,178	177	37	14	13	9,259
Maximum	1,601	7,145	7,518	9,226	10,417	7,642	6,752	9,969	8,696	2,474	458	347	40,311
Minimum	11	42	59	88	162	612	1,086	592	137	27	9	11	3,817
Average	170	901	1,397	2,017	2,142	3,255	3,903	4,316	1,679	381	84	57	20,303
Median	61	191	551	1,351	1,404	2,555	3,819	3,788	837	192	56	38	19,361

Gerle Creek at Gerle Creek Reservoir
Average Monthly Flow - Acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	206	542	525	1,107	3,393	5,600	5,387	24,450	8,109	1,450	377	130	51,276
1976	1,519	2,080	1,446	1,419	1,679	3,601	4,658	2,749	440	120	176	101	19,987
1977	119	119	279	566	940	1,293	2,316	3,006	912	112	37	42	9,741
1978	53	280	5,275	6,764	4,070	12,500	12,122	15,226	5,984	1,102	298	206	63,880
1979	161	254	453	3,269	2,592	5,385	12,359	14,433	2,776	489	126	64	42,361
1980	418	1,844	2,108	25,211	10,298	5,184	12,162	11,508	4,028	1,203	272	91	74,328
1981	104	261	696	1,409	3,495	5,198	10,035	4,783	867	113	53	61	27,075
1982	240	12,964	17,909	4,538	15,807	10,825	16,049	16,917	6,104	1,444	436	1,132	104,364
1983	4,401	5,675	6,125	4,614	6,137	12,744	8,431	28,299	22,173	6,095	1,044	300	106,038
1984	538	17,118	17,238	5,411	4,672	9,022	8,234	7,568	2,486	873	188	99	73,448
1985	299	4,078	2,179	1,631	2,325	4,194	13,391	6,132	1,192	163	96	136	35,816
1986	198	995	3,966	10,106	30,465	19,388	10,129	6,930	1,884	741	186	235	85,222
1987	399	249	535	630	3,046	5,324	7,533	2,980	498	166	77	78	21,516
1988	123	300	1,463	3,095	2,537	3,906	4,039	2,012	885	147	67	64	18,636
1989	72	1,924	1,361	1,259	2,690	19,787	16,794	8,125	2,729	417	141	144	55,443
1990	466	744	1,057	2,679	1,974	7,112	8,990	5,108	1,893	329	85	71	30,508
1991	107	169	234	359	575	6,239	9,502	10,348	2,860	548	127	66	31,135
1992	232	457	431	510	3,348	6,673	7,141	1,377	479	199	69	59	20,975
1993	206	333	1,620	6,911	4,553	15,889	16,783	18,635	8,586	1,301	350	108	75,275
1994	171	175	530	799	1,466	5,619	6,388	4,621	684	125	48	54	20,682
1995	104	1,399	2,136	13,889	6,928	20,930	17,508	26,348	14,448	5,240	1,164	244	110,339
1996	177	211	5,516	4,922	17,187	10,545	15,286	19,549	2,407	593	241	113	76,748
1997	138	3,138	20,469	28,183	4,492	8,992	9,523	5,468	2,158	656	176	86	83,480
1998	218	778	1,181	8,691	5,643	12,626	11,829	19,497	19,544	3,374	379	185	83,946
1999	248	2,066	2,985	6,917	7,431	7,647	11,614	18,901	5,984	934	272	110	65,108
2000	206	507	520	7,530	8,809	8,121	13,434	9,761	1,793	475	103	103	51,362
2001	154	485	865	774	1,211	6,512	8,210	5,633	351	106	54	46	24,401
Maximum	4,401	17,118	20,469	28,183	30,465	20,930	17,508	28,299	22,173	6,095	1,164	1,132	110,339
Minimum	53	119	234	359	575	1,293	2,316	1,377	351	106	37	42	9,741
Average	418	2,191	3,671	5,674	5,843	8,921	10,365	11,125	4,528	1,056	246	153	54,189
Median	206	542	1,446	3,269	3,495	7,112	10,035	8,125	2,407	548	176	101	51,362

South Fork Rubicon River at Robbs Peak Diversion Dam
Average Monthly Flow - Acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	226	522	455	814	2,832	4,919	4,990	22,590	8,390	1,324	387	88	47,537
1976	1,380	1,611	1,333	1,208	1,563	3,206	4,320	2,646	451	85	89	93	17,985
1977	109	114	315	664	969	1,015	1,832	2,666	928	126	41	44	8,823
1978	61	244	4,751	6,524	3,621	12,417	11,607	14,232	6,237	1,114	327	177	61,313
1979	162	242	387	2,857	1,988	4,972	11,834	14,475	2,655	480	128	76	40,257
1980	213	1,402	1,944	25,193	9,912	4,856	11,119	10,010	3,987	1,093	240	86	70,055
1981	118	238	498	1,227	3,114	4,833	9,314	4,097	822	110	54	61	24,486
1982	198	12,409	17,354	4,311	14,634	10,229	14,697	13,907	4,840	1,238	420	1,169	95,408
1983	4,170	4,758	5,564	4,277	5,632	12,337	8,503	27,302	20,074	5,393	873	237	99,121
1984	376	14,855	16,123	5,447	4,000	8,304	7,233	7,668	2,566	964	187	91	67,814
1985	253	3,641	1,611	1,609	2,198	3,800	13,161	5,879	1,027	136	90	107	33,512
1986	185	1,097	3,890	9,720	29,861	17,602	8,214	5,967	1,934	786	186	172	79,612
1987	202	204	590	611	2,600	4,833	6,762	2,638	474	162	74	80	19,229
1988	119	280	1,118	3,110	2,393	3,899	3,918	1,936	769	122	71	70	17,805
1989	80	1,428	1,268	1,271	2,706	18,722	14,959	5,660	2,734	422	134	112	49,496
1990	247	372	937	2,565	1,750	6,788	7,861	4,523	1,544	314	91	83	27,075
1991	119	184	261	404	615	5,574	8,669	9,495	2,631	510	135	77	28,673
1992	218	400	374	448	2,901	6,006	6,547	1,169	489	109	65	57	18,782
1993	157	264	1,493	6,331	4,132	15,254	15,361	17,048	7,575	1,264	370	110	69,357
1994	166	173	485	720	1,071	5,366	5,690	4,231	633	122	57	65	18,779
1995	98	1,113	1,680	13,401	6,901	19,792	17,219	24,924	13,306	5,450	1,295	243	105,420
1996	184	250	4,714	4,125	17,081	10,525	14,559	15,750	2,337	597	256	101	70,481
1997	119	2,713	19,291	28,237	4,668	8,302	8,497	4,999	2,098	690	178	93	79,886
1998	192	667	1,047	7,916	5,070	12,357	11,643	18,758	18,459	3,045	345	141	79,639
1999	227	1,723	2,702	6,418	7,188	7,777	11,073	17,220	5,640	899	258	91	61,215
2000	216	484	371	7,001	8,509	8,046	12,543	8,896	1,702	492	99	80	48,439
2001	152	464	885	641	938	6,120	7,736	5,146	258	102	60	51	22,554
Maximum	4,170	14,855	19,291	28,237	29,861	19,792	17,219	27,302	20,074	5,450	1,295	1,169	105,420
Minimum	61	114	261	404	615	1,015	1,832	1,169	258	85	41	44	8,823
Average	369	1,921	3,387	5,446	5,513	8,439	9,624	10,142	4,243	1,006	241	143	50,472
Median	185	484	1,268	3,110	3,114	6,788	8,669	7,668	2,337	510	135	91	48,439

South Fork Silver Creek at Ice House Reservoir
Average Monthly Flow - Acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	148	382	904	1,514	1,687	2,557	3,080	22,237	23,111	3,827	730	293	60,469
1976	1,598	2,972	1,807	1,633	1,419	2,310	4,409	6,822	1,202	230	320	215	24,937
1977	252	287	311	502	767	983	3,482	4,209	2,051	269	62	35	13,209
1978	50	384	3,862	3,703	2,014	6,417	9,054	22,715	17,985	5,014	768	615	72,582
1979	331	342	615	2,461	2,148	3,429	8,176	24,157	7,384	993	304	144	50,484
1980	615	1,169	1,319	18,075	7,127	4,656	11,409	19,020	14,365	6,153	621	215	84,746
1981	240	345	1,023	820	2,557	2,495	9,439	9,852	2,051	275	100	107	29,303
1982	437	9,155	14,605	5,631	15,074	8,009	14,269	28,026	14,807	4,615	995	882	116,505
1983	3,286	4,211	4,221	3,637	4,144	8,058	7,465	24,945	39,882	19,131	5,744	913	125,636
1984	1,009	17,680	12,248	6,531	3,933	6,056	8,292	21,373	9,230	2,051	457	221	89,081
1985	574	3,077	1,938	1,712	1,700	2,530	12,162	11,181	3,188	498	209	338	39,108
1986	394	529	2,111	6,146	15,419	17,448	13,666	19,951	11,165	2,903	811	659	91,202
1987	730	399	439	601	1,840	2,193	9,529	6,877	1,333	349	164	131	24,585
1988	205	410	1,995	1,729	1,933	4,126	6,087	5,026	1,846	314	141	125	23,938
1989	101	1,116	1,122	969	1,593	10,770	17,718	13,986	7,384	937	322	367	56,386
1990	738	820	917	1,752	1,333	3,998	10,433	6,631	4,795	718	199	170	32,506
1991	201	228	257	289	647	3,959	5,066	12,574	7,179	1,231	308	148	32,087
1992	422	632	591	585	2,276	3,444	9,338	4,431	1,414	343	135	96	23,706
1993	312	429	1,429	2,645	2,223	8,249	12,887	28,410	14,432	4,098	909	293	76,316
1994	338	263	820	1,084	1,194	3,075	7,007	7,984	1,436	256	99	103	23,659
1995	168	716	964	9,230	4,939	11,637	12,693	27,052	32,766	17,103	3,156	820	121,245
1996	389	316	4,560	4,059	9,309	7,970	14,303	28,983	10,315	2,597	615	287	83,704
1997	224	3,692	11,827	27,940	5,305	8,548	13,088	15,402	7,428	1,503	431	219	95,606
1998	365	765	1,052	7,033	3,766	8,619	9,598	16,766	33,515	11,598	1,190	502	94,770
1999	394	1,319	2,402	5,197	4,528	4,948	8,619	26,172	16,114	2,917	662	250	73,523
2000	291	476	523	2,994	4,189	5,122	13,080	18,569	5,260	962	250	224	51,940
2001	279	410	566	580	636	4,168	6,247	10,387	878	265	117	110	24,643
Maximum	3,286	17,680	14,605	27,940	15,419	17,448	17,718	28,983	39,882	19,131	5,744	913	125,636
Minimum	50	228	257	289	636	983	3,080	4,209	878	230	62	35	13,209
Average	522	1,945	2,757	4,409	3,841	5,769	9,652	16,435	10,834	3,376	734	314	60,588
Median	338	529	1,122	2,461	2,223	4,656	9,439	16,766	7,384	1,231	322	221	56,386

Silver Creek at Union Valley Reservoir
Average Monthly Flow - Acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	1,156	2,840	2,611	6,347	5,455	13,543	13,156	61,991	45,155	7,397	1,434	579	161,665
1976	3,917	4,394	3,967	3,967	4,217	8,047	12,149	12,888	2,380	543	698	518	57,687
1977	609	884	905	1,869	3,027	3,619	8,527	10,434	4,915	637	206	228	35,860
1978	305	1,396	12,192	16,339	10,584	28,345	28,951	47,123	34,453	7,482	1,672	1,020	189,860
1979	863	1,325	1,826	9,209	6,592	15,550	27,073	57,782	14,491	2,587	678	375	138,352
1980	1,666	6,251	6,819	70,464	28,240	16,328	31,694	41,381	27,964	11,367	1,365	474	244,012
1981	595	1,329	3,174	3,331	8,004	10,493	24,793	19,285	3,035	595	286	325	75,244
1982	1,164	36,005	46,900	16,269	51,938	30,544	53,661	92,428	50,142	9,192	2,286	6,147	396,676
1983	14,440	13,507	18,907	15,881	20,574	43,748	29,737	75,450	118,498	55,465	9,918	1,428	417,554
1984	2,426	73,883	60,247	24,786	14,246	21,510	22,551	43,013	20,383	4,915	1,002	506	289,469
1985	1,470	13,394	5,860	5,168	6,967	11,570	36,445	25,852	5,910	793	496	647	114,572
1986	1,022	4,329	11,193	25,761	99,386	82,675	32,494	37,382	18,038	2,891	992	1,079	317,241
1987	1,587	1,203	1,713	2,859	7,985	11,585	24,171	13,106	2,595	876	403	423	68,507
1988	647	1,547	5,307	7,245	7,702	12,201	13,400	10,375	4,406	716	369	357	64,270
1989	409	4,831	4,601	3,783	6,598	45,274	43,518	31,809	14,591	2,241	734	680	159,068
1990	1,882	2,946	3,325	7,395	5,028	16,175	26,105	17,024	9,145	1,716	470	413	91,623
1991	606	944	1,091	1,412	2,341	17,019	18,806	29,786	14,642	2,823	698	383	90,553
1992	1,200	2,281	2,412	2,856	9,441	14,347	23,034	6,770	2,585	813	357	309	66,406
1993	964	1,587	5,195	15,190	10,838	38,254	41,459	62,132	33,056	6,846	1,924	581	218,027
1994	899	930	3,048	3,069	4,037	13,119	19,003	18,049	3,511	661	282	319	66,926
1995	540	3,769	5,746	30,695	18,080	51,619	47,427	72,717	63,126	28,812	6,581	1,299	330,410
1996	966	1,236	14,032	17,289	43,344	33,221	43,563	65,303	18,149	3,179	1,329	571	242,182
1997	684	15,366	51,486	99,793	17,672	24,457	31,533	28,322	11,773	3,598	946	480	286,110
1998	1,094	2,887	4,032	21,575	17,951	35,666	33,162	51,438	74,423	24,175	1,932	867	269,200
1999	1,265	6,035	8,470	17,845	25,645	21,205	29,863	59,617	33,411	4,890	1,414	535	210,195
2000	1,127	2,645	2,298	16,023	22,025	20,854	35,518	41,799	9,326	2,584	539	486	155,225
2001	817	1,709	3,206	2,556	3,272	14,630	19,611	21,307	1,615	555	304	259	69,842
Maximum	14,440	73,883	60,247	99,793	99,386	82,675	53,661	92,428	118,498	55,465	9,918	6,147	417,554
Minimum	305	884	905	1,412	2,341	3,619	8,527	6,770	1,615	543	206	228	35,860
Average	1,641	7,757	10,762	16,629	17,081	24,281	28,571	39,058	23,767	6,976	1,456	788	178,768
Median	1,022	2,840	4,601	9,209	9,441	17,019	28,951	37,382	14,591	2,823	734	506	159,068

Silver Creek at Junction Reservoir
Average Monthly Flow - Acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	2,163	4,268	5,167	9,877	11,408	24,760	23,274	93,690	71,709	12,940	2,922	1,479	263,658
1976	8,032	8,773	6,905	6,664	6,982	12,441	18,242	20,546	4,194	1,376	1,852	1,378	97,385
1977	1,603	1,851	1,879	3,497	4,535	5,455	12,528	15,621	7,430	1,053	306	336	56,094
1978	489	2,566	20,349	35,949	18,938	48,523	47,980	75,286	55,436	14,228	3,312	3,017	326,071
1979	2,014	2,697	3,468	14,098	11,498	26,021	42,463	88,430	24,729	4,626	1,815	1,068	222,929
1980	3,376	9,258	10,284	136,180	49,443	30,290	49,360	64,645	45,334	19,631	2,865	1,291	421,957
1981	1,448	2,623	5,717	5,993	13,273	20,007	39,102	31,630	6,353	1,661	942	890	129,638
1982	2,626	54,029	70,433	29,132	84,333	55,150	84,961	130,602	68,918	15,772	4,395	8,503	608,854
1983	21,842	21,245	37,914	30,158	40,324	84,764	48,943	111,959	163,302	77,747	17,763	4,067	660,027
1984	5,066	109,121	96,984	40,497	25,313	37,518	36,493	68,304	32,125	8,195	2,212	1,390	463,217
1985	3,070	19,970	10,355	8,739	11,135	18,459	57,045	41,042	10,907	2,085	1,427	2,007	186,240
1986	2,576	6,426	16,931	38,661	160,086	118,063	51,613	60,918	31,872	6,908	2,690	2,544	499,286
1987	3,485	2,574	3,139	4,523	12,929	19,180	36,044	22,136	5,227	1,890	1,186	1,104	113,418
1988	1,861	2,740	8,693	11,112	11,334	18,449	21,183	17,189	7,542	1,675	1,108	1,112	103,999
1989	1,136	7,505	6,913	5,819	10,126	74,597	68,570	49,350	24,331	4,041	1,673	2,036	256,097
1990	3,859	5,086	5,480	11,048	8,012	25,709	40,114	26,406	15,931	3,161	1,322	1,058	147,186
1991	1,484	1,857	2,103	2,488	3,964	26,243	29,914	46,020	23,824	5,043	1,788	1,201	145,930
1992	2,630	3,952	4,050	4,492	16,060	22,498	35,358	13,159	5,311	2,021	1,047	697	111,275
1993	2,020	2,670	8,965	26,867	19,091	67,912	68,021	96,420	52,100	13,297	4,662	2,052	364,077
1994	2,405	2,568	5,540	5,899	7,299	21,553	28,614	28,068	6,141	1,733	1,047	1,062	111,928
1995	1,144	5,940	10,269	60,494	31,763	88,029	81,520	123,327	100,820	48,261	11,778	3,847	567,192
1996	2,535	2,866	22,361	27,956	72,207	59,433	70,930	105,980	32,553	8,169	3,582	2,183	410,755
1997	2,483	22,990	81,991	196,440	35,108	40,899	49,106	46,536	21,802	6,763	2,697	2,083	508,898
1998	2,744	5,231	7,334	41,334	33,299	63,613	57,687	81,520	120,409	39,993	5,590	3,284	462,037
1999	3,134	9,943	14,601	33,682	50,514	42,372	49,926	92,590	52,753	9,813	3,835	2,202	365,365
2000	2,254	4,478	4,239	27,652	38,061	36,885	54,498	64,913	17,220	4,584	1,918	1,678	258,382
2001	2,054	4,001	5,833	4,701	5,896	25,052	32,049	34,400	3,736	1,733	1,199	992	121,645
Maximum	21,842	109,121	96,984	196,440	160,086	118,063	84,961	130,602	163,302	77,747	17,763	8,503	660,027
Minimum	489	1,851	1,879	2,488	3,964	5,455	12,528	13,159	3,736	1,053	306	336	56,094
Average	3,316	12,120	17,700	30,517	29,368	41,255	45,761	61,136	37,482	11,792	3,220	2,021	295,687
Median	2,483	4,478	7,334	14,098	16,060	30,290	47,980	60,918	24,331	5,043	1,918	1,479	258,382

Silver Creek at Camino Diversion Dam
Average Monthly Flow - Acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	2,927	5,001	6,348	11,343	14,510	30,182	27,301	100,543	74,667	14,655	3,742	2,124	293,344
1976	10,273	9,759	7,715	7,437	7,959	13,746	19,206	21,151	4,719	1,978	2,756	2,064	108,763
1977	2,263	2,328	2,353	4,315	5,074	5,989	12,825	16,330	7,828	1,201	347	415	61,268
1978	607	3,117	23,421	47,515	23,548	57,137	53,689	79,230	58,011	15,960	4,256	4,484	370,976
1979	2,745	3,419	4,202	15,864	13,504	30,430	46,592	93,153	27,193	5,672	2,717	1,651	247,141
1980	4,351	10,546	11,819	170,821	59,677	36,117	52,942	67,717	47,914	21,742	3,818	1,929	489,391
1981	1,993	3,289	6,805	7,332	15,244	24,400	41,889	33,435	7,441	2,453	1,544	1,376	147,201
1982	3,538	60,244	76,819	34,390	96,928	65,539	94,708	137,949	72,327	17,737	5,602	10,068	675,850
1983	25,508	23,716	48,489	37,895	51,672	105,397	55,663	120,333	167,529	80,897	20,039	5,899	743,034
1984	6,517	121,423	114,500	47,172	30,500	43,748	39,727	71,140	34,283	9,424	3,027	2,093	523,554
1985	3,984	22,421	12,184	10,090	12,930	21,187	61,875	43,944	12,460	2,877	2,210	3,091	209,255
1986	3,609	7,524	19,525	43,571	193,011	129,293	54,734	63,514	34,164	8,022	3,651	3,400	564,017
1987	4,525	3,255	3,844	5,295	15,186	22,562	37,385	23,695	6,342	2,556	1,857	1,689	128,192
1988	2,760	3,288	9,688	12,667	12,570	19,777	22,154	18,483	8,649	2,320	1,756	1,782	115,896
1989	1,693	8,597	7,764	6,595	11,534	86,212	72,768	51,924	26,355	4,903	2,342	3,085	283,771
1990	4,961	6,010	6,365	12,430	9,213	29,174	42,161	28,398	17,641	3,888	2,030	1,563	163,835
1991	2,087	2,338	2,643	3,061	4,673	29,538	33,371	48,670	25,544	6,032	2,636	1,914	162,506
1992	3,527	4,680	4,799	5,257	19,217	25,445	37,066	14,576	6,437	2,886	1,648	1,006	126,547
1993	2,683	3,129	10,639	33,433	23,474	81,314	75,847	100,678	56,061	15,650	6,642	3,303	412,853
1994	3,445	3,532	6,735	7,169	8,802	24,908	30,105	29,541	7,166	2,548	1,769	1,742	127,462
1995	1,533	6,959	12,814	75,450	38,121	103,537	93,768	140,387	105,053	50,607	13,988	5,681	647,898
1996	3,585	3,787	25,057	32,761	86,425	70,853	78,406	114,448	36,064	10,562	5,356	3,589	470,894
1997	3,885	25,744	95,351	246,398	43,929	45,840	51,674	48,572	24,036	8,425	4,127	3,553	601,534
1998	3,887	6,337	8,943	50,588	41,719	75,712	66,229	91,162	131,119	44,214	8,265	5,317	533,494
1999	4,448	11,756	17,268	41,419	65,304	52,526	56,475	97,514	55,525	11,818	5,741	3,706	423,501
2000	2,998	5,429	5,253	33,931	46,675	43,714	57,875	68,205	19,482	5,621	3,141	2,707	295,032
2001	2,907	5,319	7,307	5,839	7,342	28,967	35,592	36,359	4,803	2,647	2,041	1,652	140,775
Maximum	25,508	121,423	114,500	246,398	193,011	129,293	94,708	140,387	167,529	80,897	20,039	10,068	743,034
Minimum	607	2,328	2,353	3,061	4,673	5,989	12,825	14,576	4,719	1,201	347	415	61,268
Average	4,342	13,813	20,691	37,409	35,509	48,268	50,075	65,224	39,956	13,233	4,335	2,996	335,851
Median	3,527	5,429	8,943	15,864	19,217	36,117	51,674	63,514	26,355	6,032	3,027	2,124	293,344

Brush Creek at Brush Creek Reservoir
Average Monthly Flow - Acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	296	401	597	817	1,430	2,640	1,622	2,143	788	392	361	229	11,716
1976	436	444	473	449	421	279	256	187	102	61	152	57	3,316
1977	65	83	123	205	176	204	142	186	105	32	23	41	1,385
1978	5	163	814	2,697	2,013	3,293	3,443	1,457	506	303	233	287	15,215
1979	200	293	405	1,085	1,138	2,497	1,947	1,741	493	288	235	174	10,497
1980	245	389	529	4,692	10,221	2,579	941	865	400	290	210	237	21,598
1981	228	235	397	794	664	885	607	348	199	117	105	107	4,685
1982	184	971	2,593	2,199	8,881	3,888	8,636	3,128	890	564	361	329	32,623
1983	625	1,376	4,207	2,986	8,689	11,741	6,172	4,530	1,376	783	473	406	43,365
1984	464	3,667	9,603	2,875	2,021	2,002	875	696	463	328	270	234	23,500
1985	363	868	918	683	793	847	934	423	248	144	154	215	6,591
1986	216	346	693	1,236	16,477	4,865	1,340	761	386	367	217	231	27,134
1987	313	306	327	476	721	1,155	383	267	144	81	37	60	4,270
1988	96	198	439	917	266	287	350	258	161	53	44	51	3,118
1989	83	315	401	515	524	3,295	724	323	167	68	82	121	6,617
1990	234	372	165	565	722	997	347	391	250	115	74	69	4,300
1991	78	121	211	187	187	1,958	546	408	271	172	98	73	4,310
1992	144	207	198	332	1,417	787	325	186	101	66	34	30	3,829
1993	76	98	1,068	4,112	2,941	2,422	1,537	517	458	187	99	139	13,654
1994	182	278	415	347	984	492	265	285	182	87	33	47	3,595
1995	138	518	1,266	5,778	1,199	7,809	2,748	3,480	1,409	838	429	339	25,952
1996	383	391	881	3,158	4,160	2,995	1,926	1,829	972	508	324	278	17,806
1997	292	793	7,235	13,019	2,638	1,448	1,071	820	500	288	203	161	28,469
1998	240	372	506	3,998	6,424	2,771	3,855	2,874	1,735	1,072	537	410	24,794
1999	409	593	861	2,742	6,226	3,110	2,273	1,365	852	581	647	353	20,010
2000	376	449	513	1,798	5,252	2,479	1,011	1,189	562	389	283	298	14,601
2001	461	387	479	660	1,260	1,044	893	452	262	176	121	111	6,306
Maximum	625	3,667	9,603	13,019	16,477	11,741	8,636	4,530	1,735	1,072	647	410	43,365
Minimum	5	83	123	187	176	204	142	186	101	32	23	30	1,385
Average	253	542	1,345	2,197	3,253	2,547	1,673	1,152	518	309	216	188	14,195
Median	234	372	513	1,085	1,417	2,422	941	696	400	288	203	174	11,716

South Fork American River at Slab Creek Reservoir Unregulated (proposed Project 184/UARP unregulated flow)
Average Monthly Flow - Acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	10,556	13,510	15,105	22,674	31,271	63,214	58,822	237,608	194,372	42,746	13,901	12,975	716,754
1976	24,240	25,421	22,419	16,393	16,933	27,084	37,390	47,463	11,280	5,942	5,979	5,617	246,160
1977	6,087	6,462	4,510	7,886	8,597	10,223	23,729	30,591	18,898	4,513	1,589	2,415	125,500
1978	2,557	7,514	39,344	88,137	50,305	121,622	127,987	194,019	154,352	42,429	13,670	17,674	859,612
1979	11,524	11,928	11,207	37,500	29,741	69,908	109,271	222,258	72,699	18,801	8,605	7,414	610,855
1980	13,802	22,888	23,297	296,641	155,347	83,869	121,365	181,280	131,480	59,115	15,588	12,625	1,117,296
1981	8,358	10,135	14,170	15,749	30,050	45,899	85,506	81,866	23,055	9,061	3,253	5,994	333,095
1982	10,321	101,871	146,643	73,828	225,517	145,503	238,240	314,540	167,123	54,839	18,662	26,765	1,523,853
1983	58,946	57,599	107,807	83,837	133,466	250,893	138,127	302,363	391,316	183,480	44,746	24,176	1,776,755
1984	27,998	209,519	247,820	108,554	70,066	100,957	91,351	189,046	97,577	27,953	11,677	11,126	1,193,646
1985	14,188	42,799	29,068	21,574	26,273	40,538	129,072	101,207	30,331	10,334	6,132	11,539	463,056
1986	10,140	17,241	36,237	79,027	423,220	256,237	130,421	171,267	103,474	25,186	13,027	14,208	1,279,684
1987	13,062	9,300	7,579	10,332	26,724	41,264	67,034	51,186	13,362	7,418	3,336	5,359	255,956
1988	6,325	8,355	16,896	23,804	21,708	36,035	41,208	40,111	19,388	8,055	3,166	4,478	229,529
1989	4,350	16,322	13,028	12,287	21,438	171,882	154,098	118,315	64,351	15,032	9,280	11,443	611,825
1990	13,512	16,942	12,613	23,122	18,907	55,973	83,558	59,279	36,326	10,955	5,103	7,629	343,919
1991	5,714	6,566	5,186	5,649	8,133	54,528	64,974	99,605	61,899	15,248	6,899	8,329	342,730
1992	8,970	12,979	9,331	10,010	37,812	47,010	69,818	34,060	11,731	8,347	3,227	5,779	259,074
1993	6,920	8,424	23,401	76,436	56,579	168,291	162,266	238,243	141,720	40,660	16,007	13,180	952,127
1994	10,385	10,455	13,219	13,370	16,989	43,033	54,526	58,402	17,638	8,545	3,298	4,777	254,639
1995	5,181	15,033	24,775	155,440	74,960	240,337	196,737	318,273	279,155	157,907	34,408	18,983	1,521,188
1996	16,460	13,637	47,719	64,623	180,935	145,596	166,759	267,135	104,666	30,894	12,896	13,091	1,064,410
1997	11,222	48,169	195,682	500,955	96,137	107,827	128,241	163,423	76,128	20,787	10,603	9,436	1,368,610
1998	10,251	15,216	17,130	93,602	99,404	158,292	147,155	217,468	330,394	137,985	23,976	19,471	1,270,344
1999	15,532	27,991	35,259	78,973	135,836	104,766	125,249	244,139	165,366	36,845	15,791	13,527	999,274
2000	10,846	14,277	11,526	64,955	108,351	95,466	135,989	178,696	63,564	17,457	9,050	9,187	719,363
2001	9,212	12,286	13,631	12,797	17,782	54,053	70,128	97,752	15,380	9,012	3,800	5,655	321,489
Maximum	58,946	209,519	247,820	500,955	423,220	256,237	238,240	318,273	391,316	183,480	44,746	26,765	1,776,755
Minimum	2,557	6,462	4,510	5,649	8,133	10,223	23,729	30,591	11,280	4,513	1,589	2,415	125,500
Average	12,839	28,253	42,393	74,006	78,610	101,493	109,593	157,763	103,594	37,391	11,766	11,217	768,916
Median	10,385	14,277	17,130	37,500	37,812	83,869	121,365	171,267	72,699	18,801	9,280	11,126	716,754

South Fork American River at Slab Creek Reservoir Natural
Average Monthly Flow - Acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	6,993	10,705	14,260	21,918	30,377	63,714	60,341	252,516	210,188	45,622	11,910	6,183	734,729
1976	23,562	23,483	17,629	15,641	16,298	29,068	43,170	60,610	14,503	5,107	7,861	4,548	261,479
1977	4,576	4,516	4,516	8,096	8,736	11,373	29,140	38,140	25,924	3,771	1,056	1,383	141,227
1978	1,480	5,951	39,648	87,741	49,765	121,243	131,181	210,738	166,771	45,254	11,565	13,191	884,529
1979	6,545	8,213	10,455	36,526	28,734	70,382	113,583	239,996	80,913	18,356	7,339	4,834	625,876
1980	10,539	19,772	22,434	299,943	154,141	84,057	132,407	187,867	135,977	62,900	11,785	6,569	1,128,392
1981	5,462	7,361	13,402	15,138	29,593	46,764	96,338	94,913	27,843	6,222	3,338	2,995	349,370
1982	8,229	105,067	149,249	74,732	223,519	144,223	244,528	319,084	172,979	58,358	17,841	23,566	1,541,375
1983	57,064	56,857	105,807	83,065	130,977	245,748	139,093	312,221	398,054	187,037	47,848	21,897	1,785,667
1984	18,584	210,207	243,726	107,989	69,900	100,989	98,601	196,001	103,554	28,403	9,104	6,316	1,193,374
1985	11,483	42,579	24,777	20,630	25,830	42,000	139,668	115,278	36,448	8,000	4,924	7,076	478,694
1986	8,012	15,026	35,947	81,038	416,210	256,719	142,063	177,447	109,771	25,969	8,594	8,440	1,285,236
1987	9,835	7,170	7,446	10,594	26,496	42,240	79,455	64,589	16,302	5,025	2,941	2,834	274,926
1988	4,252	6,306	16,872	23,848	21,992	38,933	50,461	47,924	23,183	4,733	2,765	2,774	244,042
1989	2,858	14,914	13,877	13,330	22,331	175,643	167,060	129,060	71,571	13,463	5,160	7,069	636,335
1990	11,735	13,786	12,603	23,203	19,002	58,247	97,131	69,492	42,558	8,995	3,892	3,249	363,893
1991	3,595	4,499	5,188	5,865	8,314	56,083	70,310	113,743	71,577	15,222	5,570	3,563	363,529
1992	6,847	10,751	9,345	10,214	38,497	48,359	83,701	44,214	13,913	8,548	3,110	1,929	279,426
1993	4,815	6,371	22,943	76,139	54,903	166,648	167,092	254,036	151,259	44,682	13,504	6,379	968,770
1994	6,805	7,117	12,148	12,730	17,074	44,376	63,735	69,175	19,346	5,050	2,920	2,952	263,428
1995	3,616	14,154	25,358	154,299	74,992	239,537	199,685	327,522	295,411	161,477	36,570	12,884	1,545,506
1996	7,689	9,613	47,731	65,633	181,669	144,945	174,693	276,782	110,200	32,861	11,115	7,529	1,070,459
1997	7,640	47,449	196,192	496,062	95,381	108,670	138,744	169,052	80,335	19,656	8,356	5,927	1,373,464
1998	7,385	12,211	16,311	93,084	98,618	158,700	152,272	225,610	344,602	141,523	22,375	14,587	1,287,281
1999	10,408	23,437	33,835	78,295	134,172	104,469	129,264	262,423	173,328	37,465	14,147	8,235	1,009,478
2000	7,159	11,268	10,566	64,354	107,214	95,948	145,760	193,604	68,822	14,169	6,704	5,950	731,516
2001	7,515	9,862	12,907	12,235	17,187	57,281	79,469	113,830	15,075	5,079	3,177	3,441	337,058
Maximum	57,064	210,207	243,726	496,062	416,210	256,719	244,528	327,522	398,054	187,037	47,848	23,566	1,785,667
Minimum	1,480	4,499	4,516	5,865	8,314	11,373	29,140	38,140	13,913	3,771	1,056	1,383	141,227
Average	9,803	26,246	41,673	73,790	77,849	102,087	117,368	169,106	110,385	37,517	10,573	7,270	783,669
Median	7,385	11,268	16,872	36,526	38,497	84,057	129,264	177,447	80,335	18,356	7,861	6,183	731,516

South Fork American River at Chili Bar Reservoir Unregulated (proposed Project 184/UARP unregulated flow)
Average Monthly Flow - Acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	12,427	16,043	18,878	27,830	40,300	79,885	69,062	251,138	199,348	45,219	16,178	14,422	790,730
1976	26,994	28,222	25,403	19,228	19,589	28,845	39,009	48,641	11,923	6,327	6,938	5,980	267,099
1977	6,498	6,989	5,289	9,177	9,710	11,511	24,626	31,763	19,563	4,714	1,732	2,674	134,245
1978	2,592	8,541	44,486	105,166	63,018	142,414	149,728	203,218	157,548	44,345	15,139	19,488	955,683
1979	12,787	13,781	13,763	44,353	36,927	85,677	121,563	233,250	75,809	20,621	10,090	8,514	677,136
1980	15,349	25,342	26,640	326,267	219,882	100,152	127,308	186,739	134,004	60,946	16,916	14,122	1,253,668
1981	9,800	11,619	16,675	20,760	34,240	51,489	89,338	84,063	24,310	9,802	3,914	6,668	362,679
1982	11,486	108,003	163,012	87,709	281,592	170,051	292,770	334,288	172,743	58,400	20,944	28,842	1,729,840
1983	62,895	66,285	134,368	102,691	188,330	325,029	177,101	330,968	400,004	188,422	47,734	26,739	2,050,566
1984	30,926	232,675	308,457	126,707	82,829	113,598	96,875	193,444	100,502	30,027	13,381	12,604	1,342,024
1985	16,483	48,283	34,863	25,884	31,278	45,889	134,969	103,877	31,898	11,246	7,106	12,894	504,672
1986	11,504	19,428	40,613	86,831	527,257	286,952	138,883	176,069	105,910	27,502	14,398	15,665	1,451,013
1987	15,035	11,229	9,643	13,336	31,279	48,559	69,454	52,874	14,272	7,930	3,568	5,740	282,919
1988	6,928	9,604	19,670	29,594	23,385	37,848	43,415	41,739	20,402	8,387	3,443	4,801	249,215
1989	4,872	18,309	15,560	15,541	24,746	192,690	158,670	120,356	65,405	15,458	9,796	12,204	653,605
1990	14,991	19,288	13,652	26,690	23,468	62,266	85,746	61,750	37,903	11,683	5,568	8,062	371,068
1991	6,208	7,327	6,519	6,832	9,313	66,888	68,423	102,183	63,610	16,335	7,517	8,790	369,946
1992	9,877	14,287	10,581	12,109	46,761	51,982	71,872	35,233	12,371	8,766	3,442	5,967	283,248
1993	7,399	9,044	30,144	102,400	75,149	183,582	171,974	241,507	144,611	41,839	16,631	14,061	1,038,342
1994	11,534	12,210	15,838	15,562	23,199	46,138	56,197	60,201	18,788	9,092	3,504	5,074	277,336
1995	6,055	18,305	32,768	191,921	82,530	289,647	214,089	340,247	288,051	163,198	37,118	21,121	1,685,050
1996	18,880	16,108	53,281	84,563	207,201	164,504	178,921	278,685	110,804	34,101	14,940	14,849	1,176,836
1997	13,068	53,178	241,364	583,159	112,793	116,970	135,001	168,603	79,284	22,605	11,888	10,452	1,548,366
1998	11,767	17,562	20,325	118,844	139,963	175,788	171,499	235,613	341,349	144,753	27,369	22,062	1,426,894
1999	18,117	31,732	40,694	96,284	175,145	124,401	139,600	252,757	170,744	40,515	19,875	15,755	1,125,621
2000	13,219	17,112	14,767	76,310	141,515	111,120	142,373	186,203	67,113	19,915	10,838	11,070	811,554
2001	12,120	14,730	16,653	16,967	25,736	60,644	75,768	100,609	17,034	10,125	4,565	6,357	361,307
Maximum	62,895	232,675	308,457	583,159	527,257	325,029	292,770	340,247	400,004	188,422	47,734	28,842	2,050,566
Minimum	2,592	6,989	5,289	6,832	9,313	11,511	24,626	31,763	11,923	4,714	1,732	2,674	134,245
Average	14,438	31,675	50,885	87,878	99,153	117,575	120,157	165,038	106,863	39,344	13,131	12,407	858,543
Median	12,120	17,112	20,325	44,353	46,761	100,152	127,308	176,069	75,809	20,621	10,838	12,204	790,730

South Fork American River at Chili Bar Reservoir Natural
Average Monthly Flow - Acre-feet

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	8,865	13,239	18,033	27,074	39,405	80,385	70,581	266,046	215,165	48,095	14,186	7,631	808,705
1976	26,316	26,284	20,613	18,476	18,954	30,828	44,789	61,788	15,146	5,492	8,820	4,911	282,418
1977	4,986	5,043	5,295	9,388	9,849	12,661	30,037	39,312	26,589	3,973	1,198	1,642	149,972
1978	1,515	6,978	44,789	104,769	62,479	142,035	152,921	219,937	169,967	47,170	13,034	15,005	980,600
1979	7,809	10,066	13,011	43,380	35,919	86,151	125,875	250,989	84,023	20,177	8,825	5,933	692,157
1980	12,086	22,226	25,777	329,570	218,676	100,341	138,350	193,327	138,501	64,730	13,113	8,067	1,264,764
1981	6,904	8,844	15,908	20,149	33,784	52,354	100,170	97,110	29,098	6,964	4,000	3,669	378,954
1982	9,394	111,198	165,619	88,614	279,595	168,771	299,058	338,832	178,598	61,919	20,123	25,642	1,747,362
1983	61,013	65,543	132,369	101,920	185,841	319,884	178,067	340,826	406,742	191,979	50,836	24,460	2,059,478
1984	21,512	233,363	304,363	126,142	82,663	113,630	104,125	200,398	106,478	30,477	10,809	7,794	1,341,753
1985	13,777	48,063	30,573	24,940	30,836	47,351	145,565	117,948	38,015	8,912	5,898	8,432	520,310
1986	9,376	17,212	40,323	88,843	520,247	287,434	150,525	182,250	112,207	28,285	9,965	9,897	1,456,565
1987	11,808	9,099	9,510	13,598	31,050	49,535	81,875	66,276	17,211	5,538	3,174	3,215	301,889
1988	4,855	7,555	19,646	29,637	23,669	40,746	52,668	49,552	24,196	5,064	3,042	3,097	263,728
1989	3,381	16,901	16,409	16,584	25,639	196,450	171,632	131,100	72,625	13,889	5,676	7,830	678,115
1990	13,214	16,132	13,642	26,771	23,563	64,539	99,319	71,963	44,136	9,723	4,356	3,683	391,042
1991	4,090	5,261	6,521	7,048	9,493	68,443	73,759	116,321	73,288	16,309	6,188	4,024	390,745
1992	7,754	12,060	10,595	12,313	47,445	53,330	85,755	45,387	14,553	8,966	3,325	2,117	303,600
1993	5,294	6,991	29,686	102,103	73,473	181,940	176,800	257,300	154,149	45,862	14,128	7,259	1,054,985
1994	7,954	8,872	14,767	14,921	23,284	47,480	65,406	70,973	20,496	5,597	3,125	3,249	286,125
1995	4,490	17,426	33,351	190,780	82,562	288,847	217,036	349,496	304,308	166,769	39,280	15,022	1,709,367
1996	10,109	12,084	53,292	85,572	207,935	163,854	186,855	288,333	116,338	36,069	13,159	9,287	1,182,886
1997	9,486	52,458	241,874	578,266	112,038	117,813	145,504	174,232	83,491	21,475	9,640	6,944	1,553,220
1998	8,901	14,557	19,506	118,326	139,178	176,197	176,616	243,755	355,557	148,291	25,768	17,179	1,443,831
1999	12,993	27,178	39,270	95,606	173,481	124,103	143,614	271,041	178,706	41,136	18,231	10,463	1,135,824
2000	9,532	14,103	13,807	75,709	140,378	111,602	152,144	201,111	72,371	16,626	8,492	7,832	823,707
2001	10,422	12,306	15,929	16,405	25,141	63,871	85,108	116,687	16,729	6,191	3,942	4,143	376,875
Maximum	61,013	233,363	304,363	578,266	520,247	319,884	299,058	349,496	406,742	191,979	50,836	25,642	2,059,478
Minimum	1,515	5,043	5,295	7,048	9,493	12,661	30,037	39,312	14,553	3,973	1,198	1,642	149,972
Average	11,401	29,668	50,166	87,663	98,392	118,169	127,932	176,381	113,655	39,470	11,938	8,460	873,295
Median	9,376	14,103	19,646	43,380	47,445	100,341	138,350	182,250	83,491	20,177	8,825	7,631	808,705

APPENDIX C

COMPUTATION OF SIMULATED DATA INFLOW TO JUNCTION, CAMINO AND BRUSH CREEK RESERVOIRS

Relationships were drawn by hand and computed. A relationship using Union Valley is assumed for the months December through June, and for other months using Pilot Creek.

The location of many of the USGS gages used to develop the relationships have been relocated throughout the historical period. The following modification was made to the recoreded data prior to computing the equations:

Pilot Creek Transformation
The gage at Pilot Creek near Georgetown (drainage area of 15.1 square miles) has been replaced by the gage at Pilot Creek above Stumpy Meadows (drainage area of 11.7 square miles). The adjustment to the recorded data prior to developing the relationship was:

$\text{Plotting Point}_{\text{Pilot Creek above Stumpy Meadows}} = \text{Plotting Point}_{\text{Pilot Creek near Georgetown}}$ times 11.7/15.1

Union Valley Transformation
The gage at Silver Creek at Union Valley (drainage area of 83 square miles) has been replaced the computed inflow to Union Valley (drainage area of 83.9 square miles). The adjustment to the reported data prior to developing the relationship was:

$\text{Plotting Point}_{\text{Inflow to Union Valley}} = \text{Plotting Point}_{\text{Silver Creek at Union Valley}}$ times 83.9/83

Adjusted Silver Creek near Placerville Transformation
The original drainage area for the adjusted Silver Creek near Placerville in 1957 was:

Adjusted Silver Creek near Placerville	=	Silver Creek near Placerville (177 square miles) - South Fork Silver Creek near Ice House (27.3 square miles) - Silver Creek at Union Valley (83 square miles)
	=	66.7 square miles

The current drainage area for the accretions to Junction and Camino is:

Accretions to Junction and Camino	=	Silver Creek below Camino Diversion Dam (171 square miles) Inflow to Ice House (27.5 square miles) - Inflow to Union Valley (83.9 square miles)
	=	59.6 square miles

The adjustment to the reported data prior to developing the relationship was:
$\text{Plotting Point}_{\text{Junction-Camino}} = \text{Plotting Point}_{\text{Adj Silver Creek near Placerville}}$ times 59.6/66.7

Relationships Applied
$JC_{Oct} = MIN\,(2.37*Pilot,\ Pilot*0.462+18)$
$JC_{Nov} = MAX\,(0.104*Pilot+18,\ 0.395*Pilot+11)$
$JC_{Dec} = 4.729*UV76$
$JC_{Jan} = MAX\,(4.85*UV,\ 8.517*UV-458)$

JC_{Feb} =MIN (5.197*UV, 3.492*UV+126)
JC_{Mar} =4.911*UV
JC_{Apr} =MIN (4.292*UV, 1.773*UV+231)
JC_{May} =MIN (3.929*UV+25, 2.557*UV+68)
JC_{Jun} =MIN (7.795*UV, 2.154*UV+67)
JC_{Jul} =MIN (Pilot*0.325+17, Pilot*0.083+67)
JC_{Aug} =MIN (1.327*Pilot+14, Pilot*0.396+23)
JC_{Sep} =MIN (4.976*Pilot-13, Pilot*0.479+19)

Where:

JC is the combined accretions for Silver Creek at Junction Reservoir and Silver Creek at Camino Reservoir (excluding the flow above Union Valley and Ice House Reservoir and diversions from Brush Creek Reservoir)
Pilot is the observed daily flow for the Pilot Creek above Stumpy Meadows
UV is the computed unimpaired inflow to Union Valley Reservoir

Exceptions to the above described procedure occurred. Based on water year type and the available USGS record, the application of the monthly relationship may vary. For example, the 1995 spring melt extended into the month of August and the monthly volumes computed using the above procedures appeared too low as compared to the accretions computed from the USGS record. Therefore these equations were not used and the daily flow for these two months was decayed at a rate (0.998 in August and 0.97 in September) to compute monthly volumes comparable to the accretions computed from the USGS record.

Computation of Simulated Data
Inflow to Junction, Camino and Brush Creek Reservoirs

Brush Creek Daily Flow Equations

The Brush Creek unimpaired daily flow computed by using data reported in the USGS water supply records was plotted against the USGS daily flow record at Forest Creek near Wilseyville for the period water year 1986-2001. The daily data were plotted by month and relationships drawn by hand (eye-fitted) and computed.

$Brush_{Oct} = MIN\ (4.091*Forest, Forest*11.9-8)$
$Brush_{Nov} = 4.286*Forest$
$Brush_{Dec} = MIN\ (5.4054*Forest,\ 5.282*Forest+193.66)$
$Brush_{Jan} = MIN\ (6*Forest,\ 3.261*Forest+14)$
$Brush_{Feb} = MAX\ (MIN\ (4*Forest, 3.111*Forest+18.89), 8.621*Forest-474)$
$Brush_{Mar} = MIN\ (3.125*Forest-12.5, 2.917*Forest)$
$Brush_{Apr} = MAX\ (1.815*Forest+1.21, 4.237*Forest-136)$
$Brush_{May} = MIN\ (MAX\ (3.289*Forest-23.03, 1.875*Forest+3.13), 1.5*Forest+38)$
$Brush_{Jun} = MIN\ (4.211*Forest-4.21, 1.25*Forest+44, 2.225*Forest+4)$
$Brush_{Jul} = MAX\ (3.08*Forest, 5.52*Forest-47)$
$Brush_{Aug} = MAX\ (0, MIN\ (3.651*Forest+2, 8.4*Forest-5))$
$Brush_{Sep} = MAX\ (0, MIN\ (2.857*Forest+5, 4.167*Forest349+1, 9.33*Forest-2.67))$

Where:

Brush is the estimated daily flow for Brush Creek to Brush Creek Reservoir in cfs
Forest is the observed daily flow at Forest Creek near Wilseyville in cfs

Modifications were made to the daily totals based on the relationship between the annual simulated volumes and the volumes at Pilot Creek, Ice House Reservoir and the computed accretions to Chili Bar Reservoir computed by subtracting the SFAR gage at Placerville minus the SFAR gage at Camino. Modifications were made as needed to reduce scatter in the scatter diagrams and straighten out the double mass diagram.

Junction-Camino Daily Flow Equations

The Junction-Camino unimpaired daily flow relationships were computed from daily USGS record for the water year period 1951 through 1957. The following data were plotted:

Y-axis:

Silver Creek at Placerville Excluding flow above Union Valley Reservoir and Ice House Reservoir (Adjusted Silver Creek near Placerville)	=	Silver Creek near Placerville minus South Fork Silver Creek near Ice House minus Silver Creek at Union Valley

X-axis:

Plot 1) Pilot Creek near Georgetown, and
Plot 2) Silver Creek at Union Valley

APPENDIX D

COMPUTATION OF SIMULATED DATA ACCRETIONS

Computation of Simulated Data
Accretions

Procedures for computing accretions have been divided into three categories:

- Unregulated daily accretions: Accretions for those points not impacted by upstream diversions or storage. Data for these points will not be impacted by re-operation of the UARP. Procedures to compute the unregulated daily accretions are summarized in Table 4-1.

- Regulated daily accretions: Accretions for those points impacted by upstream diversions or storage. Data for these points will be impacted by re-operation of the UARP. Accretions will be computed for the unregulated portion of the drainage area and added to the upstream regulated data. Procedures to compute the regulated daily accretions are summarized in Table 4-2.

Table 4-1 Unregulated Daily Nodes

Node Identification	Description	Drainage Area Square Miles [1/]	Estimated Average Annual Precipitation (inches)	Coefficients to Compute Accretions
Rubicon 4	Rubicon River at Rubicon Springs	4.57	51.49	• Rubicon 4 accretion estimate = Inflow to Rubicon Reservoir times .1383 • To compute the TOTAL impaired flow at Rubicon 4, add the "Rubicon 4 accretion estimate" to the spill and release from Rubicon Reservoir • To compute the TOTAL unimpaired flow at Rubicon 4, add the "Rubicon 4 accretion estimate" to inflow to Rubicon Reservoir
Rubicon 5	Rubicon River below Miller Creek	6.38	51.92	• Rubicon 5 accretion estimate = Inflow to Rubicon Reservoir times .226 • To compute the TOTAL impaired flow at Rubicon 5, add the "Rubicon 4 accretion estimate" plus the "Rubicon 5 accretion estimate" to the spill and release from Rubicon Reservoir • To compute the TOTAL unimpaired flow at Rubicon 5, add the "Rubicon 4 accretion estimate" plus the "Rubicon 5 accretion estimate" to inflow to Rubicon Reservoir
Rubicon 6	Rubicon River below Little Rubicon River	4.03	52.8	• Rubicon 6 accretion estimate = (Inflow to Rubicon Reservoir plus Inflow to Buck Island Reservoir) times 1.429 – Inflow to Rubicon Reservoir – Inflow to Buck Island Reservoir - "Rubicon 4 accretion estimate" - "Rubicon 5 accretion estimate" • To compute the TOTAL impaired flow at Rubicon 6, add the "Rubicon 4 accretion estimate" plus the "Rubicon 5 accretion estimate" to the spill and release from Rubicon Reservoir and Buck Island Reservoir • To compute the TOTAL unimpaired flow at Rubicon 6, add the "Rubicon 4 accretion estimate" plus the "Rubicon 5 accretion estimate" to inflow to Rubicon Reservoir and the inflow to Buck Island Reservoir

Table 4-1 Unregulated Daily Nodes

Node Identification	Description	Drainage Area Square Miles [1/]	Estimated Average Annual Precipitation (inches)	Coefficients to Compute Accretions
Rockbound 1	Rockbound Lake release to Buck Island Reservoir	4.19	51.5[2/]	• Rockbound 1 accretion estimate = Inflow to Buck Island Reservoir times .72 • To compute the TOTAL impaired flow at Rockbound 1, add the "Rockbound 1 accretion estimate" to the diversion from the Rubicon Reservoir • The accretion estimated is the TOTAL unimpaired flow at Rockbound 1
Loon 4	Gerle Creek below Jerrett Creek	5.17	47.23[2/]	• Loon 4 accretion estimate = Accretions to Gerle Reservoir[4/] times .221 • To compute the TOTAL impaired flow at Loon 4, add the "Loon 4 accretion estimate" to the spill and release from Loon Lake Reservoir • To compute the TOTAL unimpaired flow at Loon 4, add the "Loon 4 accretion estimate" to the inflow to Loon Lake Reservoir
Loon 5	Gerle Creek below Barts and Dellar Creek	7.22	49.64[2/]	• Loon 5 accretion estimate = Accretions to Gerle Reservoir times .325 • To compute the TOTAL impaired flow at Loon 5, add the "Loon 5 accretion estimate" plus the "Loon 4 accretion estimate" to the spill and release from Loon Lake Reservoir • To compute the TOTAL unimpaired flow at Loon 5, add the "Loon 5 accretion estimate" plus the "Loon 4 accretion estimate" to the inflow to Loon Lake Reservoir
Loon 6	Gerle Creek Inflow Above Rocky Basin Creek	0.9	48.64[2/]	• Loon 6 accretion estimate = Accretions to Gerle Reservoir times .039 • To compute the TOTAL impaired flow at Loon 6, add the "Loon 6 accretion estimate" plus the "Loon 5 accretion estimate" plus the "Loon 4 accretion estimate" to the spill and release from Loon Lake Reservoir • To compute the TOTAL unimpaired flow at Loon 6, add the "Loon 6 accretion estimate" plus the "Loon 5 accretion estimate" plus the "Loon 4 accretion estimate" to the inflow to Loon Lake Reservoir

Table 4-1 Unregulated Daily Nodes				
Node Identification	**Description**	**Drainage Area Square Miles** [1/]	**Estimated Average Annual Precipitation (inches)**	**Coefficients to Compute Accretions**
Loon 7	Gerle Creek below Rocky Basin Creek	4.79	47.43	• Loon 7 accretion estimate = Accretions to Gerle Reservoir times .206 • To compute the TOTAL impaired flow at Loon 7, add the "Loon 7 accretion estimate" plus the "Loon 6 accretion estimate" plus the "Loon 5 accretion estimate" plus the "Loon 4 accretion estimate" to the spill and release from Loon Lake Reservoir • To compute the TOTAL unimpaired flow at Loon 7, add the "Loon 7 accretion estimate" plus the "Loon 6 accretion estimate" plus the "Loon 5 accretion estimate" plus the "Loon 4 accretion estimate" to the inflow to Loon Lake Reservoir
Loon 8	Gerle Creek Inflow to Gerle Reservoir	2.0	[3/]	• Loon 8 accretion estimate = Accretions to Gerle Reservoir times .069 • To compute the TOTAL impaired flow at Loon 8, add the "Loon 8 accretion estimate" plus the "Loon 7 accretion estimate" plus the "Loon 6 accretion estimate" plus the "Loon 5 accretion estimate" plus the "Loon 4 accretion estimate" to the spill and release from Loon Lake Reservoir • To compute the TOTAL unimpaired flow at Loon 8, add the "Loon 8 accretion estimate" plus the "Loon 7 accretion estimate" plus the "Loon 6 accretion estimate" plus the "Loon 5 accretion estimate" plus the "Loon 4 accretion estimate" to the inflow to Loon Lake Reservoir
Gerle 4	Gerle Creek above Confluence with SF Rubicon River	1.01	[3/]	This drainage area of this sub-basin is lower than the remainder of the basin. Based on drainage area versus elevation prepared by Vestra, the daily accretions would be used to distribute this daily flow. • Gerle 4 accretion estimate = Gerle 5 accretion estimate times .123 • To compute the TOTAL impaired flow at Gerle 4, the "Gerle 4 accretion estimate" to the spill and release from Gerle Reservoir and Robbs Diversion Dam • To compute the TOTAL unimpaired flow at Gerle 4, add the "Gerle 4 accretion estimate" to the inflow at Gerle Reservoir plus the inflow to Robbs Diversion Dam

Table 4-1 Unregulated Daily Nodes

Node Identification	Description	Drainage Area Square Miles [1/]	Estimated Average Annual Precipitation (inches)	Coefficients to Compute Accretions
Gerle 5	SF Rubicon above Confluence with Rubicon River	8.2	[3/]	This drainage area of this sub-basin is lower than the remainder of the basin. Based on drainage area versus elevation prepared by Vestra, the daily accretions would be used to distribute this daily flow. • Gerle 5 accretion estimate = Accretions to Junction Reservoir times .38 • To compute the TOTAL impaired flow at Gerle 5, add the "Gerle 5 accretion estimate" plus the "Gerle 4 accretion estimate" to the spill and release from Gerle Reservoir and Robbs Diversion Dam • To compute the TOTAL unimpaired flow at Gerle 5, add the "Gerle 5 accretion estimate" plus the "Gerle 4 accretion estimate" to the inflow at Gerle Reservoir plus the inflow to Robbs Diversion Dam
Gerle Other	SF Rubicon below Gerle Creek (The location is at the USGS gage. The data for this site appear on the CD, file Accretions, page Total Flow page. These data are not included on the UnregDailyAccretions page.)	47.7	[3/]	• Estimated computed when unimpaired flow to Loon Lake, Gerle Reservoir and Robbs Diversion Dam was computed. • Accretions estimated by taking total unimpaired flow at location minus the inflow to Gerle Reservoir minus the inflow to Robbs Diversion Dam. • To compute the TOTAL regulated flow at this location, add the accretion estimate to the release and spill below both Gerle Reservoir and Robbs Diversion Dam • To compute the TOTAL unregulated flow at this location, add the accretion estimate to the inflow to Gerle Reservoir and Robbs Diversion Dam
Ice House 4	SF Silver Creek below Peavine Creek	3.49	[3/]	• Ice House 4 accretion estimate = Accretions to Junction Reservoir[5/] times .111 • To compute the TOTAL impaired flow at Ice House 4, add the "Ice House 4 accretion estimate" to the spill and release from Ice House Reservoir • To compute the TOTAL unimpaired flow at Ice House 4, add the "Ice House 4 accretion estimate" to the inflow to Ice House Reservoir

Table 4-1 Unregulated Daily Nodes

Node Identification	Description	Drainage Area Square Miles [1/]	Estimated Average Annual Precipitation (inches)	Coefficients to Compute Accretions
Ice House 5	SF Silver Creek below Windmiller Ravine	5.8	[3/]	• Ice House 5 accretion estimate = Accretions to Junction Reservoir times .185 • To compute the TOTAL impaired flow at Ice House 5, add the "Ice House 5 accretion estimate" plus the "Ice House 4 accretion estimate" to the spill and release from Ice House Reservoir • To compute the TOTAL unimpaired flow at Ice House 5, add the "Ice House 5 accretion estimate" plus the "Ice House 4 accretion estimate" to the inflow to Ice House Reservoir
Ice House 6	SF Silver Creek below Big Hill Canyon	6.2	[3/]	• Ice House 6 accretion estimate = Accretions to Junction Reservoir times .197 • To compute the TOTAL impaired flow at Ice House 6, add the "Ice House 6 accretion estimate" plus the "Ice House 5 accretion estimate" plus the "Ice House 4 accretion estimate" to the spill and release from Ice House Reservoir • To compute the TOTAL unimpaired flow at Ice House 6, add the "Ice House 6 accretion estimate" plus the "Ice House 5 accretion estimate" plus the "Ice House 4 accretion estimate" to the inflow to Ice House Reservoir
Ice House 7	SF Silver Creek at Junction Reservoir	2.2	[3/]	• Ice House 7 accretion estimate = Accretions to Junction Reservoir times .07 • To compute the TOTAL impaired flow at Ice House 7, add the "Ice House 7 accretion estimate" plus the "Ice House 6 accretion estimate" plus the "Ice House 5 accretion estimate" plus the "Ice House 4 accretion estimate" to the spill and release from Ice House Reservoir • To compute the TOTAL unimpaired flow at Ice House 7, add the "Ice House 7 accretion estimate" plus the "Ice House 6 accretion estimate" plus the "Ice House 5 accretion estimate" plus the "Ice House 4 accretion estimate" to the inflow to Ice House Reservoir

Table 4-1 Unregulated Daily Nodes

Node Identification	Description	Drainage Area Square Miles [1/]	Estimated Average Annual Precipitation (inches)	Coefficients to Compute Accretions
Junction 4	Silver Creek below Grey Horse Creek	3.6	[3/]	• Junction 4 accretion estimate = Accretions to Camino Reservoir[6/] times .147 • To compute the TOTAL impaired flow at Junction 4, add the "Junction 4 accretion estimate" to the spill and release from Junction Reservoir • To compute the TOTAL unimpaired flow at Junction 4, add the "Junction 4 accretion estimate" to the inflow to Junction Reservoir
Junction 5	Silver Creek below Onion Creek	14	[3/]	• Junction 5 accretion estimate = Accretions to Camino Reservoir times .571 • To compute the TOTAL impaired flow at Junction 5, add the "Junction 5 accretion estimate" plus the "Junction 4 accretion estimate" to the spill and release from Junction Reservoir • To compute the TOTAL unimpaired flow at Junction 5, add the "Junction 5 accretion estimate" plus the "Junction 4 accretion estimate" to the inflow to Junction Reservoir
Junction 6	Silver Creek below Sugar Pine Creek	3.2	[3/]	• Junction 6 accretion estimate = Accretions to Camino Reservoir times .131 • To compute the TOTAL impaired flow at Junction 6, add the "Junction 6 accretion estimate" plus the "Junction 5 accretion estimate" plus the "Junction 4 accretion estimate" to the spill and release from Junction Reservoir • To compute the TOTAL unimpaired flow at Junction 6, add the "Junction 6 accretion estimate" plus the "Junction 5 accretion estimate" plus the "Junction 4 accretion estimate" to the inflow to Junction Reservoir

Table 4-1 Unregulated Daily Nodes

Node Identification	Description	Drainage Area Square Miles [1/]	Estimated Average Annual Precipitation (inches)	Coefficients to Compute Accretions
Junction 7	Silver Creek at Camino Reservoir	0.4	[3/]	• Junction 7 accretion estimate = Accretions to Camino Reservoir times .016 • To compute the TOTAL impaired flow at Junction 7, add the "Junction 7 accretion estimate" plus the "Junction 6 accretion estimate" plus the "Junction 5 accretion estimate" plus the "Junction 4 accretion estimate" to the spill and release from Junction Reservoir • To compute the TOTAL unimpaired flow at Junction 7, add the "Junction 7 accretion estimate" plus the "Junction 6 accretion estimate" plus the "Junction 5 accretion estimate" plus the "Junction 4 accretion estimate" to the inflow to Junction Reservoir
Camino 3	Silver Creek below Round Tent Canyon	3.1	[3/]	• Camino 3 accretion estimate = (Accretions to Slab Creek Reservoir minus Brush Cree Reservoir Inflow)[7/] times .086 • To compute the TOTAL impaired flow at Camino 3, add the "Camino 3 accretion estimate" to the spill and release from Camino Reservoir • To compute the TOTAL unimpaired flow at Camino 3, add the "Camino 3 accretion estimate" to the inflow to Junction Reservoir
Camino 4	Silver Creek Halfway, no name creek	3.8	[3/]	• Camino 4 accretion estimate = (Accretions to Slab Creek Reservoir minus Brush Cree Reservoir Inflow) times .106 • To compute the TOTAL impaired flow at Camino 4, add the "Camino 4 accretion estimate" plus the "Camino 3 accretion estimate" to the spill and release from Camino Reservoir • To compute the TOTAL unimpaired flow at Camino 4, add the "Camino 4 accretion estimate" plus the "Camino 3 accretion estimate" to the inflow to Camino Reservoir

Table 4-1 Unregulated Daily Nodes

Node Identification	Description	Drainage Area Square Miles [1/]	Estimated Average Annual Precipitation (inches)	Coefficients to Compute Accretions
Camino 5	Mouth of Silver Creek	2.2	[3/]	• Camino 5 accretion estimate = (Accretions to Slab Creek Reservoir minus Brush Cree Reservoir Inflow) times .061 • To compute the TOTAL impaired flow at Camino 5, add the "Camino 5 accretion estimate" plus the "Camino 4 accretion estimate" plus the "Camino 3 accretion estimate" to the spill and release from Camino Reservoir • To compute the TOTAL unimpaired flow at Camino 5, add the "Camino 5 accretion estimate" plus the "Camino 4 accretion estimate" plus the "Camino 3 accretion estimate" to the inflow to Camino Reservoir
Brush 4	Brush Creek Inflow to Slab Creek Reservoir	3.3	[3/]	• Brush Creek 4 accretion estimate = Inflow to Brush Creek Reservoir times .429 • To compute the TOTAL impaired flow at Brush Creek 4, add the "Brush Creek 4 accretion estimate" to the spill and release from Brush Creek Reservoir • To compute the TOTAL unimpaired flow at Brush Creek 4, add the "Brush Creek 4 accretion estimate" to inflow to Brush Creek Reservoir
Slab 4	SF American River below Iowa Canyon Creek	8.01	[3/]	• Slab Creek 4 accretion estimate = (Accretions to Chili Bar Reservoir [8/] minus the unregulated flow at the Rock Creek gage) times .255 • To compute the TOTAL impaired flow at Slab Creek 4, add the "Slab Creek 4 accretion estimate" to the spill and release from Slab Creek Reservoir • To compute the TOTAL unimpaired flow at Slab Creek 4, add the "Slab Creek 4 accretion estimate" to the inflow to Slab Creek Reservoir

Table 4-1 Unregulated Daily Nodes

Node Identification	Description	Drainage Area Square Miles [1/]	Estimated Average Annual Precipitation (inches)	Coefficients to Compute Accretions
Slab 5	SF American River above Mosquito Road Bridge	9.5	[3/]	• Slab Creek 5 accretion estimate = (Accretions to Chili Bar Reservoir minus the unregulated flow at the Rock Creek gage) times .303 • To compute the TOTAL impaired flow at Slab Creek 5, add the "Slab Creek 5 accretion estimate" plus the "Slab Creek 4 accretion estimate" to the spill and release from Slab Creek Reservoir • To compute the TOTAL unimpaired flow at Slab Creek 5, add the "Slab Creek 5 accretion estimate" plus the "Slab Creek 4 accretion estimate" to the inflow to Slab Creek Reservoir
Slab 6	SF American River below Rock Creek	80.3	[3/]	• Slab Creek 6 accretion estimate = (Accretions to Chili Bar Reservoir minus the unregulated flow at the Rock Creek gage) times .232 plus unregulated flow at the Rock Creek Gage • To compute the TOTAL impaired flow at Slab Creek 6, add the "Slab Creek 6 accretion estimate" plus the "Slab Creek 5 accretion estimate" plus the "Slab Creek 4 accretion estimate" to the spill and release from Slab Creek Reservoir • To compute the TOTAL unimpaired flow at Slab Creek 6, add the "Slab Creek 6 accretion estimate" plus the "Slab Creek 5 accretion estimate" plus the "Slab Creek 4 accretion estimate" to the inflow to Slab Creek Reservoir
Slab 7	SF American River Above Chili Bar Reservoir	6.53	[3/]	• Slab Creek 7 accretion estimate = (Accretions to Chili Bar Reservoir minus the unregulated flow at the Rock Creek gage) times 0.2082 • To compute the TOTAL impaired flow at Slab Creek 7, add the "Slab Creek 7 accretion estimate" plus the "Slab Creek 6 accretion estimate" plus the "Slab Creek 5 accretion estimate" plus the "Slab Creek 4 accretion estimate" to the spill and release from Slab Creek Reservoir • To compute the TOTAL unimpaired flow at Slab Creek 7, add the "Slab Creek 7 accretion estimate" plus the "Slab Creek 6 accretion estimate" plus the "Slab Creek 5 accretion estimate" plus the "Slab Creek 4 accretion estimate" to the inflow to Slab Creek Reservoir

Table 4-1 Unregulated Daily Nodes

Node Identification	Description	Drainage Area Square Miles [1/]	Estimated Average Annual Precipitation (inches)	Coefficients to Compute Accretions
Chili Bar 4	SF American River below Dutch Creek	30.8	No pcp adjustment	Estimated at 42.2% of the unregulated inflow at the Rock Creek gage
Chili Bar 5	SF American River below Greenwood	32.7	No pcp adjustment	Estimated at 44.8% of the unregulated inflow at the Rock Creek gage.
Chili Bar 6	SF American River below Weber Creek	128.4	No pcp adjustment	Estimated at 175.9% of the unregulated inflow at the Rock Creek gage

[1/] Drainage area for accretions only (excludes area upstream or reservoirs) and upstream accretion flow point. With the exception of Weber Creek Reservoir only.
[2/] Precipitation for accretions area only
[3/] Precipitation not used in adjustment
[4/] Accretions to Gerle Reservoir are computed by taking the total unregulated flow at Gerle Reservoir minus the unregulated flow into Loon Lake Reservoir
[5/] Accretions to Junction Reservoir are computed by taking the total unregulated flow at Junction Reservoir minus the unregulated flow into Union Valley and Ice House reservoirs
[6/] Accretions to Camino Reservoir are computed by taking the total unregulated flow at Camino Reservoir minus the unregulated flow into Junction Reservoir
[7/] Accretions to Slab Creek Reservoir is the estimated inflow due to the drainage area below El Dorado Powerhouse. This is the estimate that will be added to the Hydrologics estimate when computing inflow to Slab Creek Reservoir (excluding flow into Brush Creek Reservoir)
[8/] Accretions to Chili Bar Reservoir are computed by taking the total unregulated flow at Chili Bar Reservoir minus the unregulated flow into Slab Creek Reservoir

Table 4-2 Unregulated Daily Nodes

Node Identification	Description	Drainage Area Square Miles	Estimated Average Annual Precipitation (inches)	Coefficients to Compute Accretions
1	Rubicon River inflow to Rubicon Reservoir (excluding reservoir)	23.1	No pcp adjustment	Estimated at 87.2% of the unregulated inflow to Rubicon Reservoir
2	Highland Creek inflow to Rockbound Reservoir	4.19	No pcp adjustment	Estimated at 72% of the unregulated inflow to Buck Island Reservoir
3	Ellis Creek Inflow to Loon Lake	1.4	No pcp adjustment	Estimated at 17.5% of the unregulated inflow to Loon Lake Reservoir
4	SF Rubicon Inflow to Robbs Peak Reservoir	15.2	No pcp adjustment	Estimated at 100% of the unregulated inflow to Robbs Peak Reservoir
5	SF Silver Creek Inflow to Ice House Reservoir	21.3	No pcp adjustment	Estimated at 72% of the unregulated inflow to Ice House Reservoir
6	Tells Creek Inflow to Union Valley Reservoir	9.22	47.72	Estimated at 10.6% of the unregulated inflow to Union Valley Reservoir
7	Big Silver Creek Inflow to Union Valley Reservoir	31.52	49.83	Estimated at 37.8% of the unregulated inflow to Union Valley Reservoir
8	Jones Fork Silver Creek Inflow to Union Valley Reservoir	25.37	49.54	Estimated at 30.3% of the unregulated inflow to Union Valley Reservoir
9	Little Silver Creek Inflow to Junction Reservoir	12.33	No pcp adjustment	Estimated at 27.4% of the unregulated inflow to Junction Reservoir
10	Slab Creek Inflow to Slab Creek	12.32	No pcp adjustment	Estimated at 34.2% of the accretions to Slab Creek Reservoir (accretions to Slab Creek Reservoir is the estimated inflow due to the drainage area below El Dorado Powerhouse and excluding inflow to Brush Creek)
11	Iowa Canyon above SF American River	7.98	No pcp adjustment	Estimated at 25.4% of the accretions to Chili Bar Reservoir excluding the computed unregulated flow at the Rock Creek gage
12	Rock Creek above SF American River	74.61	No pcp adjustment	Estimated at 5.1% of the accretions to Chili Bar Reservoir excluding the computed unregulated flow at the Rock Creek gage plus the computed unregulated flow at the Rock Creek

APPENDIX E

IHA ANALYSIS

(Provided on CD - RAW DATA on CD by Request)

APPENDIX F

DIURNAL DAILY FLUCTUATION

Diurnal Fluctuation Study

The following plots are included in this attachment:

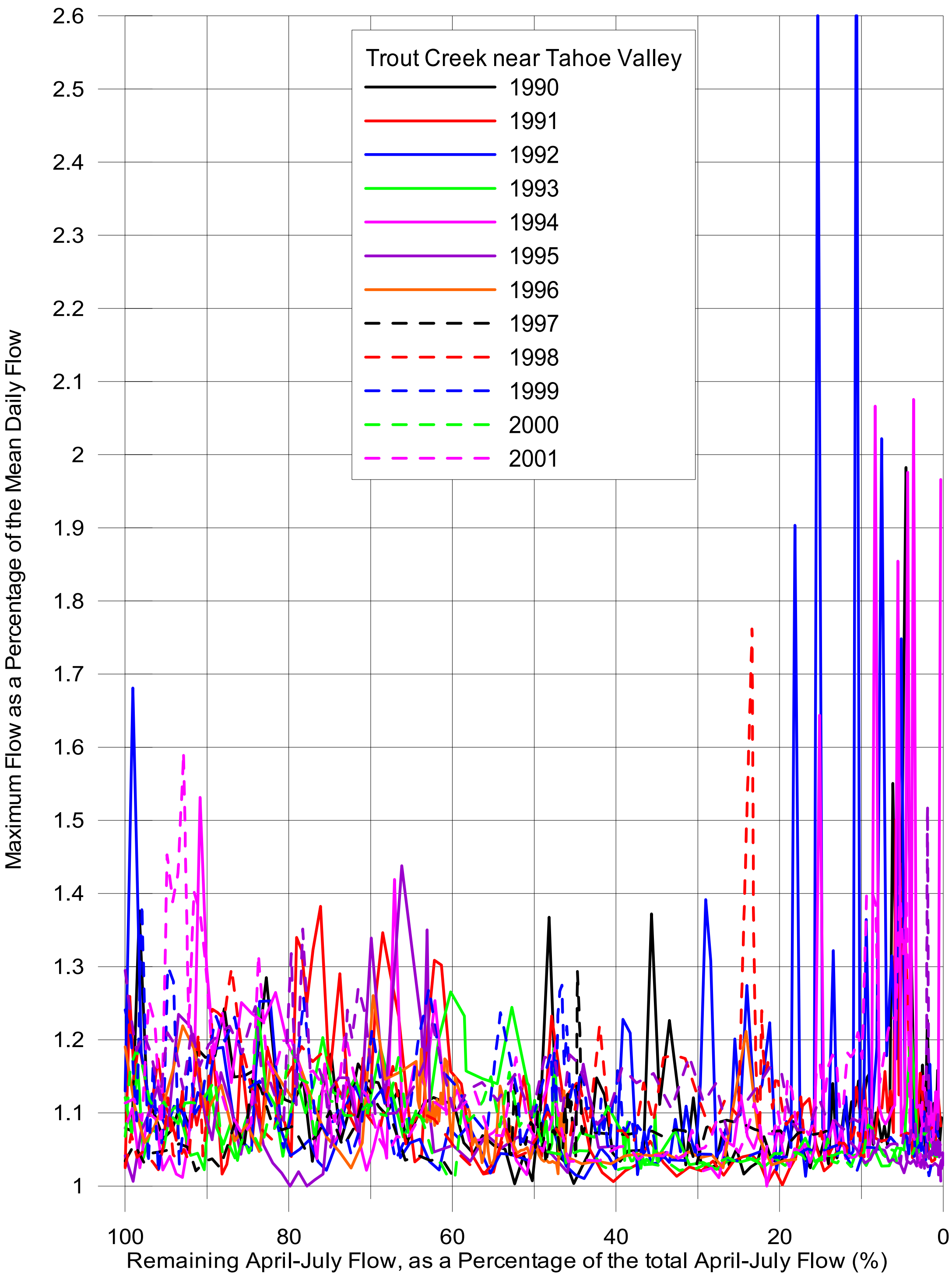

Trout Creek near Tahoe Valley
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
Maximum Flow as a Percentage of the Mean Daily Flow
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
100
80
60
40
20
0
Remaining April-July Flow, as a Percentage of the total April-July Flow (%)

Figure 1-1

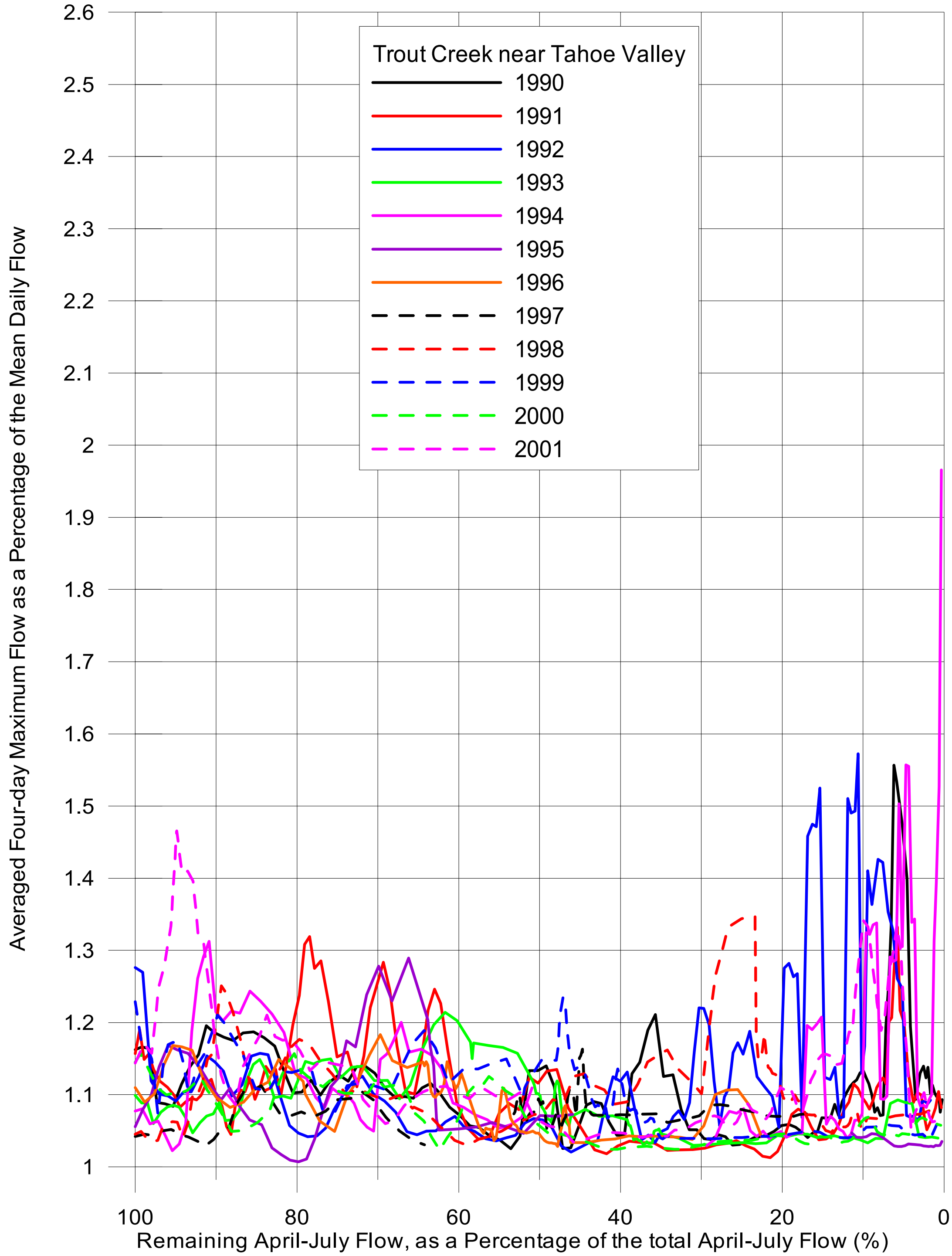

Trout Creek near Tahoe Valley
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
Averaged Four-day Maximum Flow as a Percentage of the Mean Daily Flow
Remaining April-July Flow, as a Percentage of the total April-July Flow (%)
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
100
80
60
40
20
0

Figure 1-2

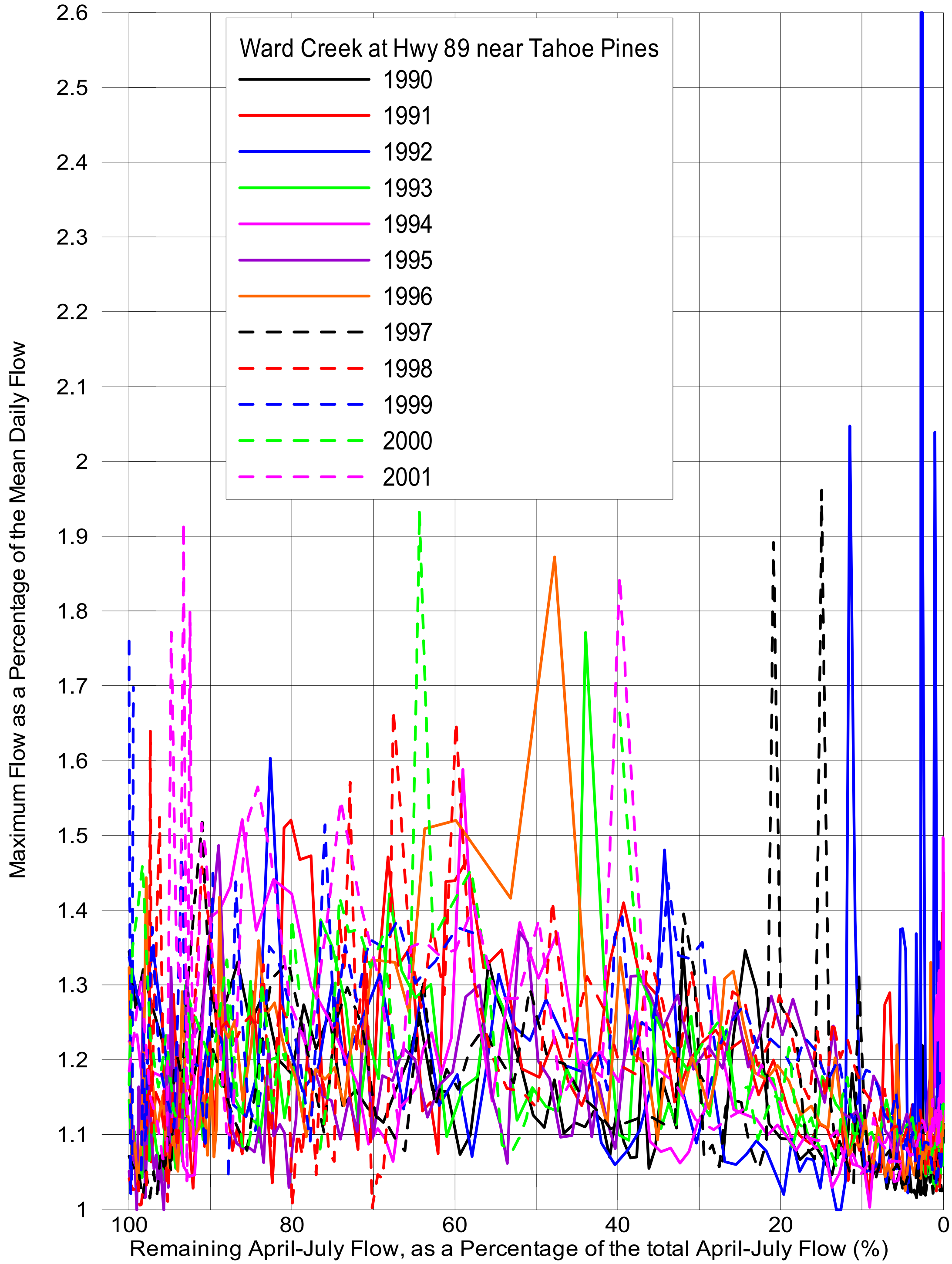
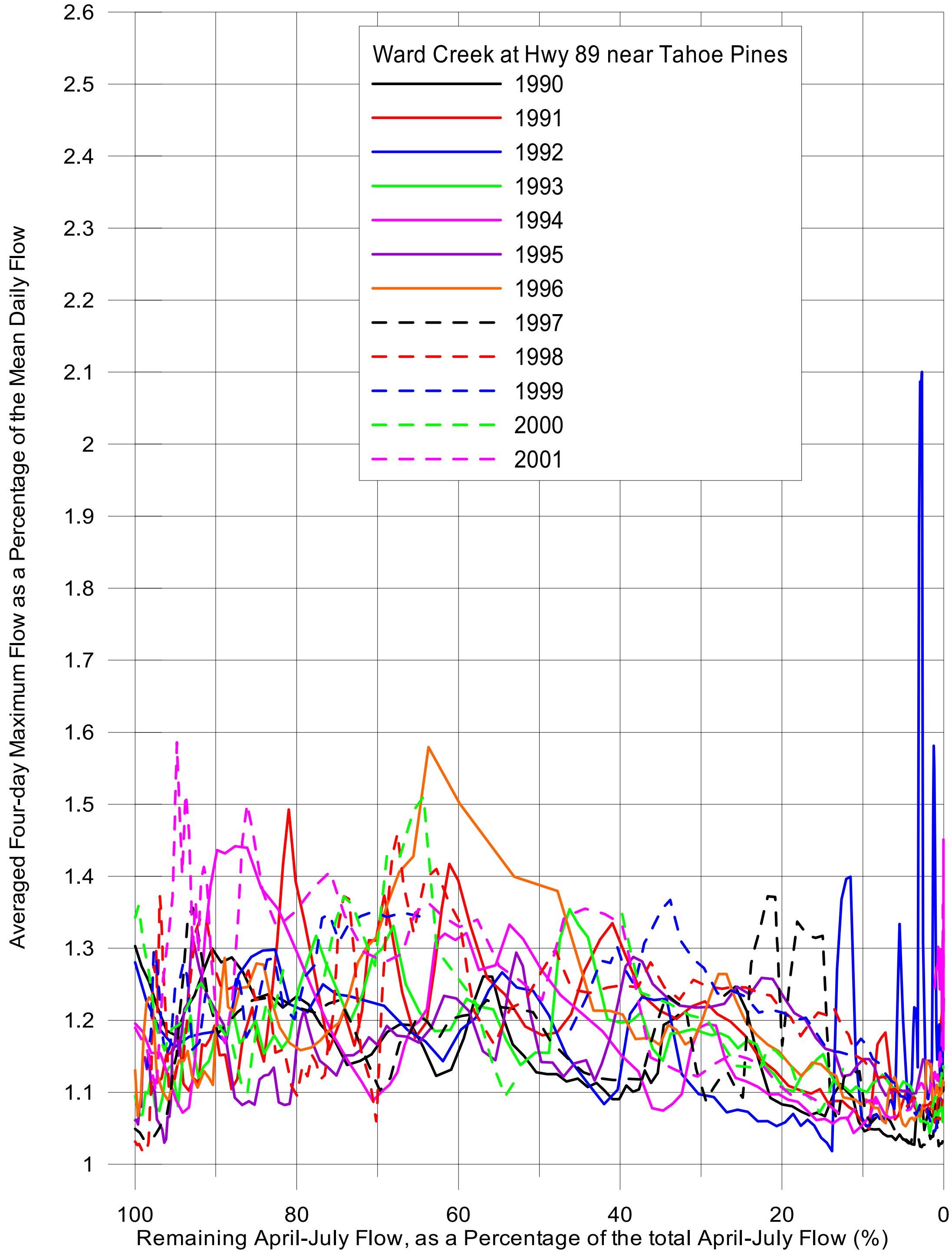

Ward Creek at Hwy 89 near Tahoe Pines
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
Maximum Flow as a Percentage of the Mean Daily Flow
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
100
80
60
40
20
0
Remaining April-July Flow, as a Percentage of the total April-July Flow (%)

Figure 1-3


Ward Creek at Hwy 89 near Tahoe Pines
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
Averaged Four-day Maximum Flow as a Percentage of the Mean Daily Flow
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
100
80
60
40
20
0
Remaining April-July Flow, as a Percentage of the total April-July Flow (%)

Figure

1-4

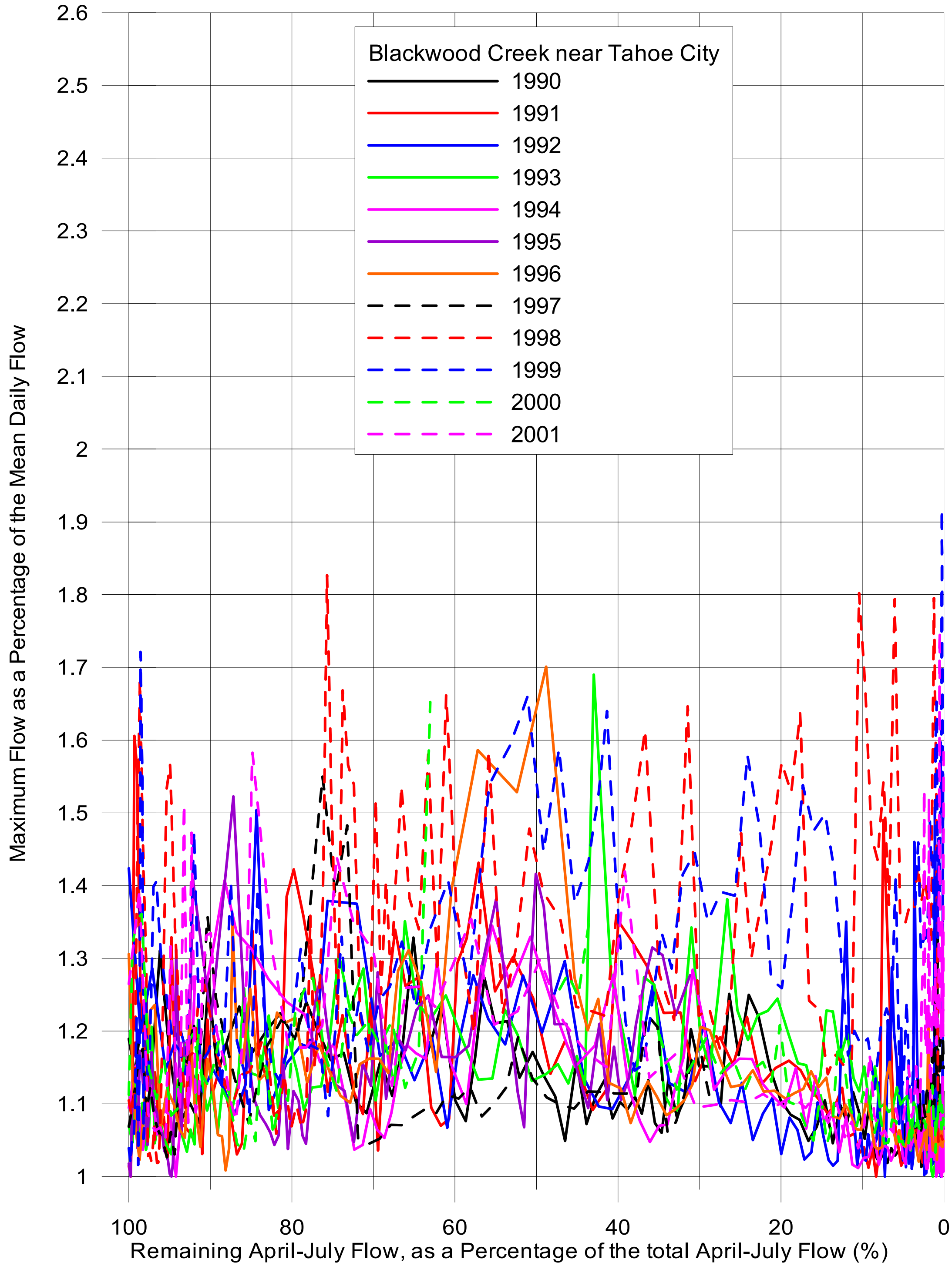
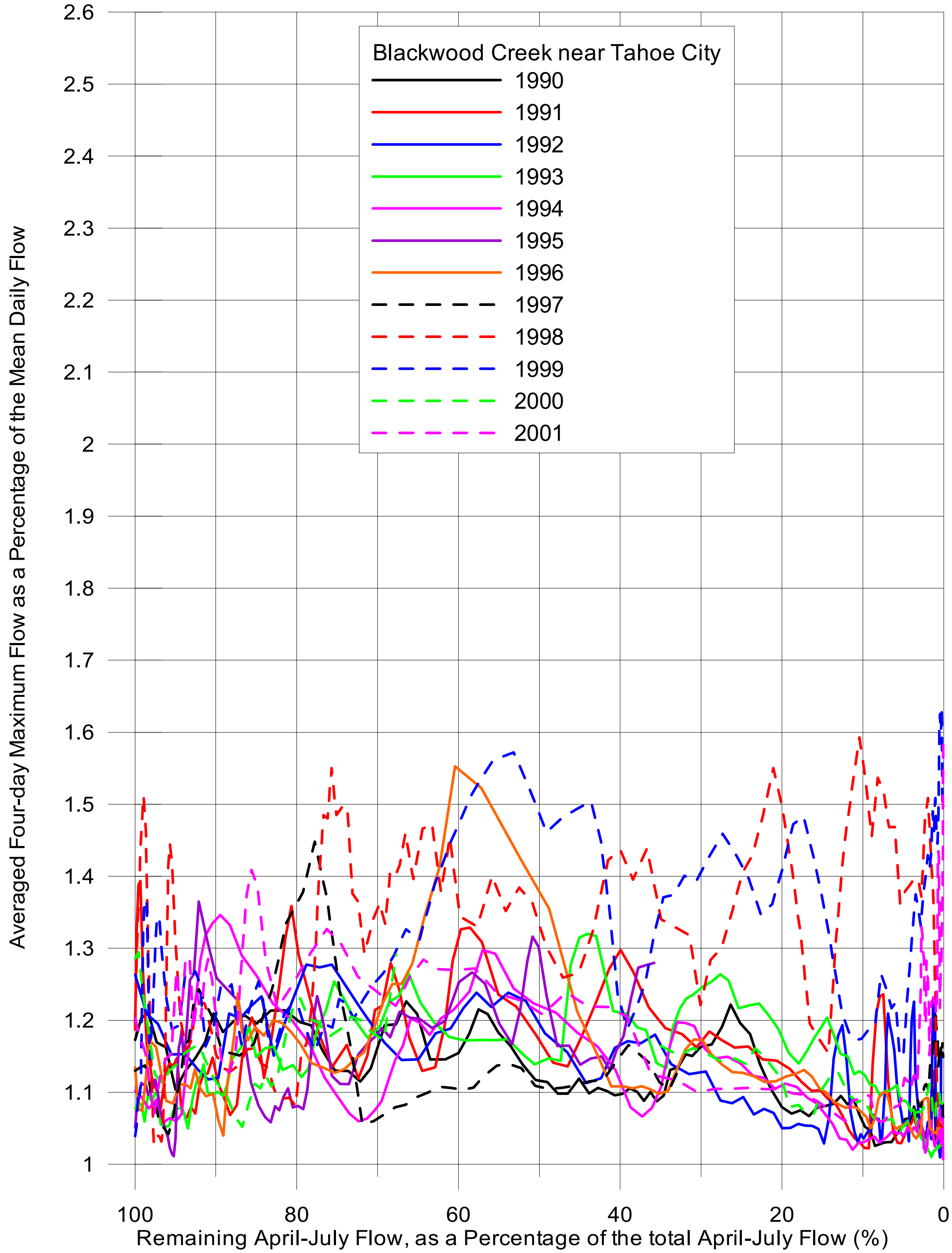

Blackwood Creek near Tahoe City
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
Maximum Flow as a Percentage of the Mean Daily Flow
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
100
80
60
40
20
0
Remaining April-July Flow, as a Percentage of the total April-July Flow (%)

Figure 1-5


Blackwood Creek near Tahoe City
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
Averaged Four-day Maximum Flow as a Percentage of the Mean Daily Flow
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
100
80
60
40
20
0
Remaining April-July Flow, as a Percentage of the total April-July Flow (%)

Figure

1-6

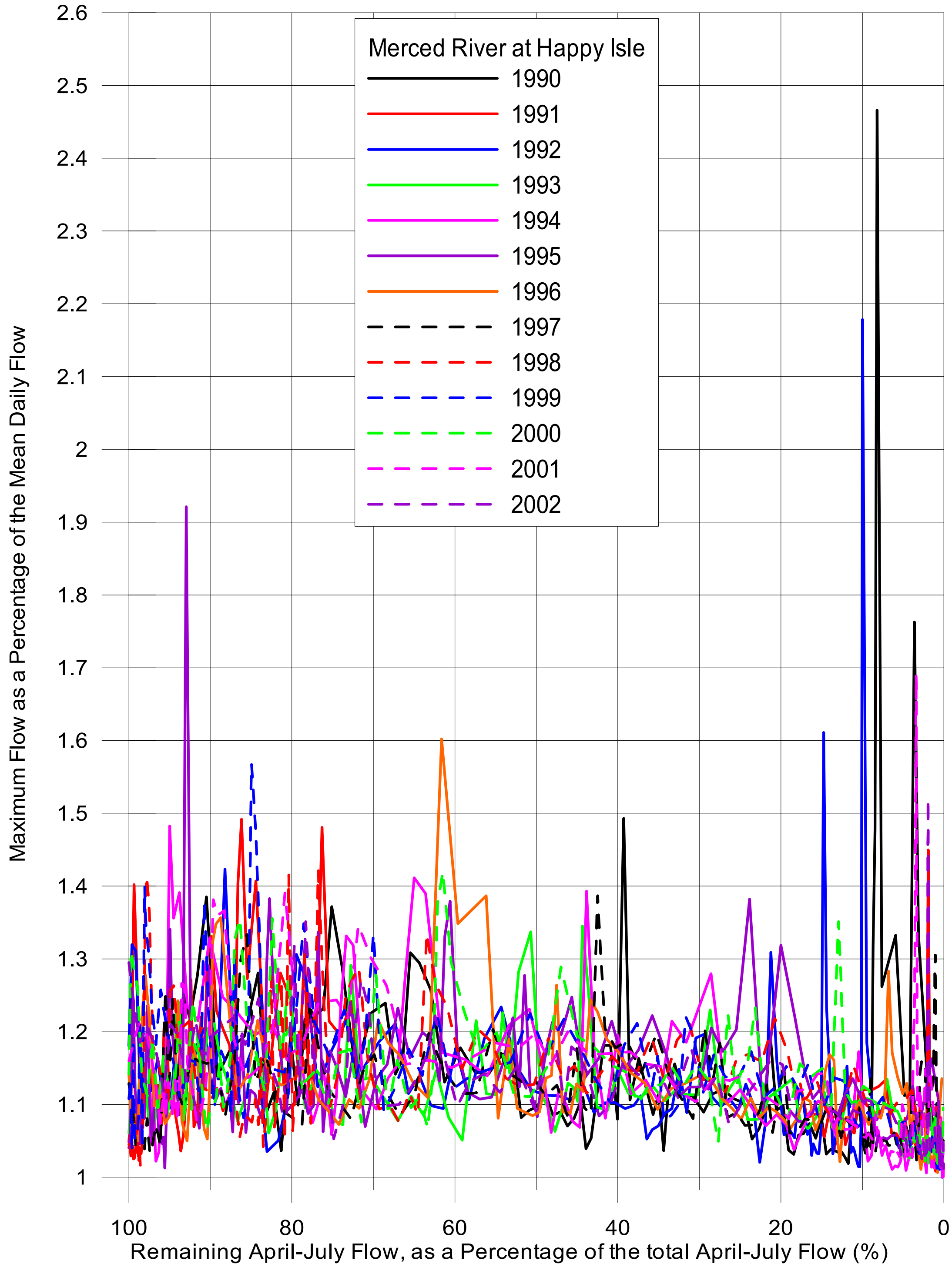

Merced River at Happy Isle
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
Maximum Flow as a Percentage of the Mean Daily Flow
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
100
80
60
40
20
0
Remaining April-July Flow, as a Percentage of the total April-July Flow (%)

Figure 1-7

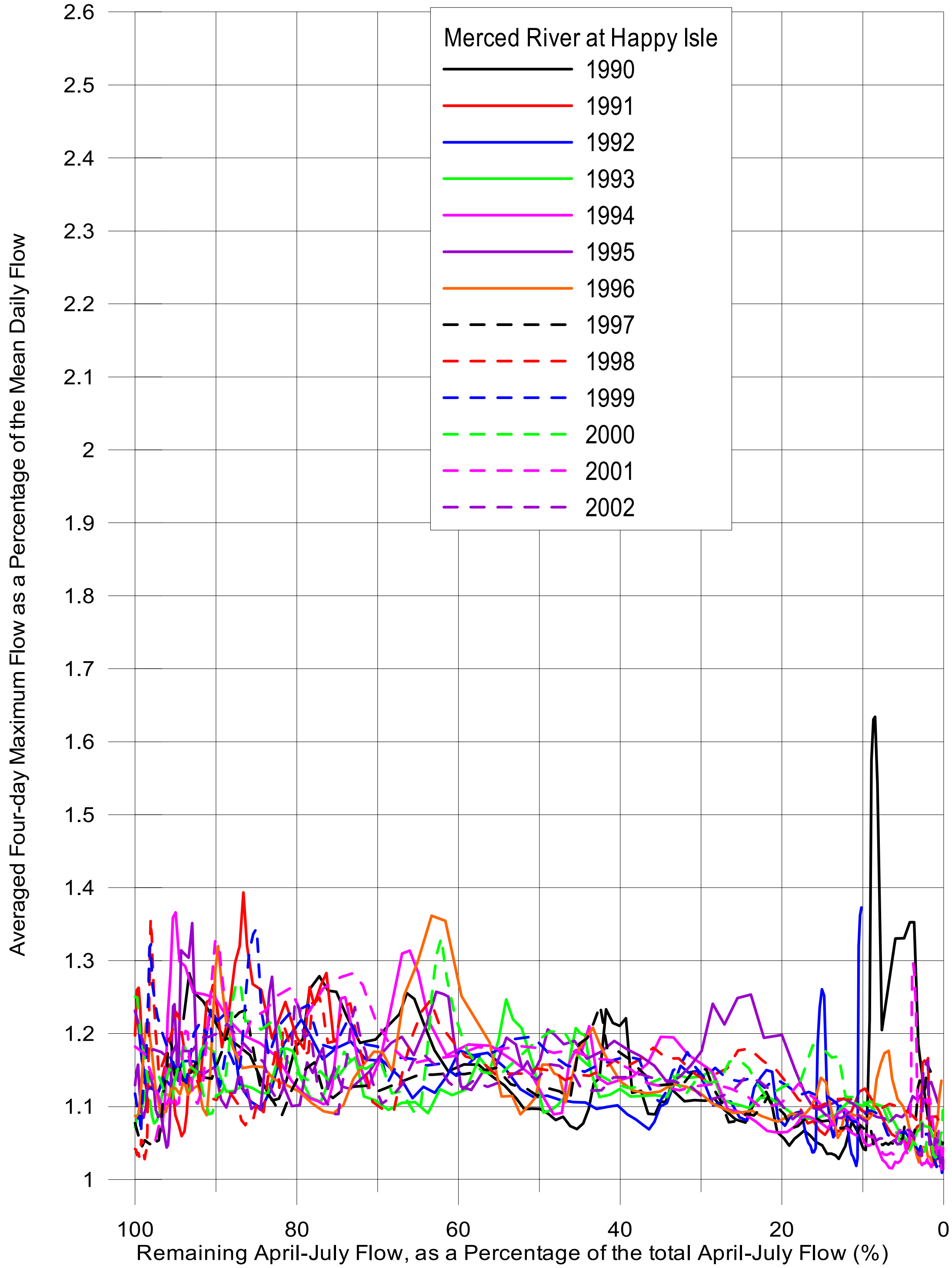

Merced River at Happy Isle
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
Averaged Four-day Maximum Flow as a Percentage of the Mean Daily Flow
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
100
80
60
40
20
0
Remaining April-July Flow, as a Percentage of the total April-July Flow (%)

Figure 1-8

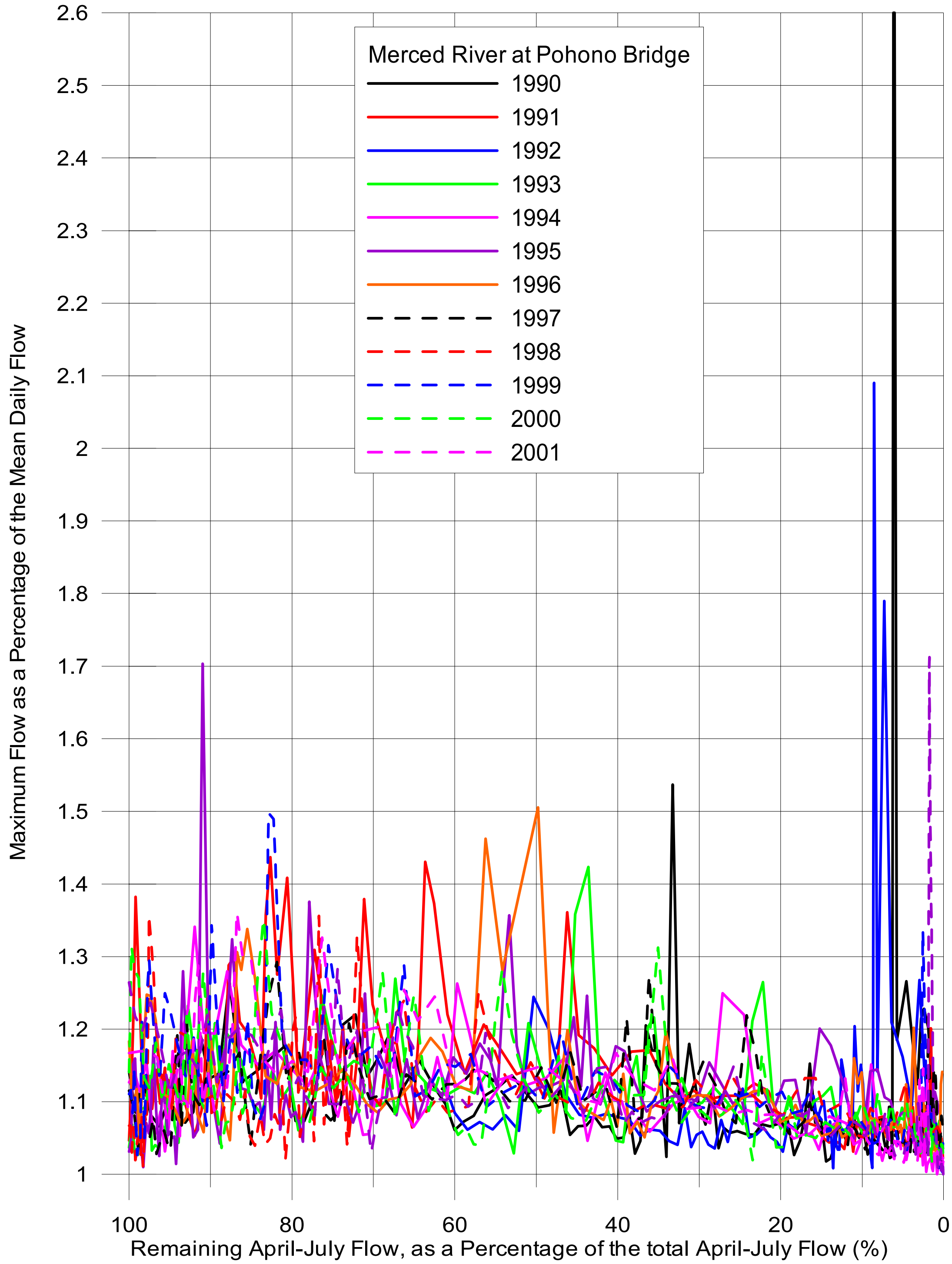

Merced River at Pohono Bridge
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
Maximum Flow as a Percentage of the Mean Daily Flow
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
100
80
60
40
20
0
Remaining April-July Flow, as a Percentage of the total April-July Flow (%)

Figure 1-9

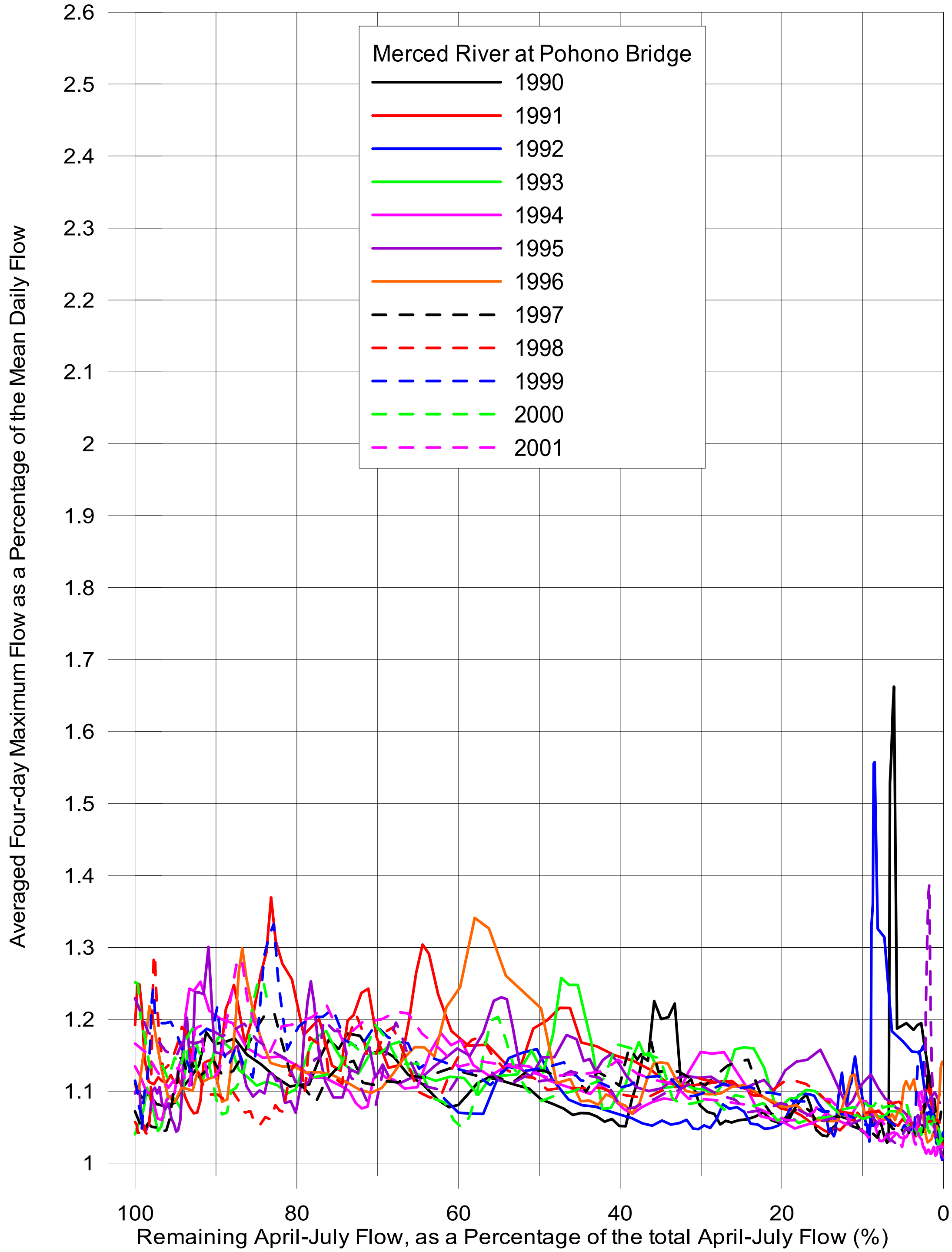

Merced River at Pohono Bridge
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
Averaged Four-day Maximum Flow as a Percentage of the Mean Daily Flow
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
100
80
60
40
20
0
Remaining April-July Flow, as a Percentage of the total April-July Flow (%)

Figure 1-10

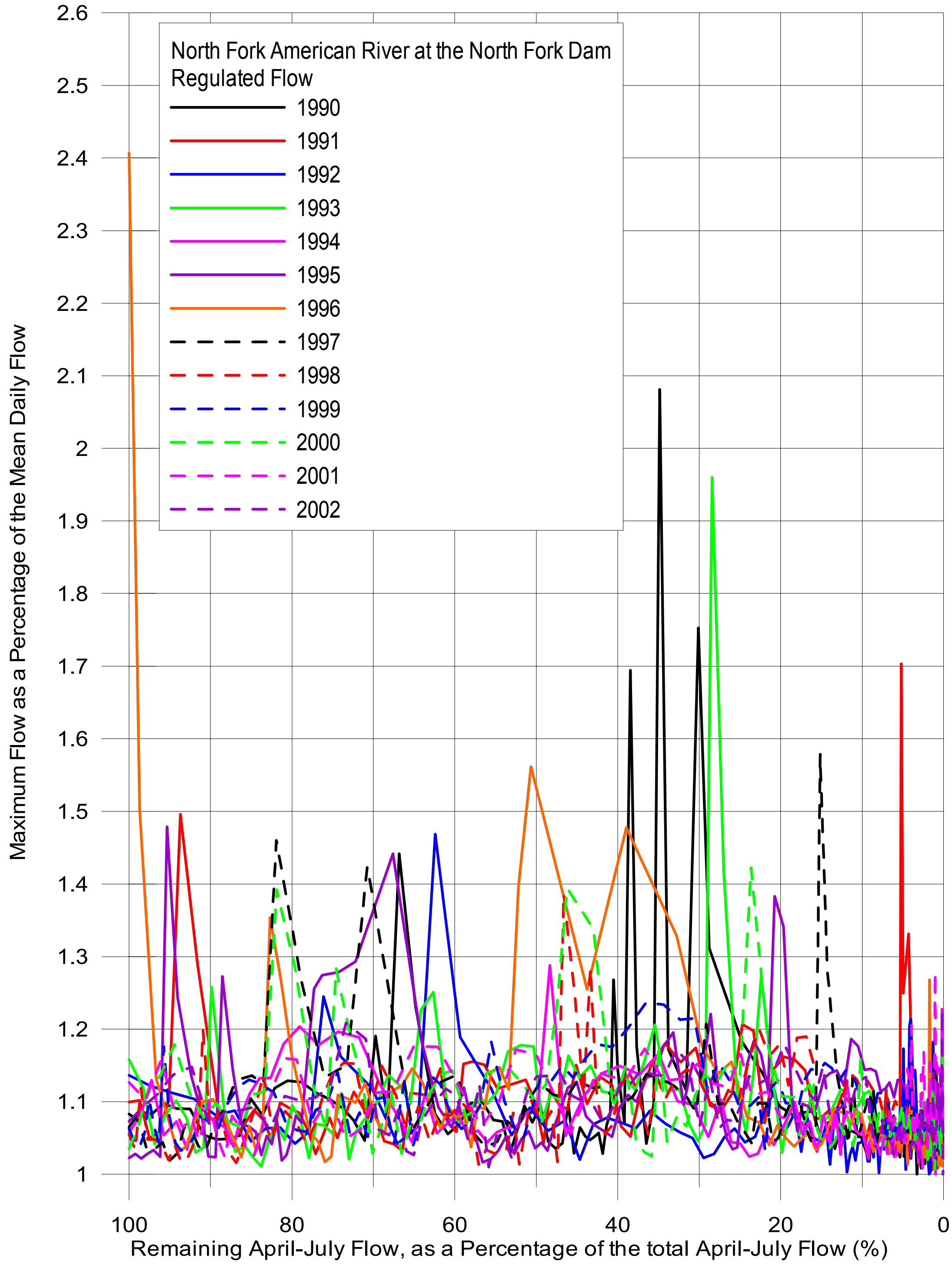

North Fork American River at the North Fork Dam
Regulated Flow
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
Maximum Flow as a Percentage of the Mean Daily Flow
Remaining April-July Flow, as a Percentage of the total April-July Flow (%)
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
100
80
60
40
20
0

Figure 1-11

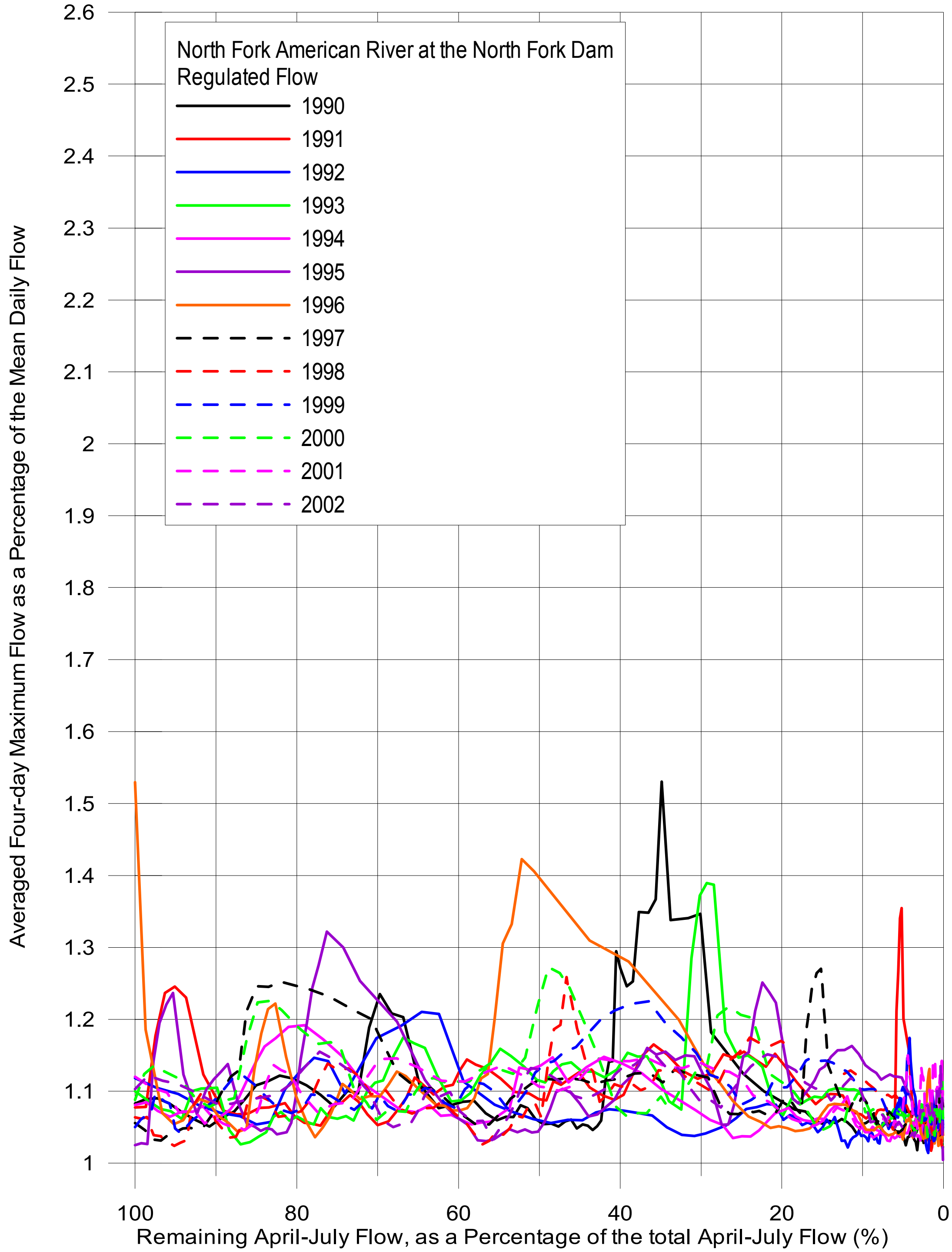

North Fork American River at the North Fork Dam
Regulated Flow
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
Averaged Four-day Maximum Flow as a Percentage of the Mean Daily Flow
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
100
80
60
40
20
0
Remaining April-July Flow, as a Percentage of the total April-July Flow (%)

Figure 1-12

APPENDIX G

FLOOD PEAK FREQUENCY DATA AND CURVES

UARP Project
Instantaneous Flow

The following plots have been prepared from the USGS gage data:

- Rubicon River at Rubicon Springs near Meeks Bay (Table 1 and Figure 1-1)
  - Unregulated by UARP: 1956-1963
  - Regulated by UARP: 1964-1986

- Gerle Creek below Loon Lake Dam (Table 2 and Figure 1-2)
  - Unregulated by UARP: not available
  - Regulated by UARP: 1964-2001

- South Fork Rubicon River below Gerle Creek near Georgetown (Table 3 and Figure 1-3)
  - Unregulated by UARP: not available
  - Regulated by UARP 1964-2001

- South Fork Silver Creek near Ice House (Figure 1-4)
  - Unregulated by UARP: 1925-1959
  - Regulated by UARP: without Jones Fork Powerhouse: 1961-1984
  - Regulated by UARP: with Jones Fork Powerhouse: 1985-2001

- South Fork Silver Creek near Ice House (Table 4 and Figure 1-5)
  - Unregulated by UARP: 1925-1959
  - Regulated by UARP: without Jones Fork Powerhouse: 1961-1984
  - Regulated by UARP: with Jones Fork Powerhouse: 1985-2001 (excl 1996) Note: During 1996, the gates at the Ice House Reservoir were opened which created a spill downstream. Because this was an abnormal event, it was removed from the analysis.

- Silver Creek near Union Valley (Table 5 and Figure 1-6)
  - Unregulated by UARP: 1925-1960
  - Regulated by UARP: not available

- Silver Creek below Camino Diversion Dam (Table 6 and Figure 1-7)
  - Unregulated: Silver Creek near Placerville (DA 177 sqmi, 1922-59)
  - Regulated: Silver Creek below Camino Diversion Dam (DA 171 sqmi, 1964-2001)

- South Fork American River near Camino (Table 7 and Figure 1-8)
  - Unregulated: 1923-1961
  - Regulated: 1963-2001

Table 1
114428000 Rubicon R @ Rubicon Springs
Instantaneous Peak Flow (cfs)
DA 31.4 sqmi

Prior to SMUD UARP			Subsequent SMUD UARP		
Date	**Flow**	**Flow/sqmi**	**Date**	**Flow**	**Flow/sqmi**
2/9/1961	850	27.1	2/21/1977	119	3.8
1/9/1959	887	28.2	11/18/1965	141	4.5
5/8/1962	960	30.6	4/14/1985	152	4.8
5/23/1958	**1660**	**52.9**	4/5/1972	160	5.1
2/8/1960	**2460**	**78.3**	2/14/1981	219	7.0
5/18/1957	3030	96.5	12/15/1977	338	10.8
12/1955	9270	295.2	6/6/1975	452	14.4
2/1/1963	11500	366.2	12/17/1972	606	19.3
			2/20/1968	630	20.1
			6/14/1969	630	20.1
			6/17/1967	805	25.6
			10/26/1975	**2570**	**81.8**
			11/11/1983	2650	84.4
			1/11/1979	2660	84.7
			3/8/1986	3170	101.0
			11/14/1963	3350	106.7
			1/21/1970	3470	110.5
			11/12/1973	3750	119.4
			6/26/1971	3850	122.6
			10/26/1982	3870	123.2
			2/16/1982	4750	151.3
			1/13/1980	5270	167.8
			12/23/1964	10100	321.7

Note: Values in red represent the event with a 2-year return period. Values in blue are assumed to be either snowmelt or rain on snow events (April through June).

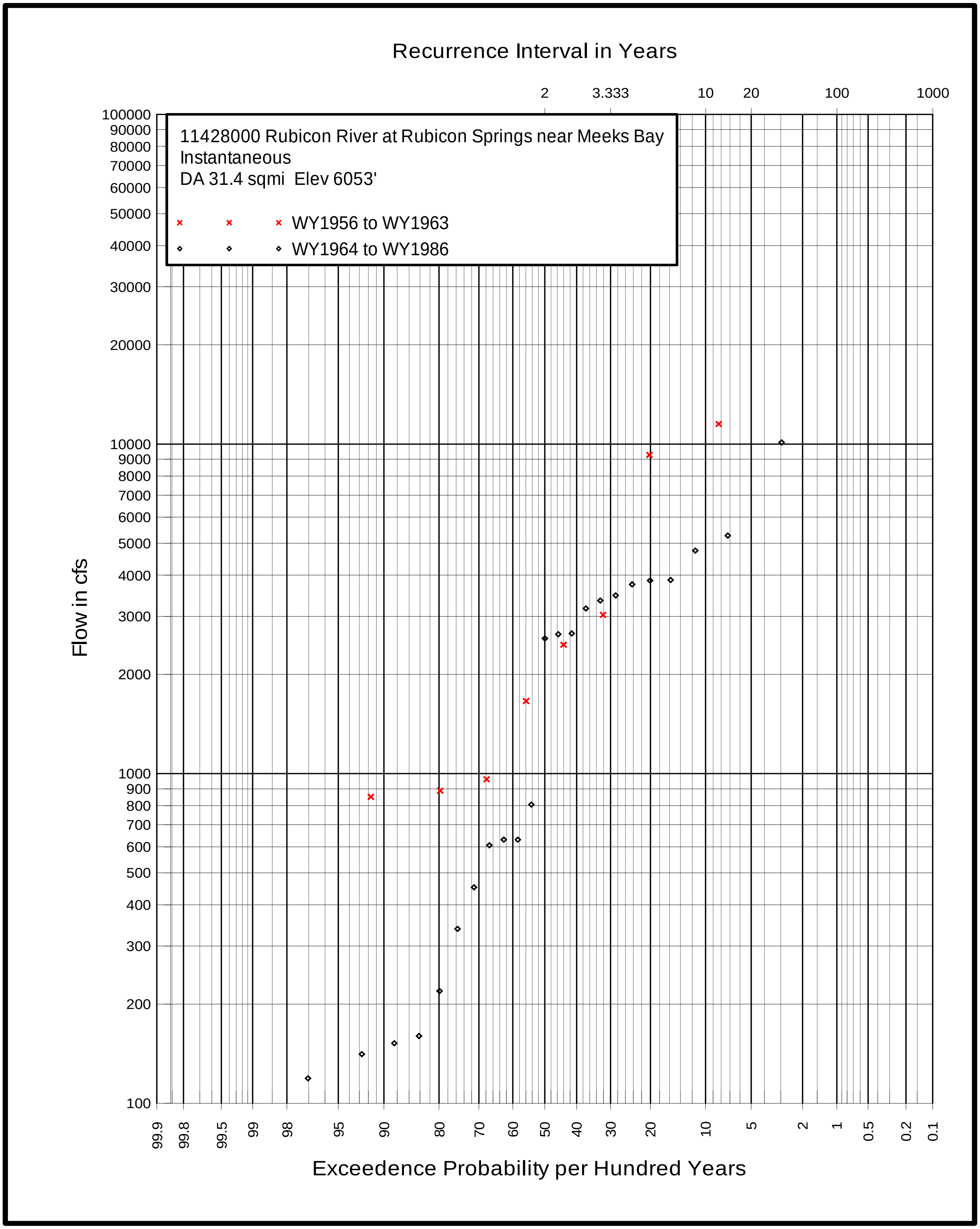
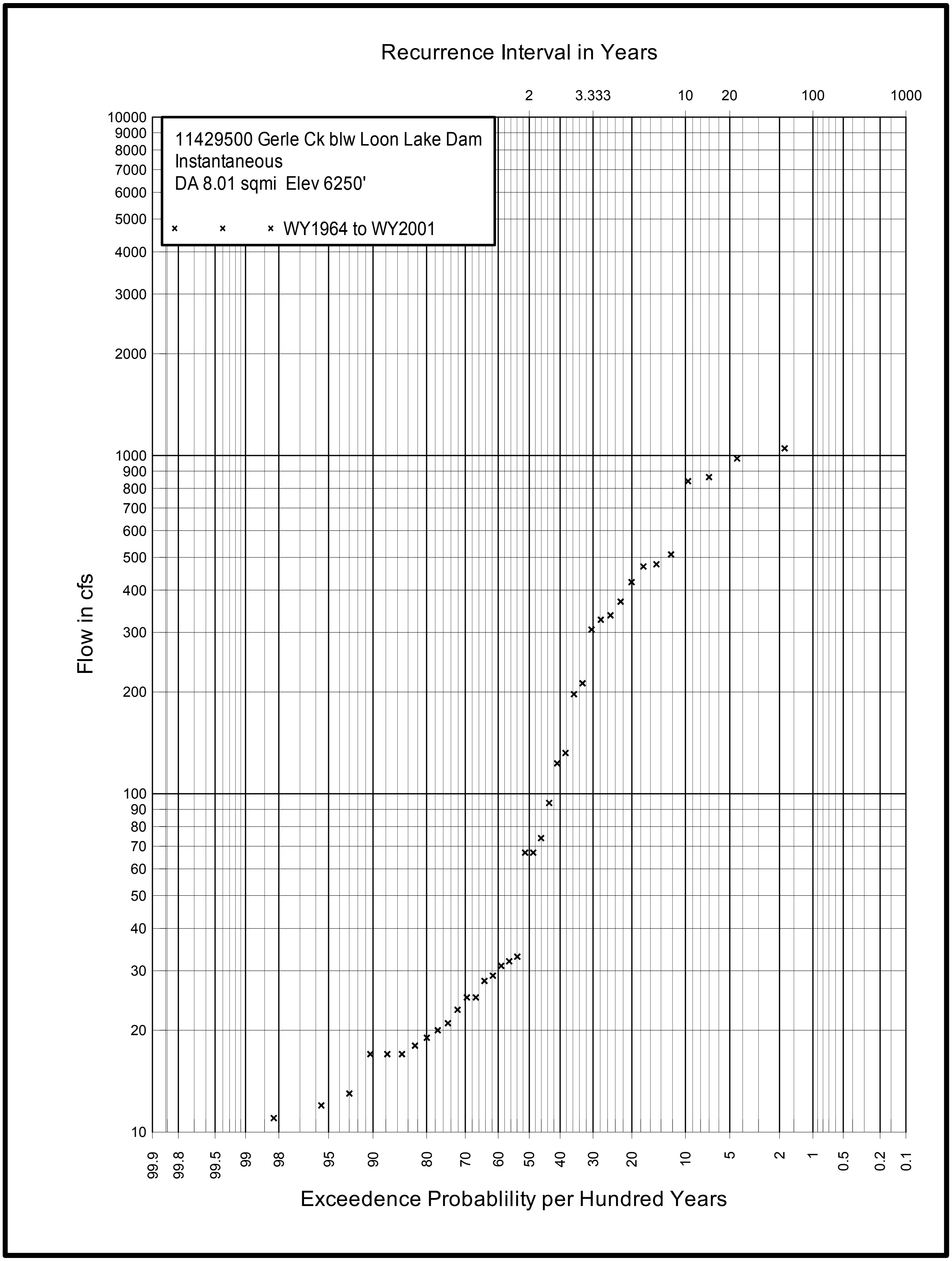

Recurrence Interval in Years
2
3.333
10
20
100
1000
11428000 Rubicon River at Rubicon Springs near Meeks Bay
Instantaneous
DA 31.4 sqmi Elev 6053'
WY1956 to WY1963
WY1964 to WY1986
Flow in cfs
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probability per Hundred Years

Figure 1-1

Table 2
11429500 Gerle Ck blw Loon Lake Dam
Instantaneous Peak Flow (cfs)
DA 8.01 sqmi

Subsequent to SMUD UARP		
Date	**Flow**	**Flow/sqmi**
10/26/1975	11	1.4
5/14/1978	12	1.5
5/18/1975	13	1.6
11/11/1971	17	2.1
6/8/1977	17	2.1
1/11/1979	17	2.1
10/22/1980	18	2.2
10/23/1989	19	2.4
7/15/1973	20	2.5
12/6/1987	21	2.6
2/14/2000	23	2.9
10/25/1982	25	3.1
6/8/1994	25	3.1
3/4/1991	28	3.5
6/14/1974	29	3.6
11/23/1988	31	3.9
10/24/1979	32	4.0
6/24/1999	33	4.1
7/11/1995	**67**	**8.4**
8/18/1998	**67**	**8.4**
11/18/1996	74	9.2
8/4/2001	94	11.7
4/22/1992	123	15.4
8/21/1985	132	16.5
8/11/1993	197	24.6
5/28/1982	212	26.5
7/29/1986	306	38.2
7/31/1964	327	40.8
8/26/1987	337	42.1
12/27/1983	370	46.2
9/18/1966	422	52.7
12/13/1967	470	58.7
6/8/1970	477	59.6
5/18/1996	510	63.7
7/5/1967	839	104.7
6/14/1965	863	107.7
6/27/1971	980	122.3
6/5/1969	1050	131.1

Note: Values in red represent the event with a 2-year return period. Values in blue are assumed to be either snowmelt or rain on snow events (April through June).

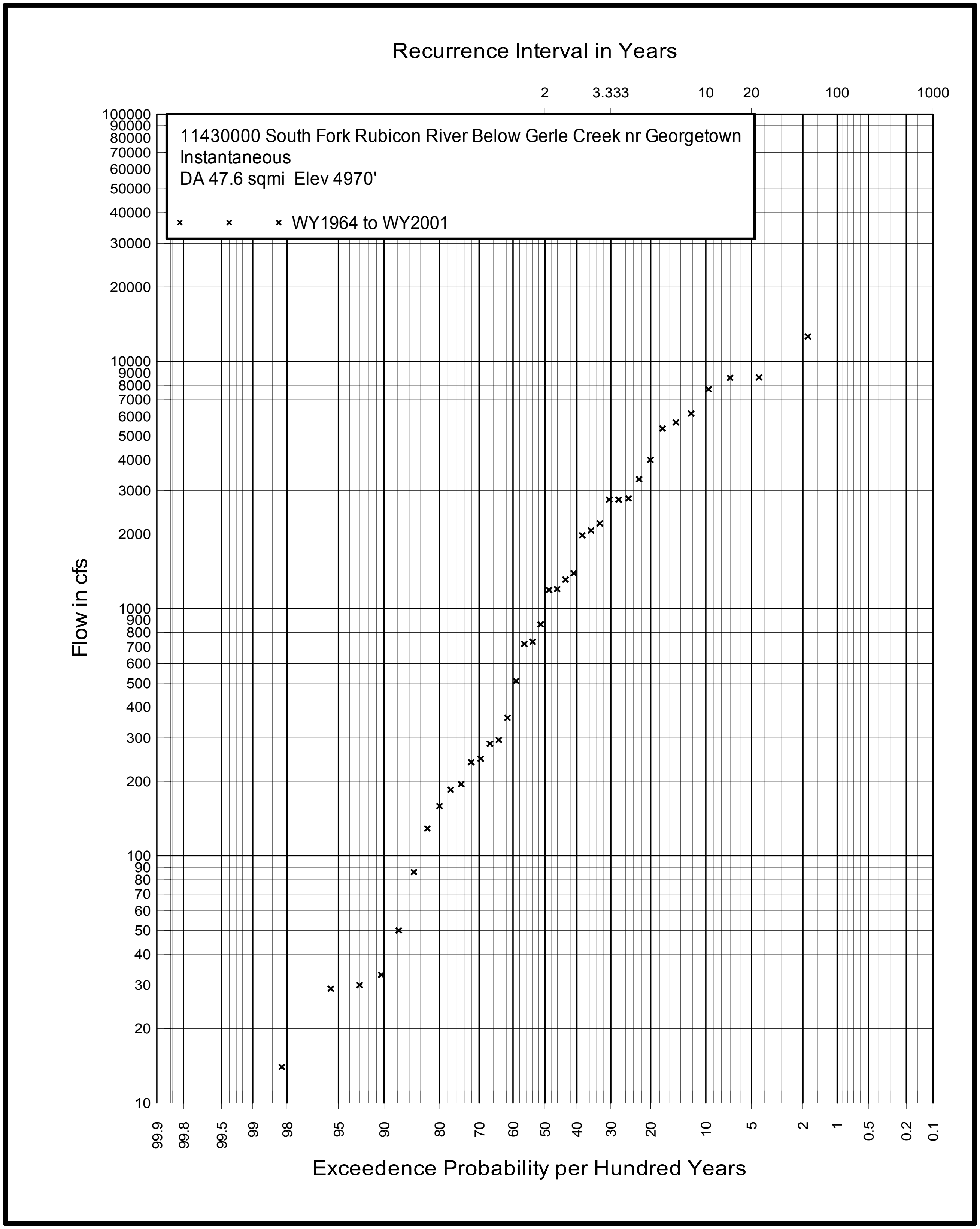


Recurrence Interval in Years
2
3.333
10
20
100
1000
11429500 Gerle Ck blw Loon Lake Dam
Instantaneous
DA 8.01 sqmi Elev 6250'
WY1964 to WY2001
Flow in cfs
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probablility per Hundred Years

Figure 1-2

Table 3 11430000 South Fork Rubicon R blw Gerle Creek nr Georgetown Instantaneous Peak Flow (cfs) DA 47.6 sqmi		
Subsequent to SMUD UARP		
Date	**Flow**	**Flow/sqmi**
10/15/1993	14	0.3
2/20/1992	29	0.6
12/26/1975	30	0.6
9/13/1977	33	0.7
6/22/2001	50	1.1
11/12/1971	86	1.8
11/5/1963	129	2.7
2/16/1990	159	3.3
12/20/1965	185	3.9
3/11/1981	195	4.1
2/9/1999	239	5.0
2/12/1988	247	5.2
5/19/1975	284	6.0
4/25/1978	294	6.2
2/20/1968	362	7.6
3/8/1989	510	10.7
2/9/1985	720	15.1
2/13/1987	734	15.4
4/17/1993	**864**	**18.2**
2/14/2000	**1190**	**25.0**
1/11/1979	1200	25.2
3/26/1971	1310	27.5
1/12/1973	1390	29.2
3/24/1998	1980	41.6
11/12/1973	2070	43.5
3/16/1967	2210	46.4
1/20/1969	2760	58.0
3/13/1983	2760	58.0
3/4/1991	2790	58.6
5/1/1995	3340	70.2
11/24/1983	4000	84.0
1/21/1970	5350	112.4
5/16/1996	5670	119.1
2/16/1982	6160	129.4
2/17/1986	7720	162.2
1/13/1980	8580	180.3
12/23/1964	8620	181.1
1/1/1997	12600	264.7

Note: Values in red represent the event with a 2-year return period. Values in blue are assumed to be either snowmelt or rain on snow events (April through June).



Recurrence Interval in Years
2
3.333
10
20
100
1000
11430000 South Fork Rubicon River Below Gerle Creek nr Georgetown
Instantaneous
DA 47.6 sqmi Elev 4970'
WY1964 to WY2001
Flow in cfs
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probability per Hundred Years

Figure 1-3

Table 4
11441500 South Fork Silver Creek nr Ice House
Instantaneous Peak Flow (cfs)
DA 27.5 sqmi

Prior to SMUD UARP			Subsequent SMUD UARP			Subsequent JFPH		
Date	**Flow**	**Flow/ sqmi**	**Date**	**Flow**	**Flow/ sqmi**	**Date**	**Flow**	**Flow/ sqmi**
4/28/1931	217	8	10/26/1976	296	11	10/1/1993	16	1
4/20/1939	339	12	10/28/1977	394	14	3/4/1991	19	1
5/20/1930	409	15	6/6/1984	411	15	4/27/1988	21	1
4/28/1926	450	16	9/26/1972	418	15	11/3/1999	25	1
5/7/1944	526	19	10/20/1975	439	16	6/23/1999	82	3
3/29/1934	558	20	10/14/1974	476	17	8/17/1989	114	4
5/9/1959	587	21	3/26/1973	494	18	8/11/1993	159	6
5/2/1947	602	22	8/17/1979	513	19	4/3/1990	**214**	**8**
5/21/1955	635	23	10/14/1980	519	19	4/22/1992	**252**	**9**
5/5/1946	636	23	11/6/1965	536	19	8/14/2001	296	11
5/16/1932	648	24	3/11/1969	545	20	8/26/1987	334	12
5/26/1948	689	25	6/1/1963	**560**	**20**	6/26/1995	460	17
5/30/1933	692	25	5/23/1961	**568**	**21**	6/20/1998	466	17
3/9/1954	746	27	1/28/1980	570	21	11/19/1984	514	19
5/11/1941	750	27	10/22/1967	592	22	3/8/1986	1000	36
6/4/1945	750	27	6/3/1964	602	22	1/2/1997	4440	161
5/23/1935	760	28	8/25/1965	627	23			
5/29/1950	**764**	**28**	6/30/1967	672	24			
6/15/1929	775	28	7/9/1974	749	27			
5/14/1937	782	28	6/24/1983	783	28			
2/6/1925	785	29	6/11/1962	802	29			
5/14/1949	792	29	6/27/1971	890	32			
5/16/1927	800	29	1/22/1970	1800	65			
5/23/1958	823	30	5/26/1982	1930	70			
6/7/1936	828	30						
5/27/1952	865	31						
3/26/1940	942	34						
12/3/1941	959	35						
5/18/1957	1070	39						
1/10/1953	1090	40						
6/1/1943	1110	40						
3/25/1928	1950	71						
12/11/1937	2640	96						
11/18/1950	3900	142						
12/23/1955	3940	143						

Note: Values in red represent the event with a 2-year return period. Values in blue are assumed to be either snowmelt or rain on snow events (April through June).

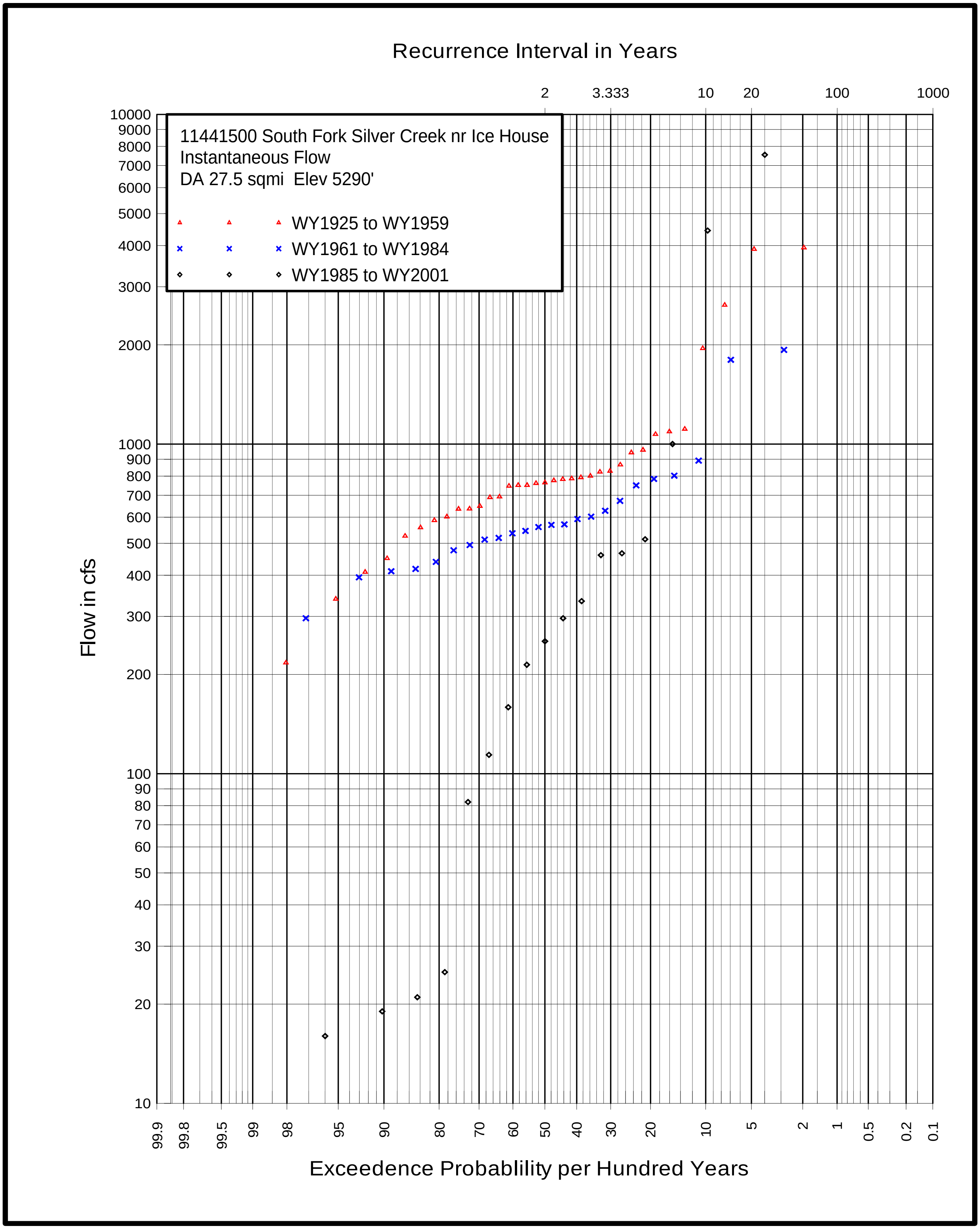

Recurrence Interval in Years
2
3.333
10
20
100
1000
11441500 South Fork Silver Creek nr Ice House
Instantaneous Flow
DA 27.5 sqmi Elev 5290'
WY1925 to WY1959
WY1961 to WY1984
WY1985 to WY2001
Flow in cfs
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probablility per Hundred Years

Figure 1-4

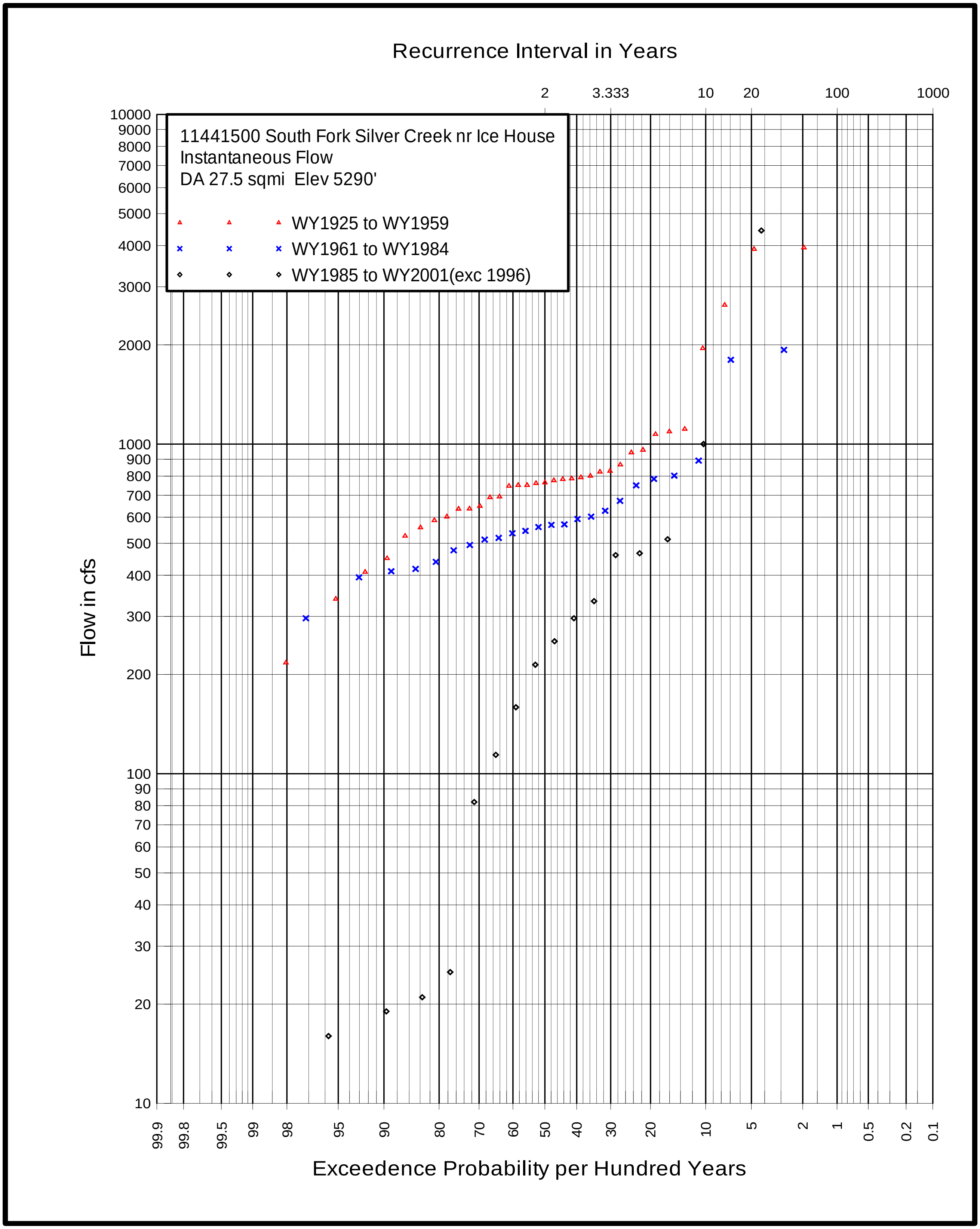
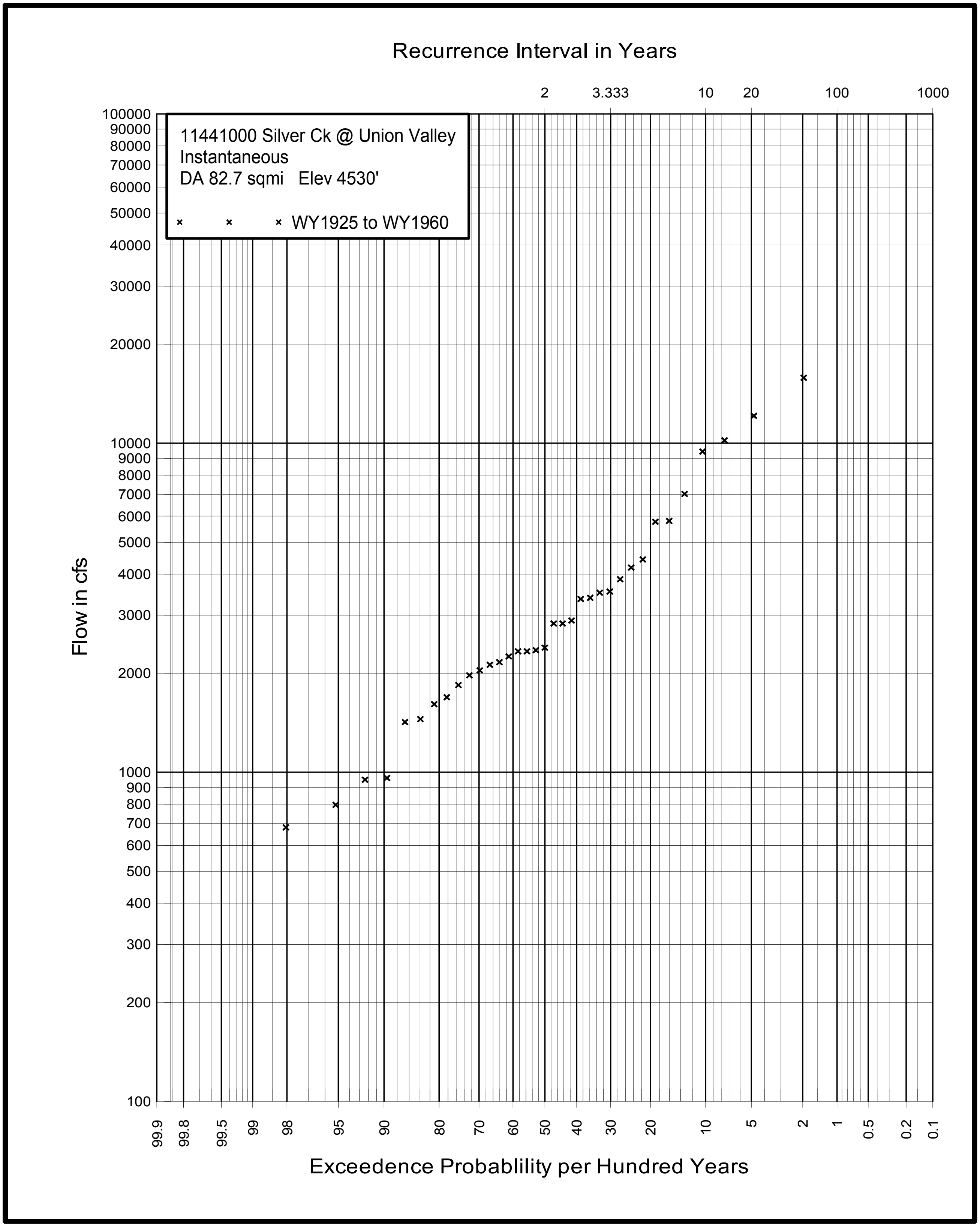

Recurrence Interval in Years
2
3.333
10
20
100
1000
11441500 South Fork Silver Creek nr Ice House
Instantaneous Flow
DA 27.5 sqmi Elev 5290'
WY1925 to WY1959
WY1961 to WY1984
WY1985 to WY2001(exc 1996)
Flow in cfs
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probability per Hundred Years

Figure 1-5

Table 5 **11441000 Silver Ck @ Union Valley** **Instantaneous Peak Flow (cfs)** **DA 82.7 sqmi**		
Subsequent to SMUD UARP		
Date	**Flow**	**Flow/sqmi**
3/18/1931	680	8.2
1/10/1959	796	9.6
4/21/1930	950	11.5
4/7/1939	960	11.6
4/5/1926	1420	17.2
5/2/1947	1450	17.5
5/21/1955	1610	19.5
5/7/1944	1690	20.4
5/5/1946	1840	22.2
5/29/1933	1970	23.8
5/16/1932	2040	24.7
5/11/1941	2120	25.6
5/26/1948	2160	26.1
5/21/1935	2250	27.2
3/29/1934	2330	28.2
5/14/1949	2330	28.2
5/16/1927	2350	28.4
5/13/1937	**2390**	**28.9**
5/27/1952	2830	34.2
2/8/1960	2830	34.2
5/23/1958	2890	34.9
6/15/1929	3360	40.6
6/7/1936	3390	41.0
4/27/1953	3510	42.4
3/9/1954	3540	42.8
12/3/1941	3860	46.7
2/2/1945	4190	50.7
5/18/1957	4430	53.6
2/6/1925	5770	69.8
3/26/1940	5800	70.1
1/21/1943	7010	84.8
3/25/1928	9430	114.0
12/11/1937	10200	123.3
11/20/1950	12100	146.3
12/23/1955	15800	191.1

Note: Values in red represent the event with a 2-year return period. Values in blue are assumed to be either snowmelt or rain on snow events (April through June).



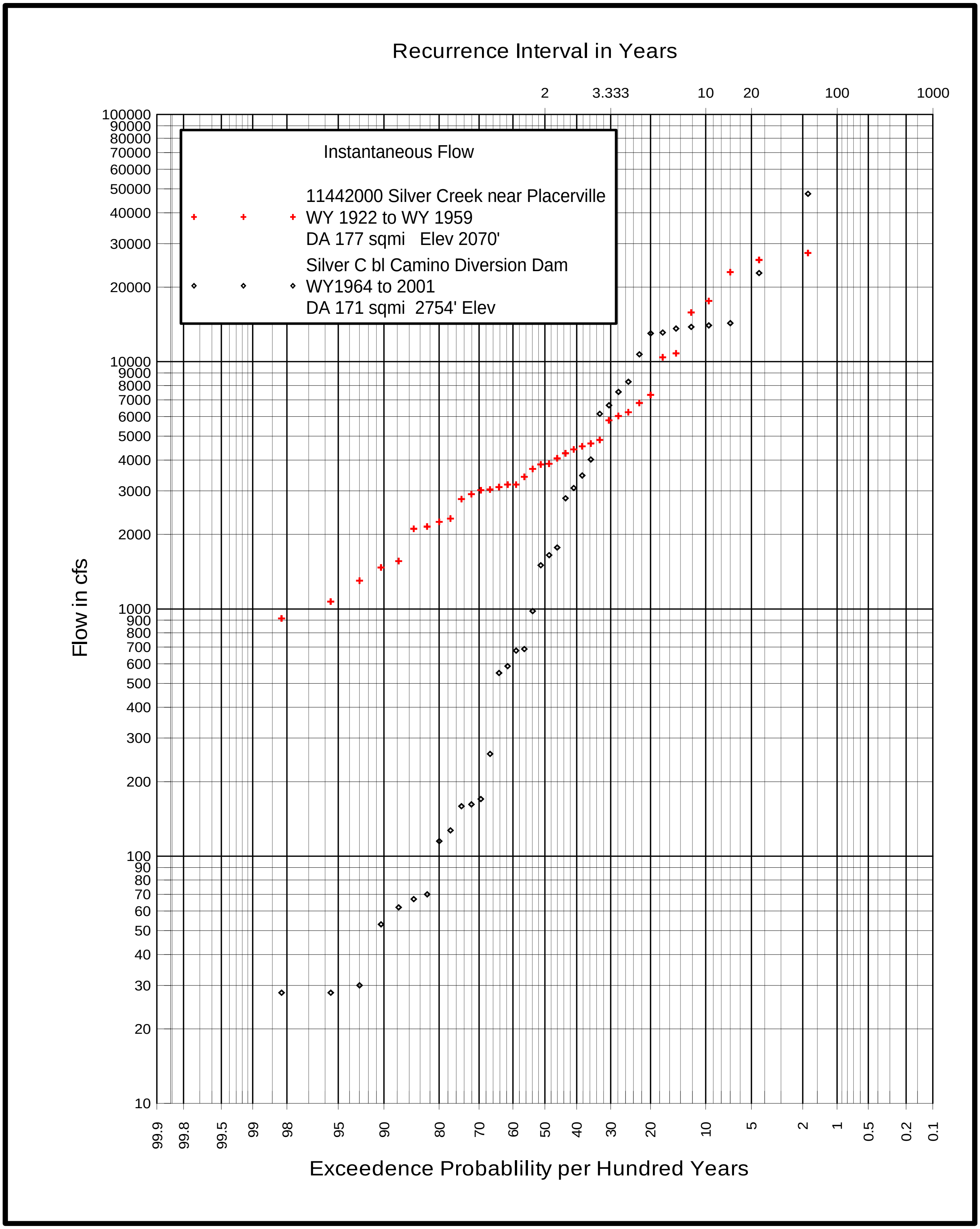
Recurrence Interval in Years
2
3.333
10
20
100
1000
11441000 Silver Ck @ Union Valley
Instantaneous
DA 82.7 sqmi Elev 4530'
WY1925 to WY1960
Flow in cfs
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probablility per Hundred Years

Figure 1-6

Table 6
Silver Creek near Placerville (DA 177 sqmi, 1922-59)
Silver Creek below Camino Diversion Dam (DA 171 sqmi, 1964-2001)
Instantaneous Peak Flow (cfs)

Prior to SMUD UARP 11442000 Silver Ck near Placerville DA 177 sqmi			Subsequent SMUD UARP 11441900 Silver Ck blw Camino Diversion Dam DA 171 sqmi		
Date	**Flow**	**Flow/sqmi**	**Date**	**Flow**	**Flow/sqmi**
2/8/1924	915	5.2	1/11/1988	28	0.2
3/18/1931	1070	6.0	10/15/1993	28	0.2
1/10/1959	1300	7.3	2/29/1976	30	0.2
4/8/1939	1470	8.3	11/27/1984	53	0.3
4/22/1930	1560	8.8	2/20/1992	62	0.4
5/3/1947	2110	11.9	2/13/1987	67	0.4
5/22/1955	2150	12.1	10/9/2000	70	0.4
4/5/1926	2250	12.7	1/17/1978	115	0.7
5/8/1944	2320	13.1	3/25/1981	127	0.7
5/12/1932	2780	15.7	11/10/1976	159	0.9
3/29/1934	2910	16.4	3/24/1975	162	0.9
4/6/1923	3020	17.1	12/4/1967	170	1.0
5/30/1933	3040	17.2	10/1/1963	259	1.5
5/26/1948	3110	17.6	12/22/1971	550	3.2
5/11/1941	3180	18.0	2/21/1991	586	3.4
12/29/1945	3180	18.0	1/11/1979	677	4.0
5/14/1949	3420	19.3	2/14/2000	688	4.0
1/22/1950	3680	20.8	1/12/1973	978	5.7
5/14/1937	**3840**	**21.7**	2/17/1990	**1500**	**8.8**
5/30/1922	**3860**	**21.8**	11/2/1965	**1650**	**9.6**
5/27/1952	4060	22.9	3/26/1971	1770	10.4
2/21/1927	4260	24.1	5/11/1967	2800	16.4
3/9/1954	4410	24.9	6/16/1998	3080	18.0
5/23/1958	4540	25.6	2/9/1999	3460	20.2
6/16/1929	4660	26.3	1/21/1969	4020	23.5
4/27/1953	4820	27.2	3/8/1989	6150	36.0
1/27/1942	5790	32.7	3/13/1983	6660	38.9
5/18/1957	6030	34.1	1/22/1970	7540	44.1
4/8/1935	6240	35.3	12/30/1973	8280	48.4
2/22/1936	6800	38.4	5/1/1995	10700	62.6
2/6/1925	7330	41.4	5/16/1996	13000	76.0
2/2/1945	10400	58.8	2/15/1982	13100	76.6
3/26/1940	10800	61.0	12/22/1964	13600	79.5
1/21/1943	15800	89.3	11/17/1983	13800	80.7
3/25/1928	17600	99.4	1/13/1980	14000	81.9
12/11/1937	23000	129.9	1/22/1993	14300	83.6
11/18/1950	25800	145.8	2/17/1986	22800	133.3
12/23/1955	27500	155.4	1/2/1997	47700	278.9

Note: Values in red represent the event with a 2-year return period. Values in blue are assumed to be either snowmelt or rain on snow events (April through June).



Recurrence Interval in Years
2
3.333
10
20
100
1000
Instantaneous Flow
11442000 Silver Creek near Placerville
WY 1922 to WY 1959
DA 177 sqmi Elev 2070'
Silver C bl Camino Diversion Dam
WY1964 to 2001
DA 171 sqmi 2754' Elev
Flow in cfs
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probablility per Hundred Years

Figure 1-7

11443500 South Fork American River nr Camino Instantaneous Peak Flow (cfs) DA 493 sqmi					
Prior to SMUD UARP			**Subsequent SMUD UARP**		
Date	**Flow**	**Flow/sqmi**	**Date**	**Flow**	**Flow/sqmi**
4/29/1931	1620	3.3	9/13/1977	30	0.1
2/8/1924	1970	4.0	10/3/2000	41	0.1
5/23/1961	2320	4.7	8/16/1976	43	0.1
4/8/1939	2650	5.4	6/29/1994	48	0.1
2/16/1959	2850	5.8	6/16/1992	50	0.1
3/29/1934	4010	8.1	4/24/1972	67	0.1
4/8/1930	4100	8.3	6/3/1987	72	0.1
5/9/1944	4450	9.0	6/20/1988	78	0.2
5/3/1947	4500	9.1	6/15/1978	84	0.2
4/5/1926	4510	9.1	11/5/1984	97	0.2
5/22/1955	4950	10.0	10/27/1980	184	0.4
5/30/1933	5930	12.0	7/12/1973	479	1.0
5/29/1950	6080	12.3	2/21/1990	639	1.3
5/12/1932	6200	12.6	1/11/1979	848	1.7
5/14/1949	6460	13.1	3/8/1989	935	1.9
5/27/1948	6580	13.3	3/4/1991	1400	2.8
5/12/1941	6990	14.2	2/21/1968	1700	3.4
12/22/1945	7110	14.4	2/14/2000	1870	3.8
5/14/1937	7140	14.5	3/25/1975	1900	3.9
4/6/1923	**7350**	**14.9**	12/30/1973	**2480**	**5.0**
6/16/1929	8300	16.8	5/13/1966	2820	5.7
5/23/1958	8350	16.9	1/22/1993	4400	8.9
3/9/1954	9340	18.9	11/15/1963	4450	9.0
2/21/1927	9350	19.0	3/26/1971	5100	10.3
5/28/1952	9420	19.1	3/24/1998	6420	13.0
2/8/1960	10200	20.7	2/9/1999	7780	15.8
5/18/1957	10400	21.1	3/16/1967	8260	16.8
4/27/1953	10600	21.5	1/21/1969	12500	25.4
4/8/1935	10700	21.7	12/26/1983	13500	27.4
2/22/1936	11700	23.7	5/1/1995	14300	29.0
1/27/1942	13300	27.0	3/13/1983	15000	30.4
2/6/1925	18000	36.5	5/16/1996	19500	39.6
3/27/1940	18400	37.3	1/21/1970	24500	49.7
2/2/1945	19100	38.7	2/16/1982	27500	55.8
1/21/1943	23100	46.9	2/18/1986	27500	55.8
3/25/1928	31500	63.9	1/13/1980	30900	62.7
12/11/1937	34400	69.8	12/23/1964	36000	73.0
11/21/1950	46000	93.3	2/1/1963	37200	75.5
12/23/1955	49800	101.0	1/2/1997	62300	126.4

Note: Values in red represent the event with a 2-year return period. Values in blue are assumed to be either snowmelt or rain on snow events (April through June).

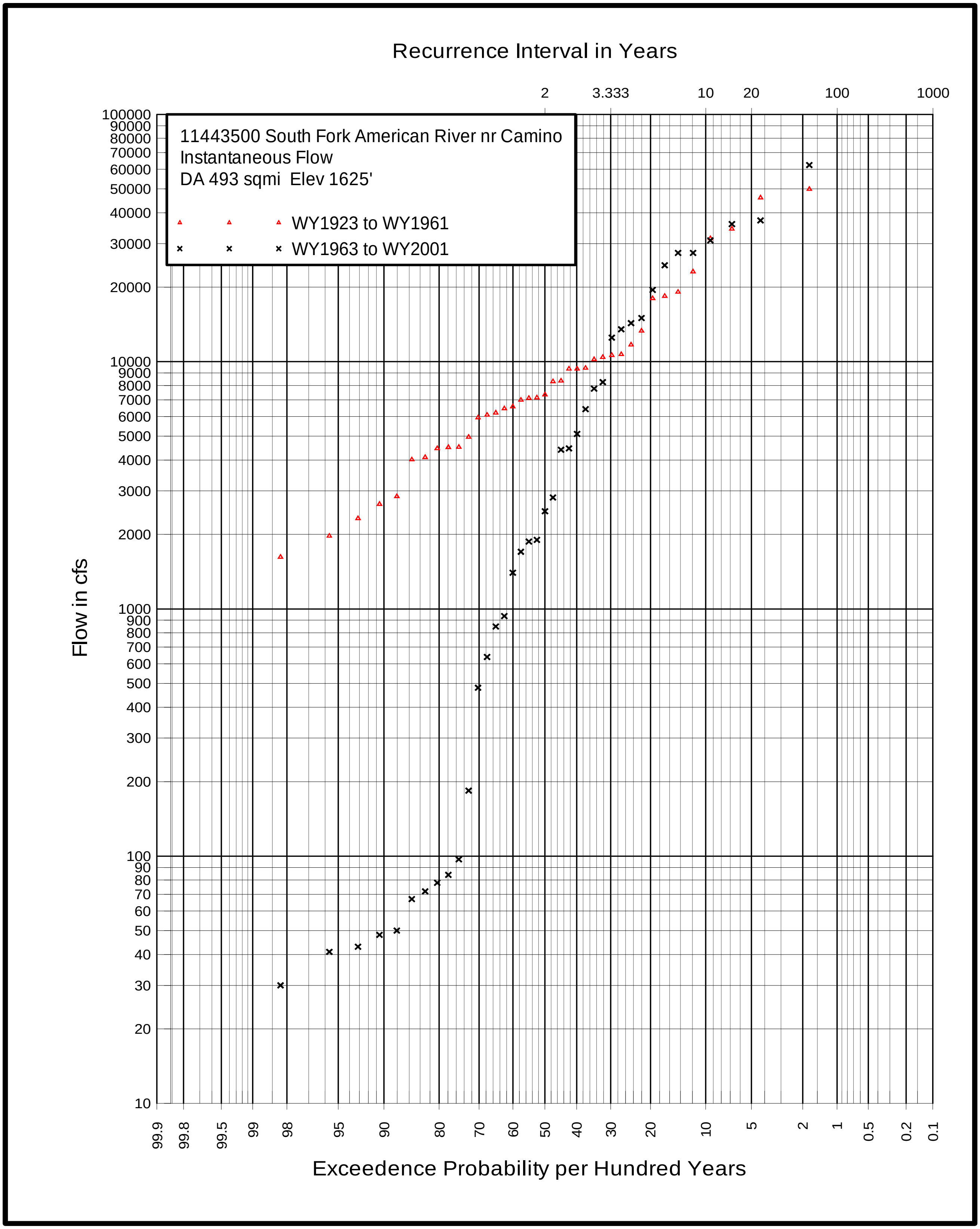

Recurrence Interval in Years
2
3.333
10
20
100
1000
11443500 South Fork American River nr Camino
Instantaneous Flow
DA 493 sqmi Elev 1625'
WY1923 to WY1961
WY1963 to WY2001
Flow in cfs
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probability per Hundred Years

Figure 1-8

South Fork American River near Placerville
Instantaneous Flow

Regulated data: A gage on the South Fork American River (SFAR) exists near Placerville, recording flows of a drainage area of 598 square miles. This data that represents a regulated stream flow (regulation due to UARP and Project 184) exists for the period 1965-2001. These data are graphically displayed on Figure 2-1.

Unregulated Data: Fow data from the following gages was available prior to regulation by the UARP:

- SFAR @ Placerville, 598 square miles, 1912-1920
- SFAR @ Coloma, 631 square miles, 1930-1941
- SFAR @ Lotus, 673 square miles, 1951-1962

The results shown in the figures described below have been developed with use of the data described above:

Figure 2-2
SFAR @ Coloma and SFAR @ Lotus have been adjusted by the percentage of the difference in areas (80%) to adjust for differences in annual precipitation (which was not available). For example, the difference in area between SFAR @ Placerville and SFAR @ Coloma is 33 sqmi (631-598). Taking 80% of the difference is 26.4 (33 *.8). The adjustment factor for SFAR @ Coloma is .958 (598/[598+26.4]).

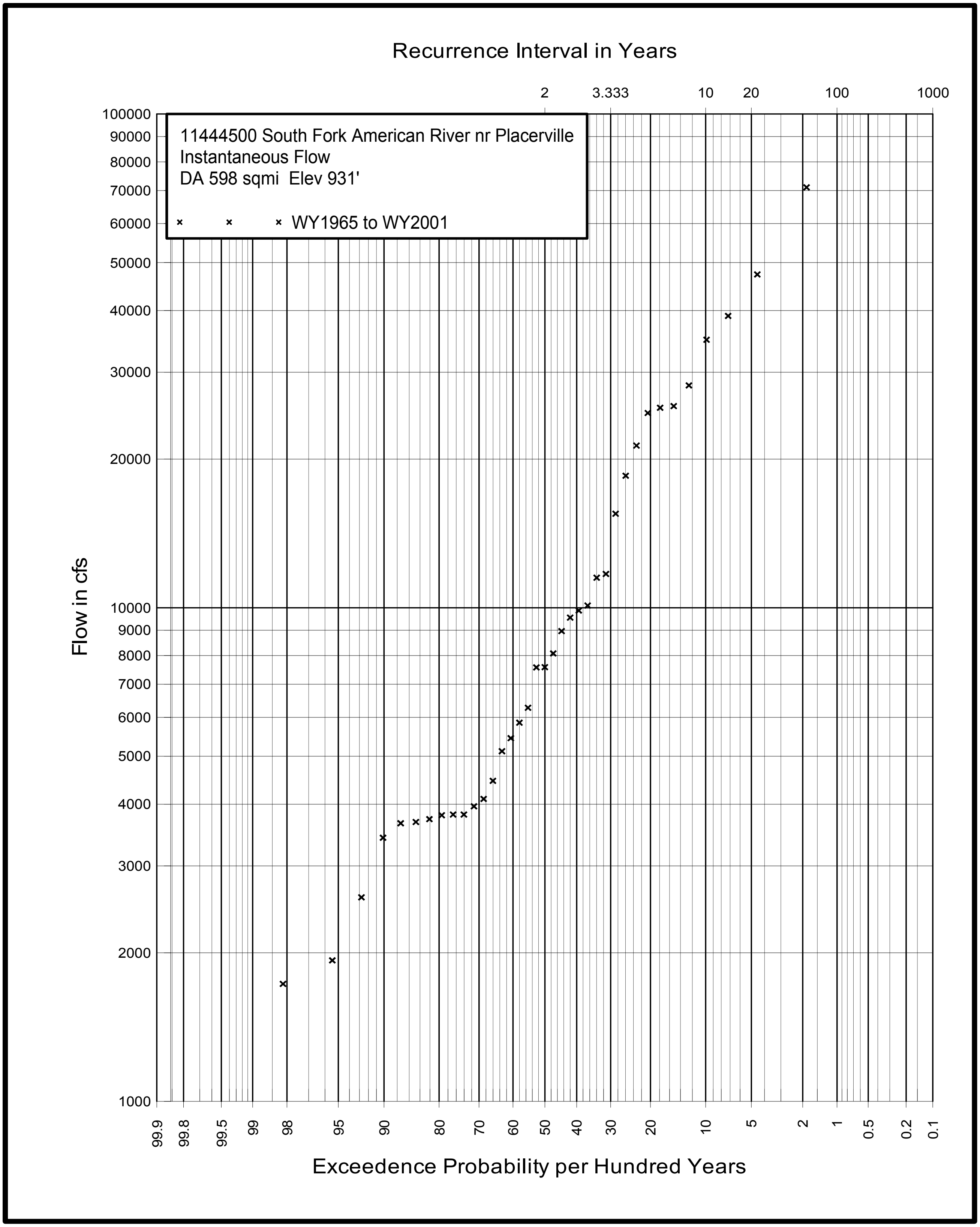
- SFAR @ Placerville, 598 square miles, 1912-1920
- SFAR @ Coloma, 631 square miles, 1930-1941 * (.958)
- SFAR @ Lotus, 673 square miles, 1951-1962 * (.9108)

Figure 2-3
SFAR @ Coloma and SFAR @ Lotus have been adjusted by the percentage of the difference in areas. The adjustment factor for SFAR @ Coloma is .948 (598/631).

- SFAR @ Placerville, 598 square miles, 1912-1920
- SFAR @ Coloma, 631 square miles, 1930-1941 * (.948)
- SFAR @ Lotus, 673 square miles, 1951-1962 * (.889)

Figure 2-4
No adjustment made to SFAR @ Coloma or SFAR @ Lotus.

- SFAR @ Placerville, 598 square miles, 1912-1920
- SFAR @ Coloma, 631 square miles, 1930-1941
- SFAR @ Lotus, 673 square miles, 1951-1962



Recurrence Interval in Years
2
3.333
10
20
100
1000
11444500 South Fork American River nr Placerville
Instantaneous Flow
DA 598 sqmi Elev 931'
WY1965 to WY2001
Flow in cfs
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probability per Hundred Years

Figure 2-1

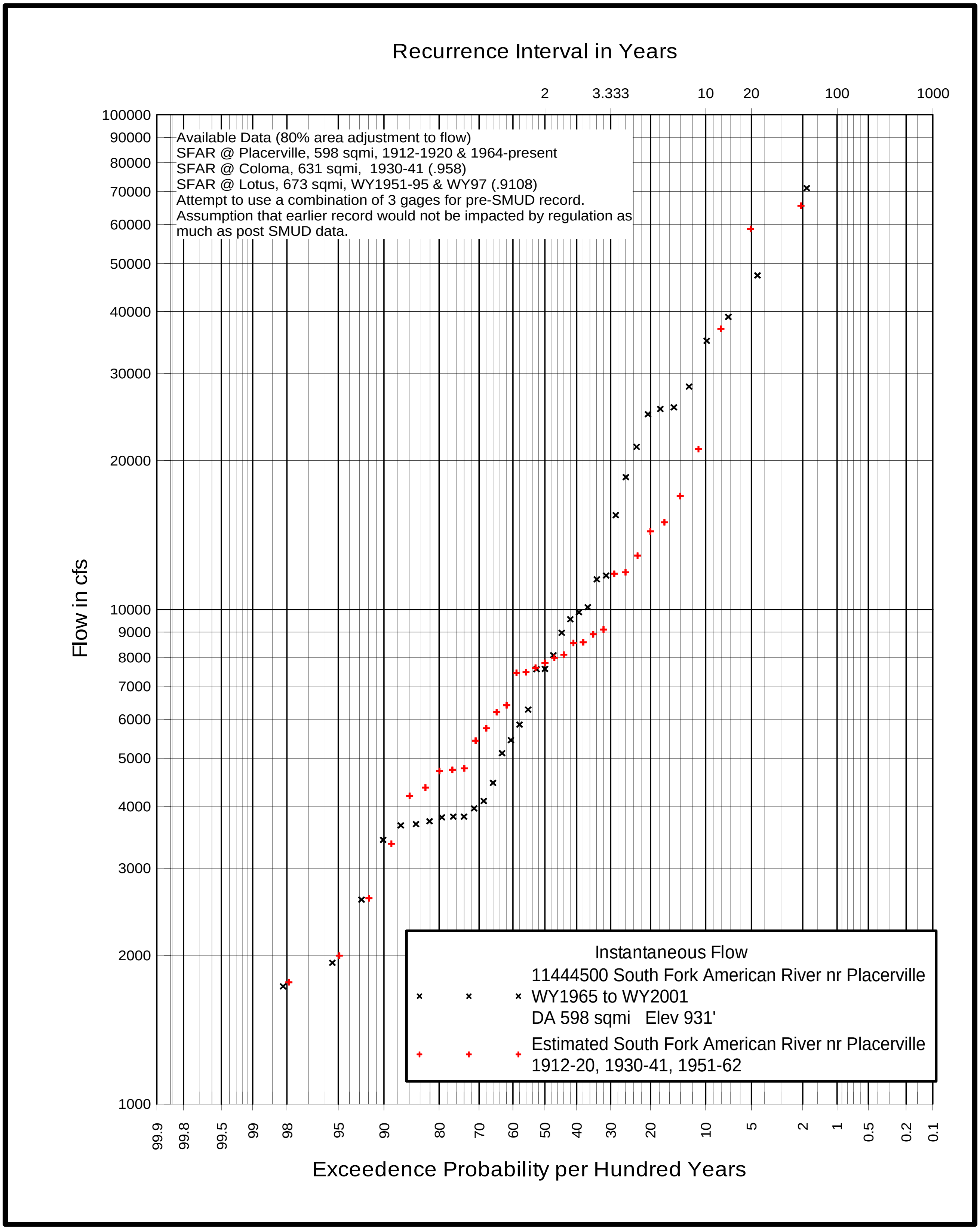

Recurrence Interval in Years
2
3.333
10
20
100
1000
Available Data (80% area adjustment to flow)
SFAR @ Placerville, 598 sqmi, 1912-1920 & 1964-present
SFAR @ Coloma, 631 sqmi, 1930-41 (.958)
SFAR @ Lotus, 673 sqmi, WY1951-95 & WY97 (.9108)
Attempt to use a combination of 3 gages for pre-SMUD record.
Assumption that earlier record would not be impacted by regulation as much as post SMUD data.
Flow in cfs
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
Instantaneous Flow
11444500 South Fork American River nr Placerville
WY1965 to WY2001
DA 598 sqmi Elev 931'
Estimated South Fork American River nr Placerville
1912-20, 1930-41, 1951-62
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probability per Hundred Years

Figure 2-2

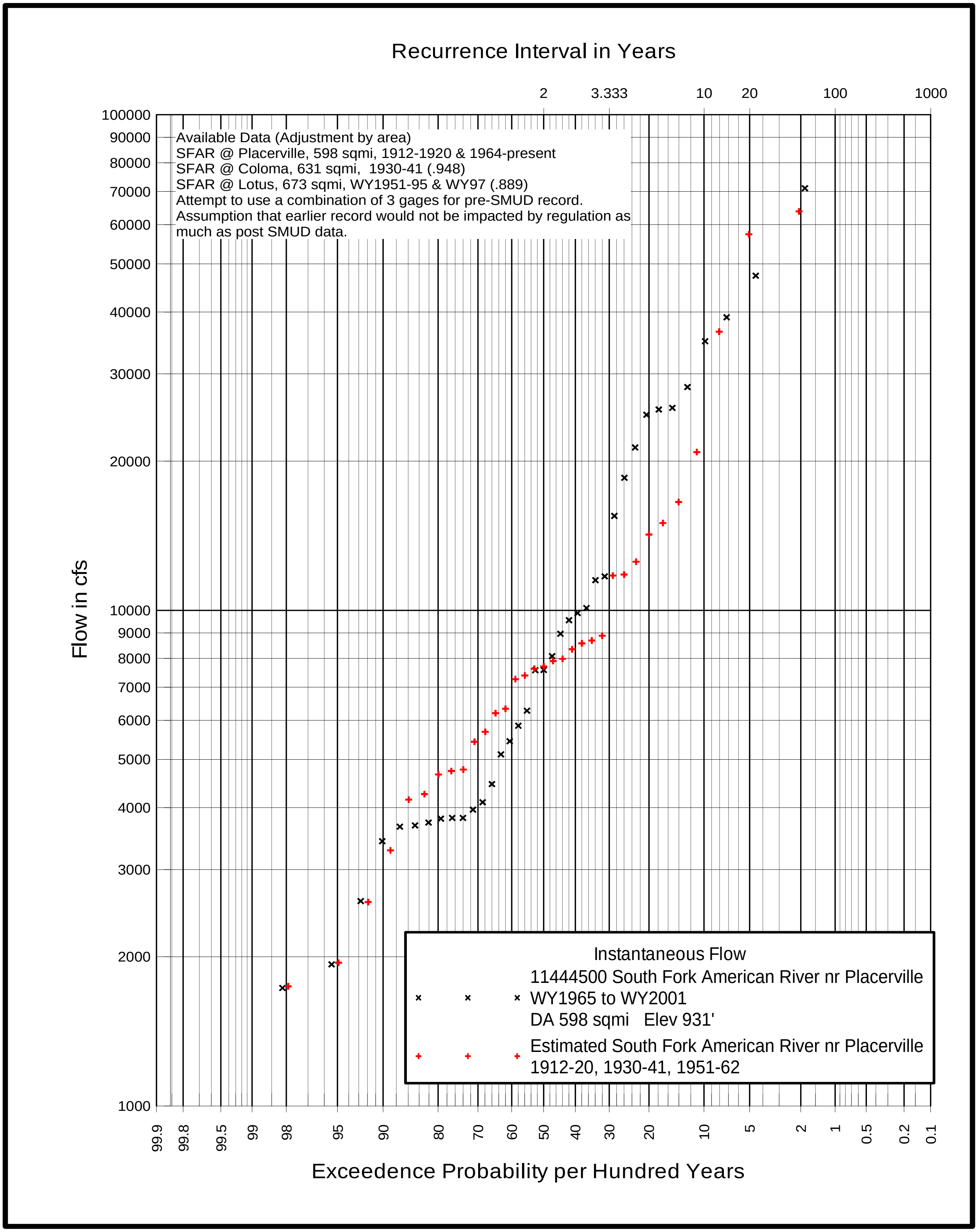

Recurrence Interval in Years
2
3.333
10
20
100
1000
Available Data (Adjustment by area)
SFAR @ Placerville, 598 sqmi, 1912-1920 & 1964-present
SFAR @ Coloma, 631 sqmi, 1930-41 (.948)
SFAR @ Lotus, 673 sqmi, WY1951-95 & WY97 (.889)
Attempt to use a combination of 3 gages for pre-SMUD record.
Assumption that earlier record would not be impacted by regulation as much as post SMUD data.
Flow in cfs
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
Instantaneous Flow
11444500 South Fork American River nr Placerville
WY1965 to WY2001
DA 598 sqmi Elev 931'
Estimated South Fork American River nr Placerville
1912-20, 1930-41, 1951-62
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probability per Hundred Years

Figure 2-3

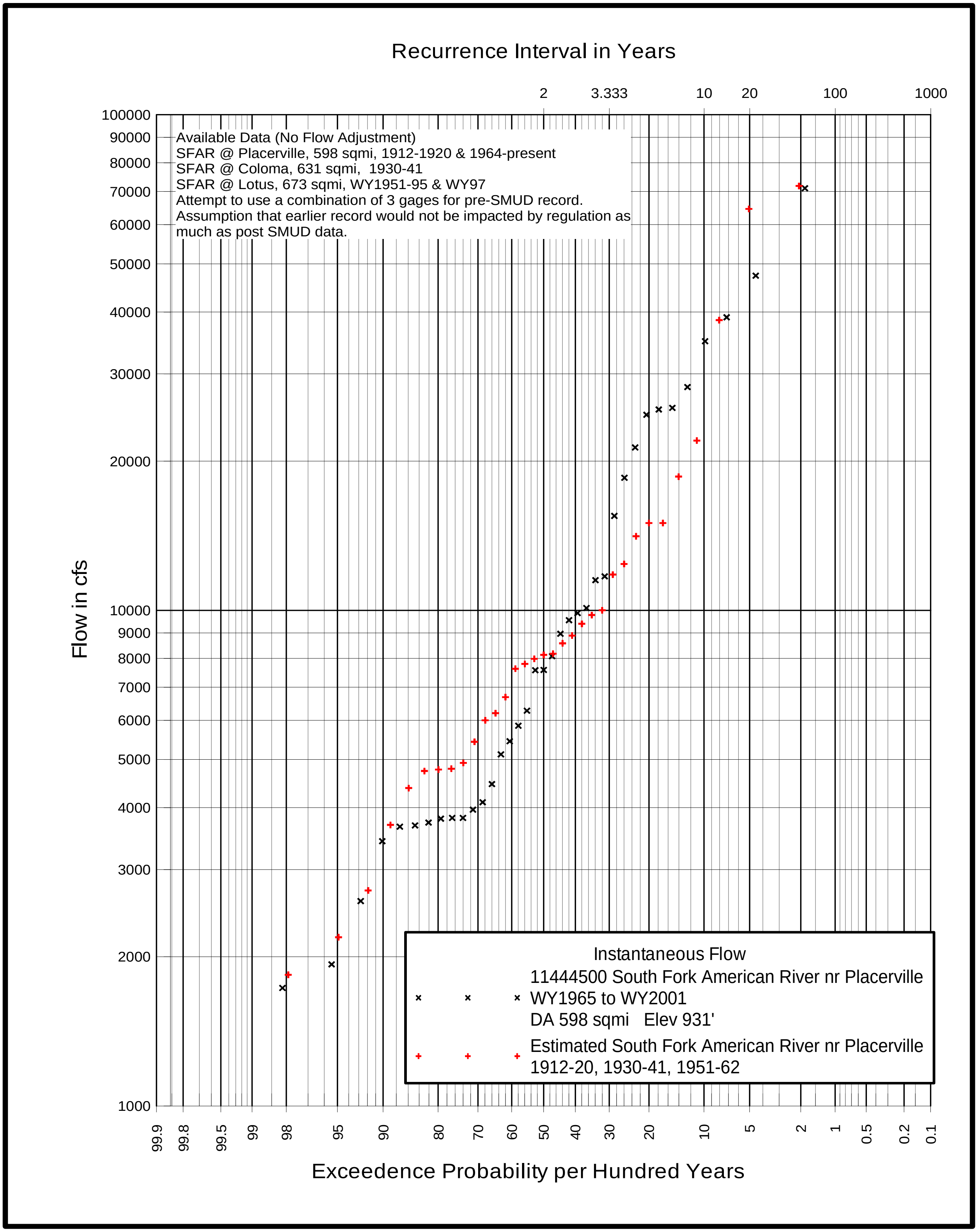

Recurrence Interval in Years
2
3.333
10
20
100
1000
Available Data (No Flow Adjustment)
SFAR @ Placerville, 598 sqmi, 1912-1920 & 1964-present
SFAR @ Coloma, 631 sqmi, 1930-41
SFAR @ Lotus, 673 sqmi, WY1951-95 & WY97
Attempt to use a combination of 3 gages for pre-SMUD record.
Assumption that earlier record would not be impacted by regulation as much as post SMUD data.
Flow in cfs
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
Instantaneous Flow
11444500 South Fork American River nr Placerville
WY1965 to WY2001
DA 598 sqmi Elev 931'
Estimated South Fork American River nr Placerville
1912-20, 1930-41, 1951-62
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probability per Hundred Years

Figure 2-4

UARP Project
Mean Daily Flow

Many of the previous figures span varying hydrological periods. In an attempt to illustrate the potential differences between the use of differing hydrological periods, flood peak frequency curves were prepared for a site where a long-term flow record exists. The unimpaired flow for South Fork Silver Creek near Ice House Reservoir was evaluated. The following plots have been prepared:

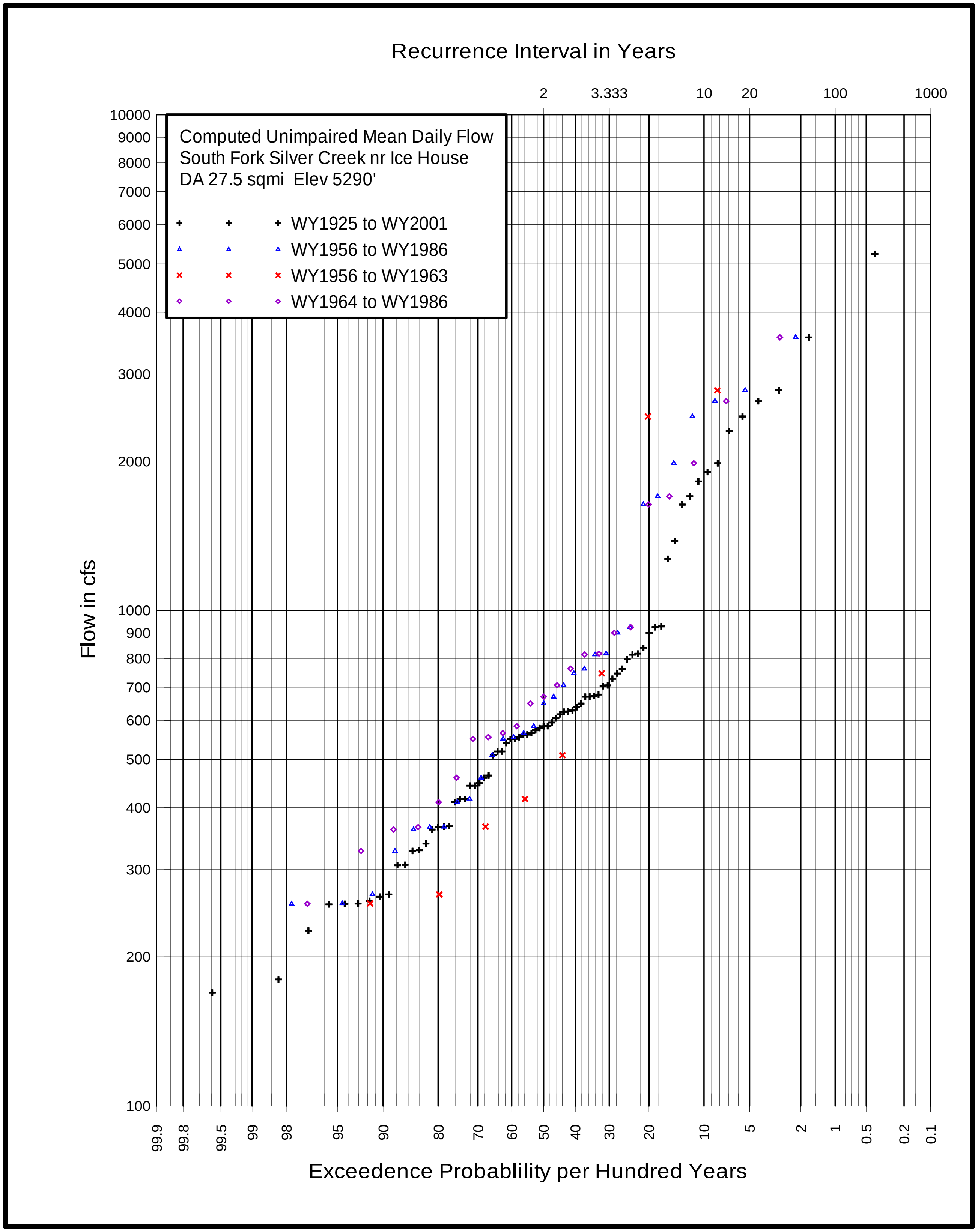
- South Fork Silver Creek near Ice House (Figure 3-1)
    - 1925-2001
    - 1956-1986
    - 1956-1963
    - 1964-1986
    - Compare with Rubicon River at Rubicon Springs near Meeks Bay (Figure 1-1)

- South Fork Silver Creek near Ice House (Figure 3-2)
    - 1956-1963
    - 1964-1986
    - Compare with Rubicon River at Rubicon Springs near Meeks Bay (Figure 1-1)

- South Fork Silver Creek near Ice House (Figure 3-3)
    - 1925-2001
    - 1925-1961
    - 1963-2001
    - Compare with South Fork American River near Camino (Figure 1-8)

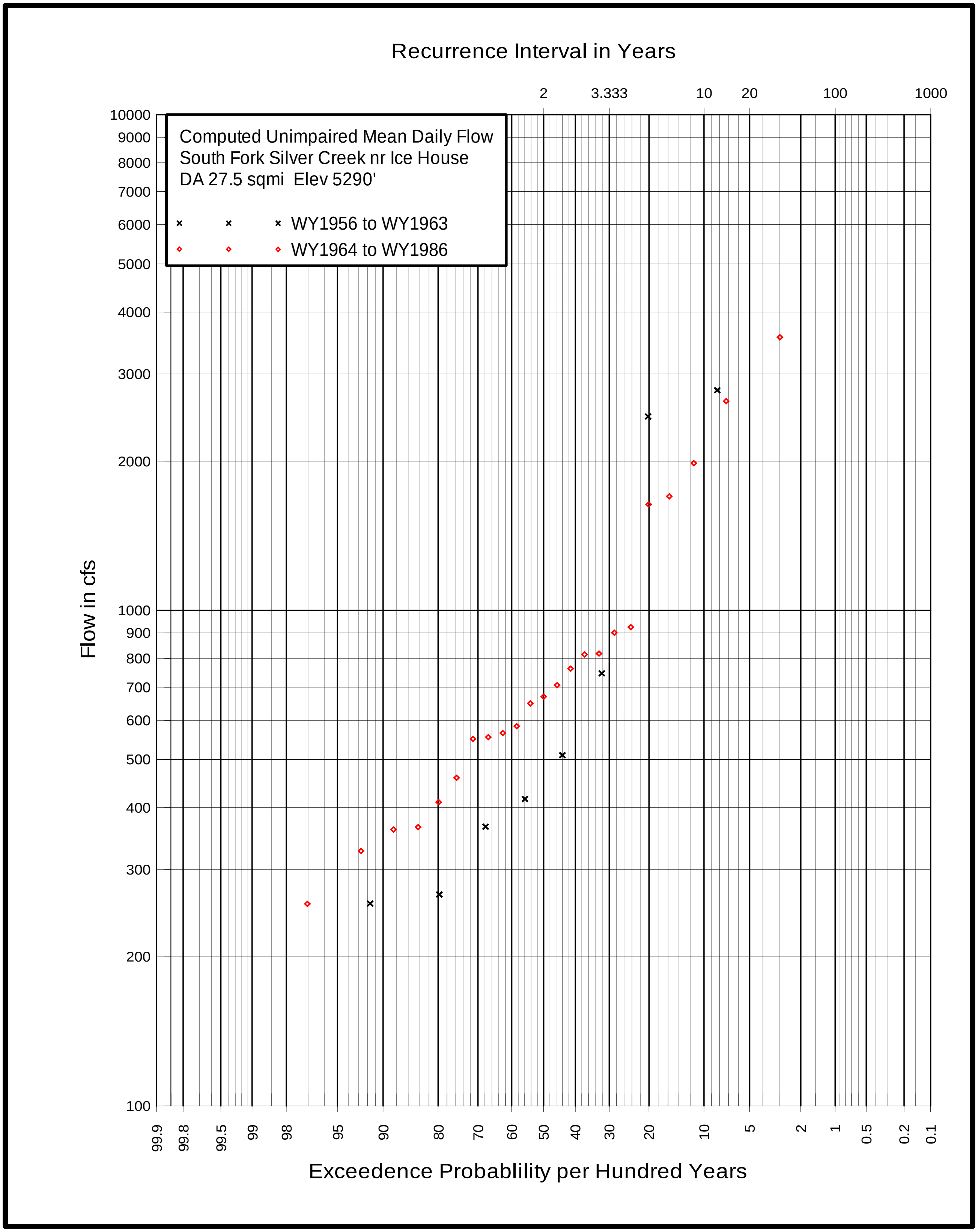
- South Fork Silver Creek near Ice House (Figure 3-4)
    - 1925-2001
    - 1925-1959
    - 1964-2001
    - Compare with
        - Gerle Creek below Loon Lake Dam (Figure 1-2)
        - South Fork Rubicon River below Gerle Creek near Georgetown (Figure 1-3)
        - Silver Creek at Union Valley (Figure 1-6)

- South Fork Silver Creek near Ice House (Figure 3-5)
    - 1925-2001 (excl 60)
    - 1925-1959
    - 1961-1984
    - 1985-2001
    - Compare with South Fork Silver Creek near Ice House (figures 1-4 and 1-5)



Recurrence Interval in Years
2
3.333
10
20
100
1000
Computed Unimpaired Mean Daily Flow
South Fork Silver Creek nr Ice House
DA 27.5 sqmi Elev 5290'
WY1925 to WY2001
WY1956 to WY1986
WY1956 to WY1963
WY1964 to WY1986
Flow in cfs
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probablility per Hundred Years

Figure 3-1



Recurrence Interval in Years
2
3.333
10
20
100
1000
Computed Unimpaired Mean Daily Flow
South Fork Silver Creek nr Ice House
DA 27.5 sqmi Elev 5290'
WY1956 to WY1963
WY1964 to WY1986
Flow in cfs
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probablility per Hundred Years

Figure 3-2

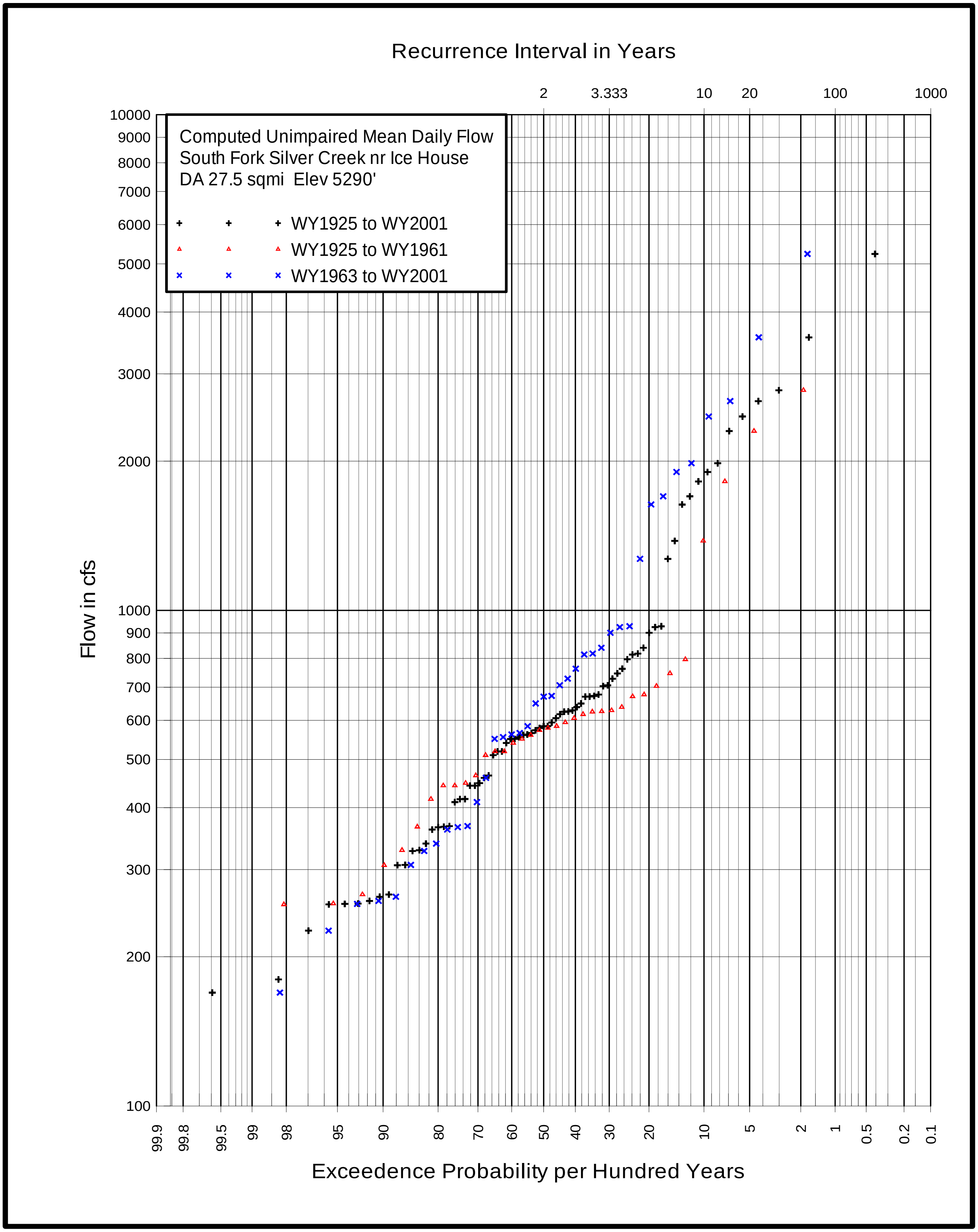

Recurrence Interval in Years
2
3.333
10
20
100
1000
Computed Unimpaired Mean Daily Flow
South Fork Silver Creek nr Ice House
DA 27.5 sqmi Elev 5290'
WY1925 to WY2001
WY1925 to WY1961
WY1963 to WY2001
Flow in cfs
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probability per Hundred Years

Figure 3-3

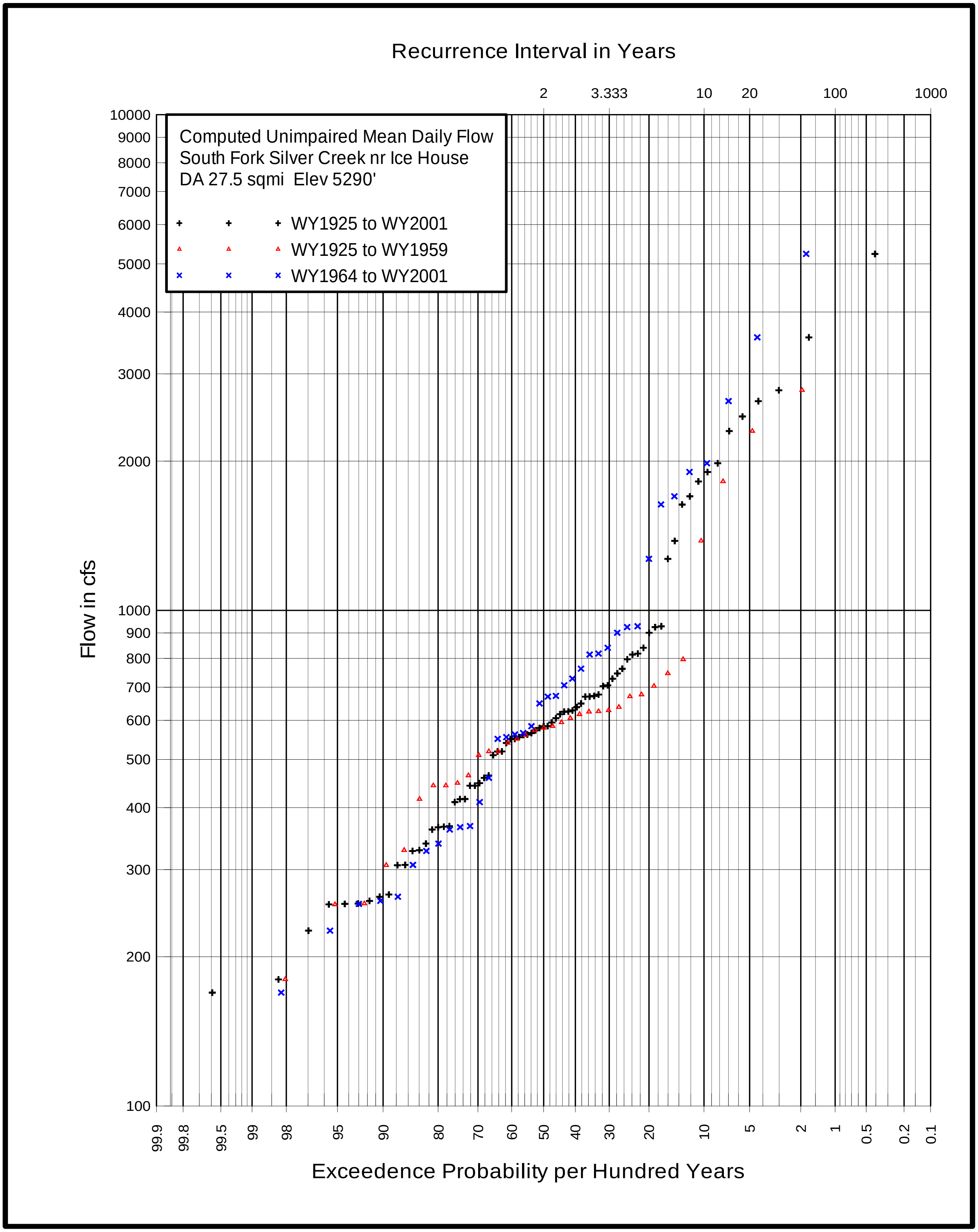
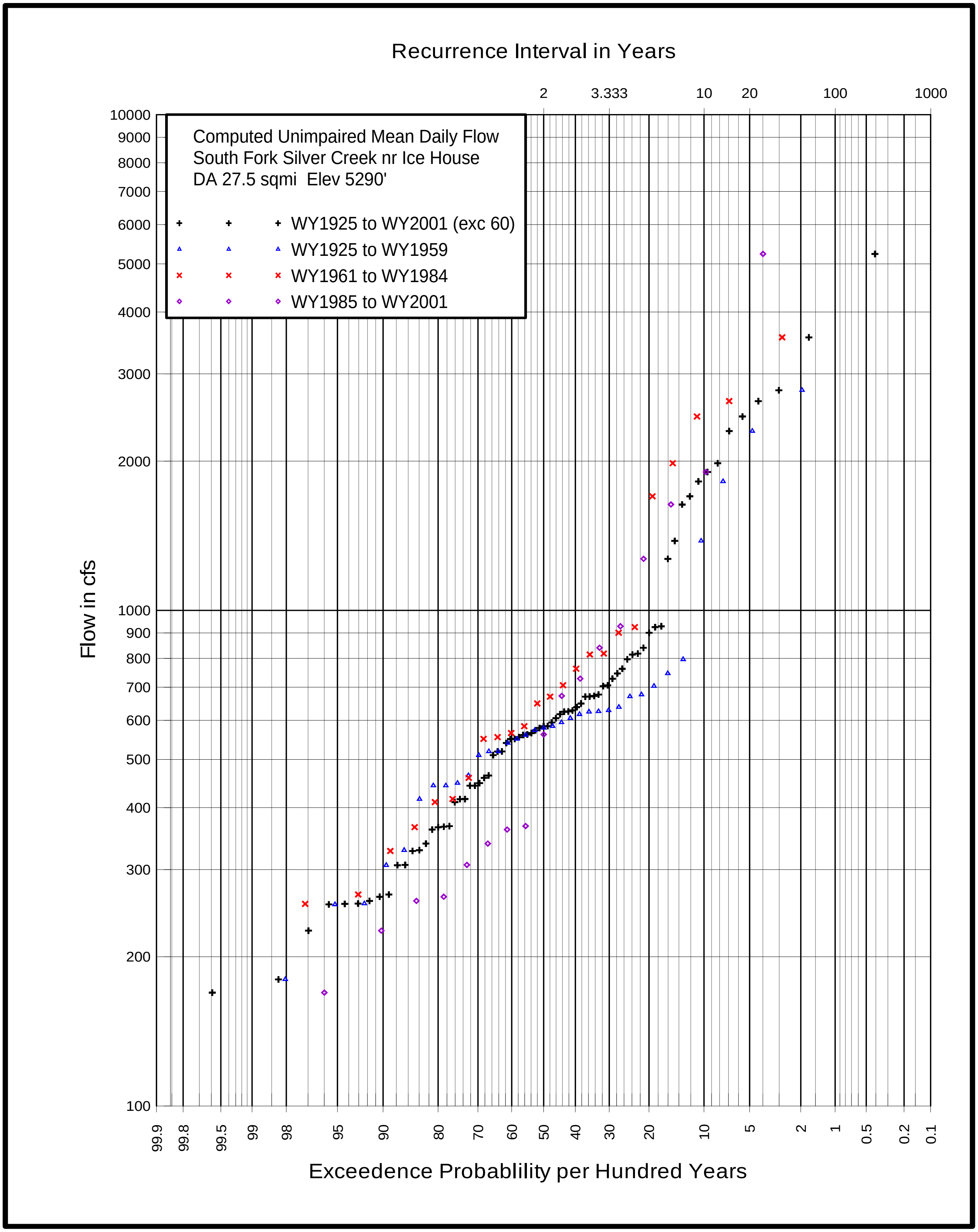

Recurrence Interval in Years
2
3.333
10
20
100
1000
Computed Unimpaired Mean Daily Flow
South Fork Silver Creek nr Ice House
DA 27.5 sqmi Elev 5290'
WY1925 to WY2001
WY1925 to WY1959
WY1964 to WY2001
Flow in cfs
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probability per Hundred Years

Figure 3-4



Recurrence Interval in Years
2
3.333
10
20
100
1000
Computed Unimpaired Mean Daily Flow
South Fork Silver Creek nr Ice House
DA 27.5 sqmi Elev 5290'
WY1925 to WY2001 (exc 60)
WY1925 to WY1959
WY1961 to WY1984
WY1985 to WY2001
Flow in cfs
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probablility per Hundred Years

Figure 3-5

Outside UARP Project
Instantaneous Flow

Additional analyses were performed to allow hydrologic comparisons to be made with basins located outside of the American River Basin. The following plots have been prepared:

- Middle Fork Tuolumne River at Oakland Recreation Camp. USGS rates these records as good. There are small upstream diversions.
  - Figure 4-1
    - 1922-2001, 1922-1959, 1961-1984, 1985-2001
    - Compare with South Fork Silver Creek near Ice House (figures 1-4 and 1-5)
  - Figure 4-2
    - 1922-2001, 1922-1959, 1964-2001
    - Compare with
      - Gerle Creek below Loon Lake Dam (Figure 1-2)
      - South Fork Rubicon River below Gerle Creek near Georgetown (Figure 1-3)
      - South Fork Silver Creek near Ice House (figures 1-4 and 1-5)
      - Silver Creek at Union Valley (Figure 1-6)
  - Figure 4-3
    - 1922-2001, 1923-1961, 1963-2001
    - Compare with South Fork American River near Camino (Figure 1-8)

- Middle Fork Mokelumne River at West Point. USGS rates these records as good. Flow regulated by Middle Fork Reservoir, capacity 1,740 acre-feet and several small diversions upstream.
  - Figure 4-4
    - 1912-20, 1930-1941, 1951-1962, 1965-2001
    - Compare with SFAR @ Placerville (figures 2-1 and 2-4)
  - Figure 4-5
    - 1912-2001, 1912-20, 1930-1941, 1951-1962, 1965-2001
    - Compare with SFAR @ Placerville (figures 2-1 and 2-4)
  - Figure 4-6
    - 1922-2001, 1922-1959, 1961-1984, 1985-2001
    - Compare with South Fork Silver Creek near Ice House (figures 1-4 and 1-5)

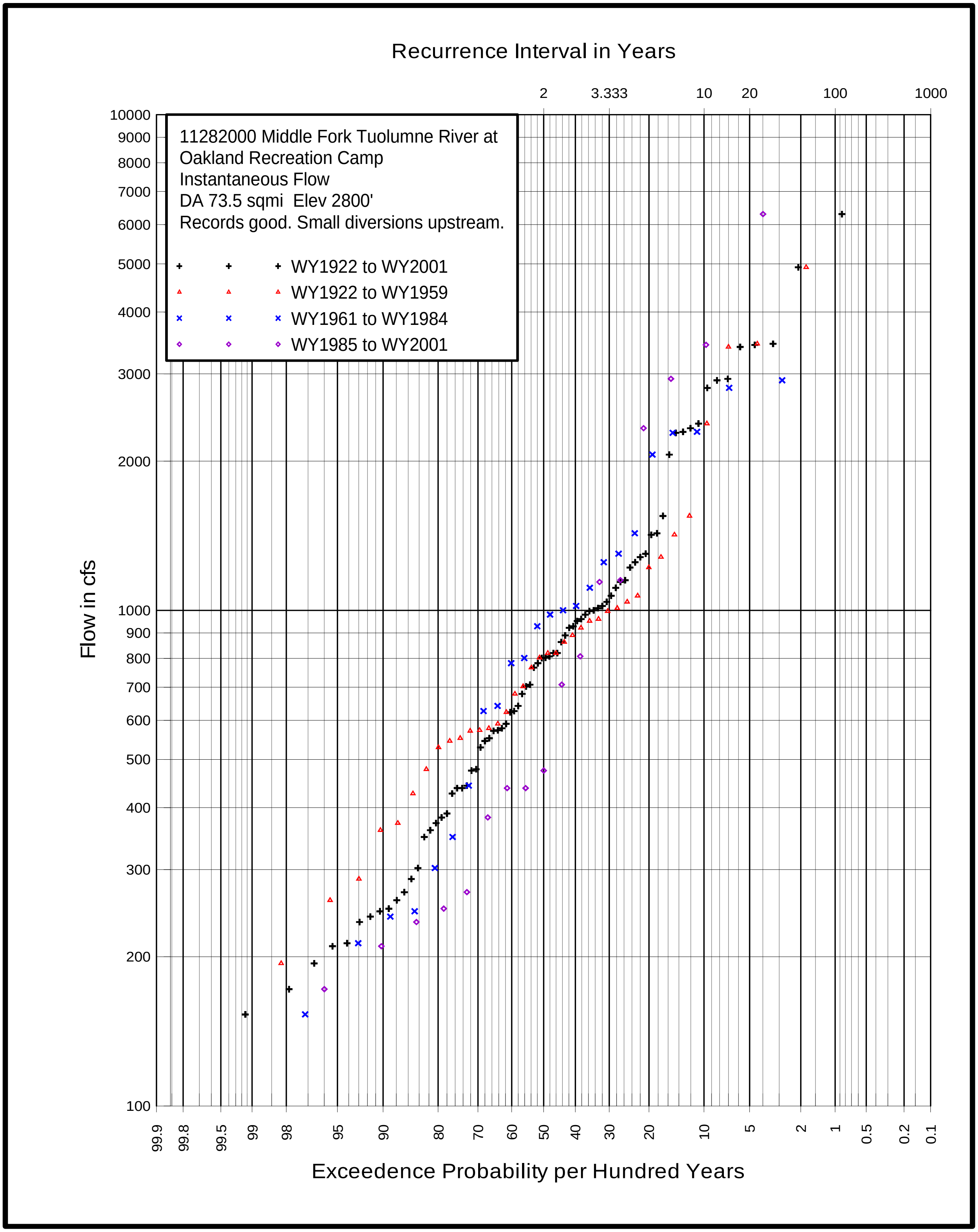
    - Figure 4-7
        - 1916-2001, 1922-1959, 1964-2001
        - Compare with
            - Gerle Creek below Loon Lake Dam (Figure 1-2)
            - South Fork Rubicon River below Gerle Creek near Georgetown (Figure 1-3)
            - South Fork Silver Creek near Ice House (figures 1-4 and 1-5)
            - Silver Creek at Union Valley (Figure 1-6)
    - Figure 4-8
        - 1916-2001, 1923-1961, 1963-2001
        - Compare with South Fork American River near Camino (Figure 1-8)

- Merced River at Happy Isle Bridge. USGS rates these records as good. Small diversions upstream.
    - Figure 4-9
        - 1916-20, 1930-1941, 1951-1962, 1965-2001
        - Compare with SFAR @ Placerville (figures 2-1 and 2-4)
    - Figure 4-10
        - 1916-2001, 1916-20, 1930-1941, 1951-1962, 1965-2001
        - Compare with SFAR @ Placerville (figures 2-1 and 2-4)
    - Figure 4-11
        - 1922-2001, 1922-1959, 1961-1984, 1985-2001
        - Compare with South Fork Silver Creek near Ice House (figures 1-4 and 1-5)
    - Figure 4-12
        - 1916-2001, 1922-1959, 1964-2001
        - Compare with
            - Gerle Creek below Loon Lake Dam (Figure 1-2)
            - South Fork Rubicon River below Gerle Creek near Georgetown (Figure 1-3)
            - South Fork Silver Creek near Ice House (figures 1-4 and 1-5)
            - Silver Creek at Union Valley (Figure 1-6)
    - Figure 4-13
        - 1916-2001, 1923-1961, 1963-2001
        - Compare with South Fork American River near Camino (Figure 1-8)

- Cole Creek near Salt Springs Dam. Occasional pumping for summer use.
    - Figure 4-14
        - 1928-2001 (excl 76), 1928-1959, 1961-1984 (excl 76), 1985-2001
        - Compare with South Fork Silver Creek near Ice House (figures 1-4 and 1-5)

  - Figure 4-15
    - 1928-2001 (excl 76), 1956-1963, 1964-1986 (excl 76)
    - Compare with Rubicon River at Rubicon Springs near Meeks Bay (Figure 1-1)

- North Fork Yuba River below Goodyears Bar. USGS rates these records as good. Small diversions upstream.
  - Figure 4-16
    - 1931-2001, 1931-1959, 1961-1984, 1985-2001
    - Compare with South Fork Silver Creek near Ice House (figures 1-4 and 1-5)



Recurrence Interval in Years
2
3.333
10
20
100
1000
11282000 Middle Fork Tuolumne River at
Oakland Recreation Camp
Instantaneous Flow
DA 73.5 sqmi Elev 2800'
Records good. Small diversions upstream.
WY1922 to WY2001
WY1922 to WY1959
WY1961 to WY1984
WY1985 to WY2001
Flow in cfs
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probability per Hundred Years

Figure 4-1

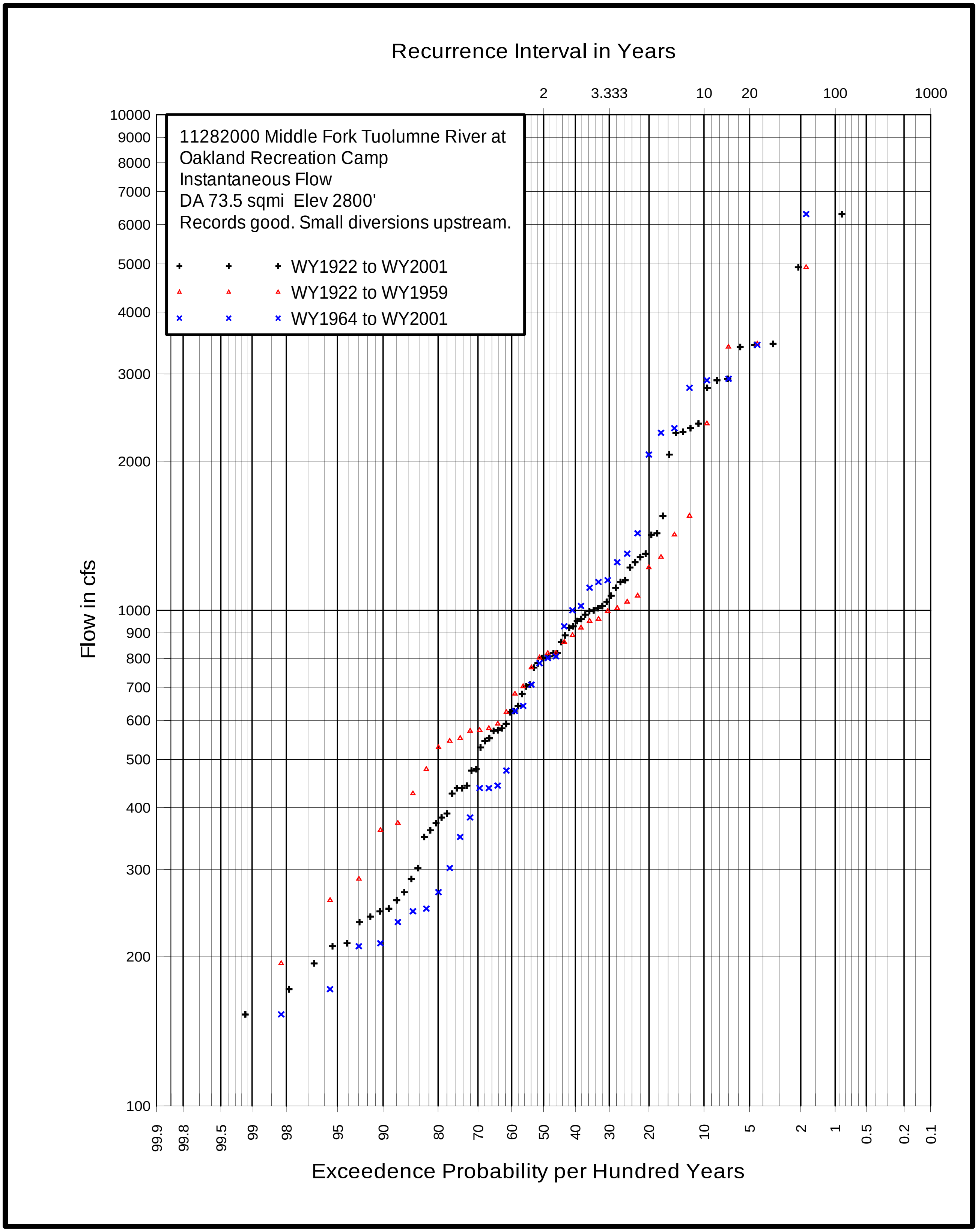

Recurrence Interval in Years
2
3.333
10
20
100
1000
11282000 Middle Fork Tuolumne River at
Oakland Recreation Camp
Instantaneous Flow
DA 73.5 sqmi Elev 2800'
Records good. Small diversions upstream.
WY1922 to WY2001
WY1922 to WY1959
WY1964 to WY2001
Flow in cfs
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probability per Hundred Years

Figure 4-2

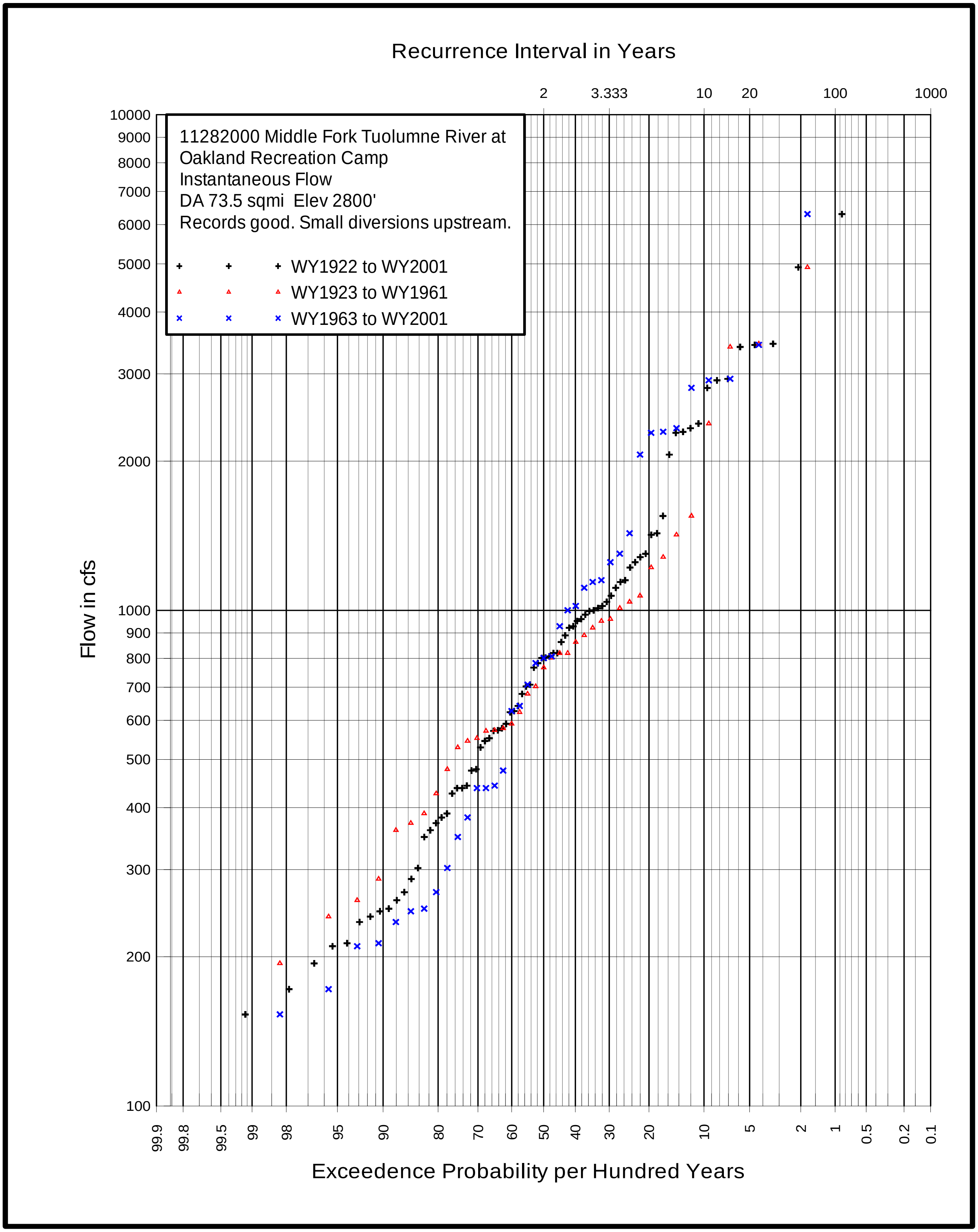

Recurrence Interval in Years
2
3.333
10
20
100
1000
11282000 Middle Fork Tuolumne River at
Oakland Recreation Camp
Instantaneous Flow
DA 73.5 sqmi Elev 2800'
Records good. Small diversions upstream.
WY1922 to WY2001
WY1923 to WY1961
WY1963 to WY2001
Flow in cfs
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probability per Hundred Years

Figure 4-3

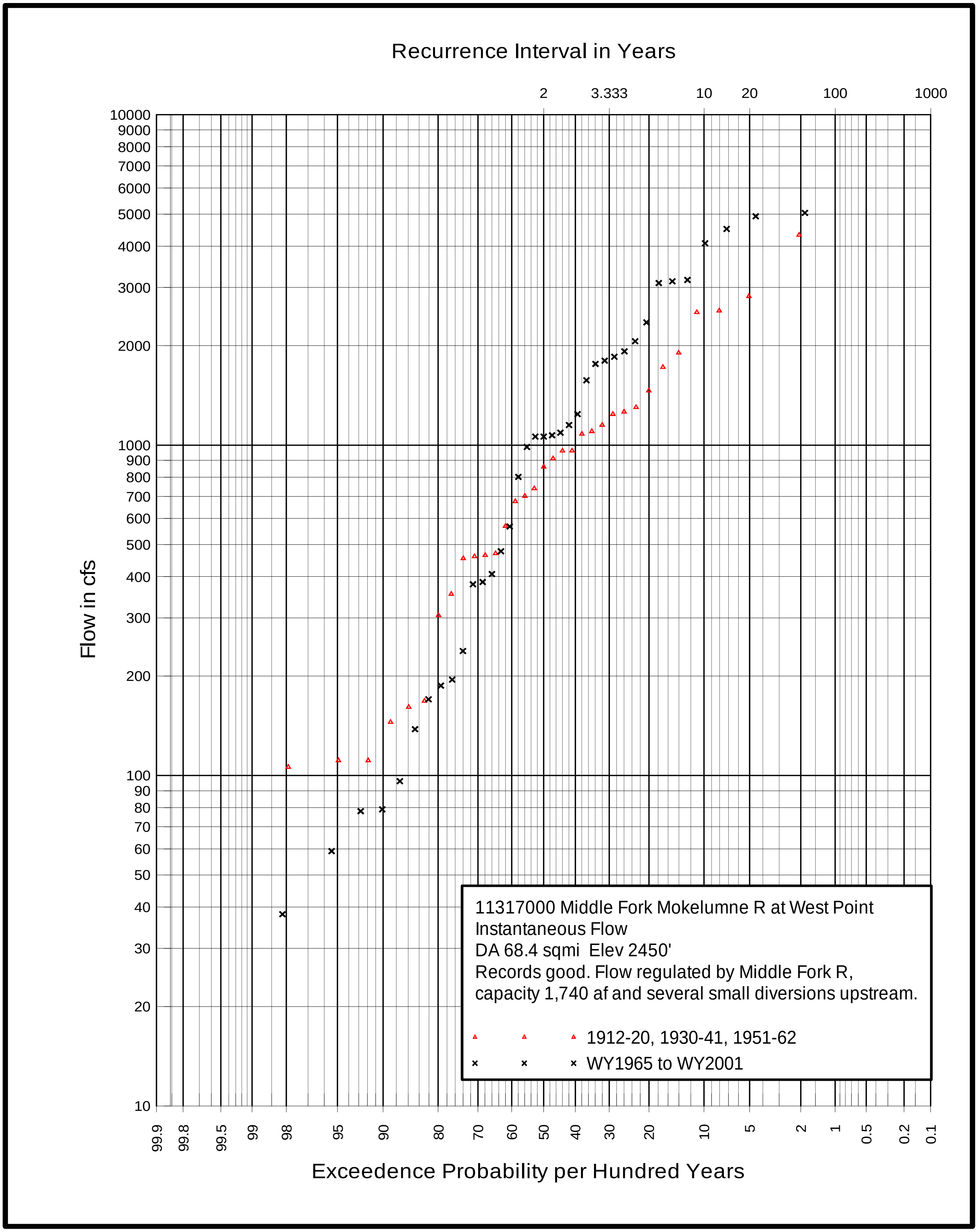

Recurrence Interval in Years
2
3.333
10
20
100
1000
Flow in cfs
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probability per Hundred Years
11317000 Middle Fork Mokelumne R at West Point
Instantaneous Flow
DA 68.4 sqmi Elev 2450'
Records good. Flow regulated by Middle Fork R, capacity 1,740 af and several small diversions upstream.
1912-20, 1930-41, 1951-62
WY1965 to WY2001

Figure 4-4

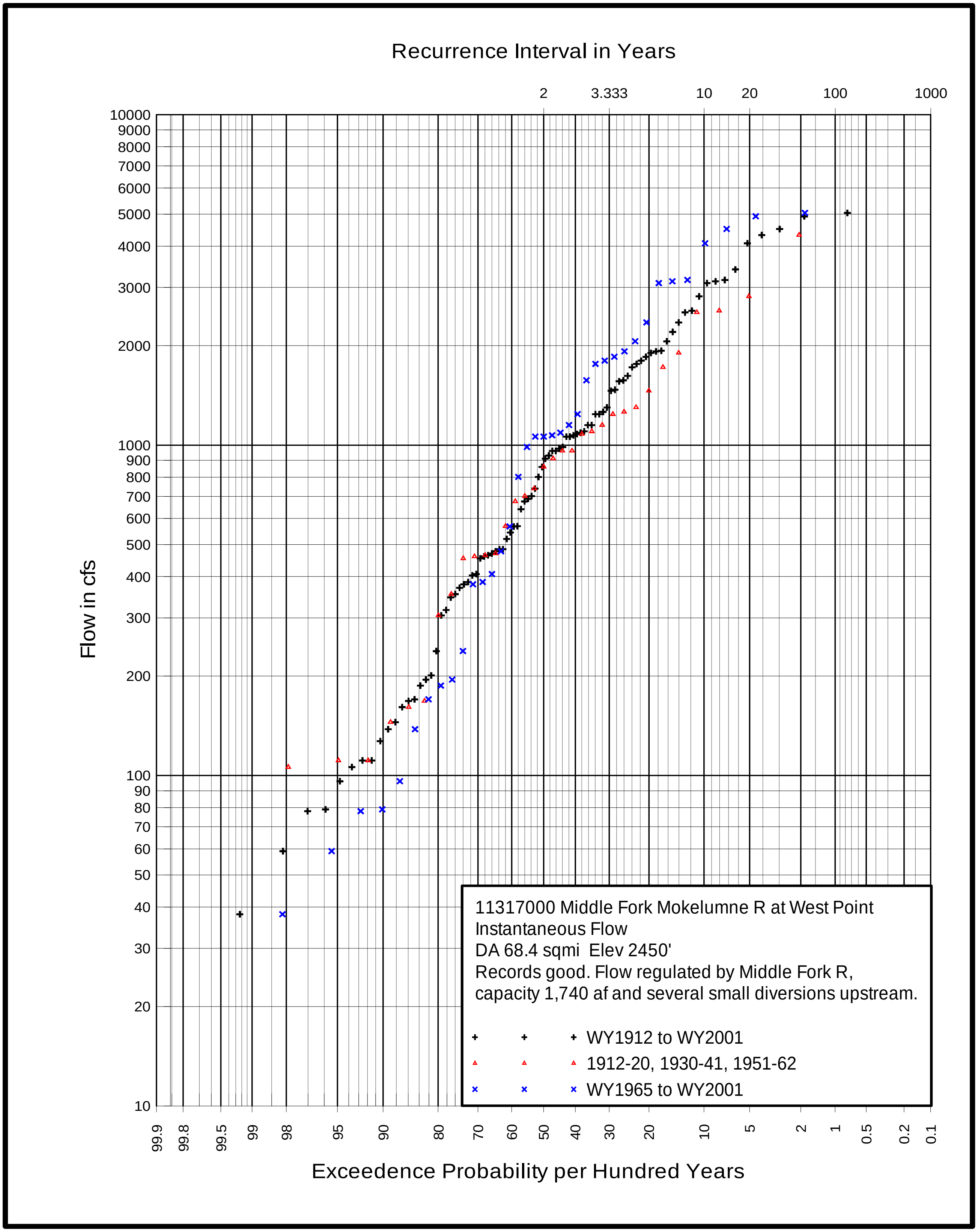
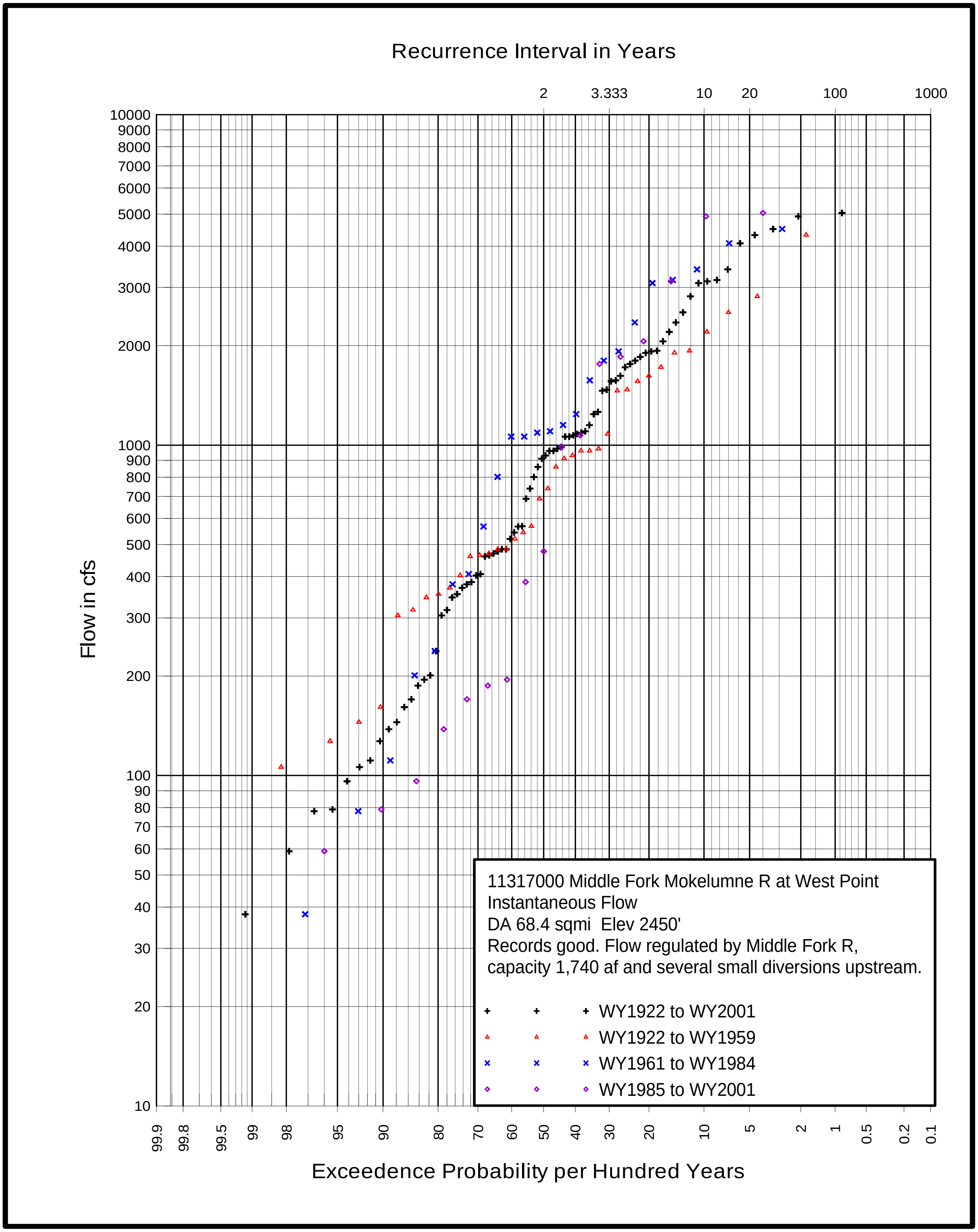
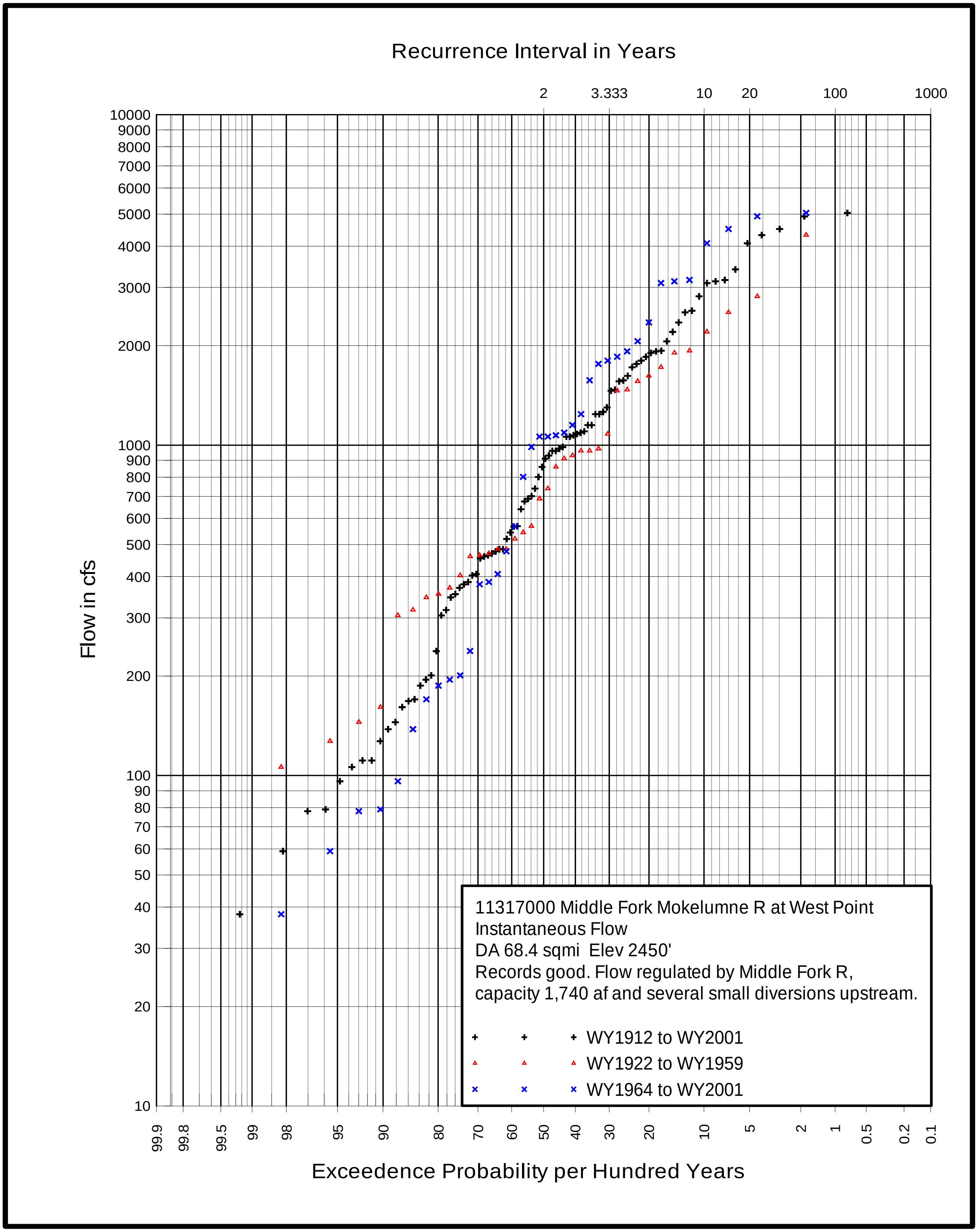

Recurrence Interval in Years
2
3.333
10
20
100
1000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
Flow in cfs
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probability per Hundred Years
11317000 Middle Fork Mokelumne R at West Point
Instantaneous Flow
DA 68.4 sqmi Elev 2450'
Records good. Flow regulated by Middle Fork R, capacity 1,740 af and several small diversions upstream.
WY1912 to WY2001
1912-20, 1930-41, 1951-62
WY1965 to WY2001

Figure 4-5



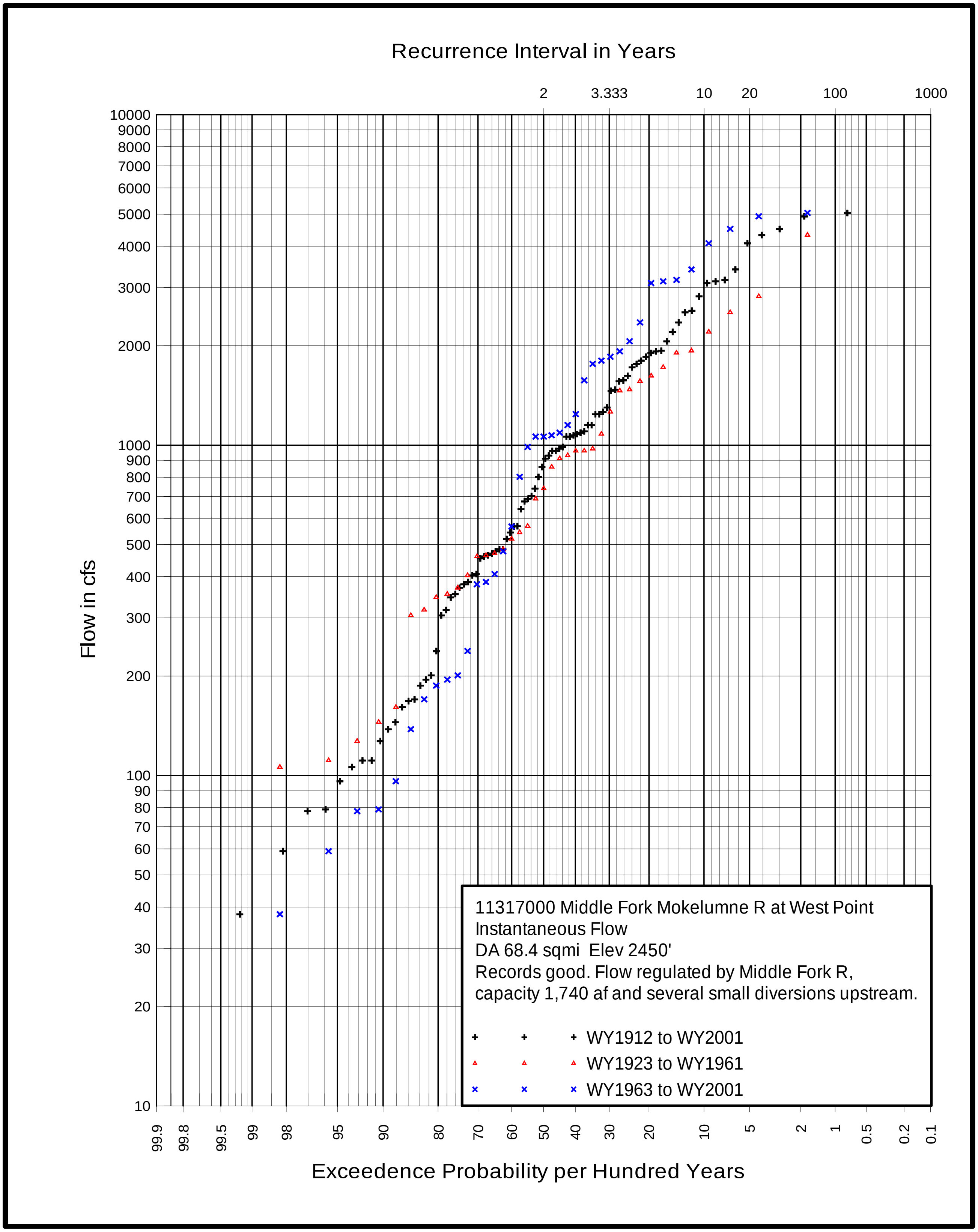
Recurrence Interval in Years
2
3.333
10
20
100
1000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
Flow in cfs
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probability per Hundred Years
11317000 Middle Fork Mokelumne R at West Point
Instantaneous Flow
DA 68.4 sqmi Elev 2450'
Records good. Flow regulated by Middle Fork R,
capacity 1,740 af and several small diversions upstream.
WY1922 to WY2001
WY1922 to WY1959
WY1961 to WY1984
WY1985 to WY2001

Figure 4-6



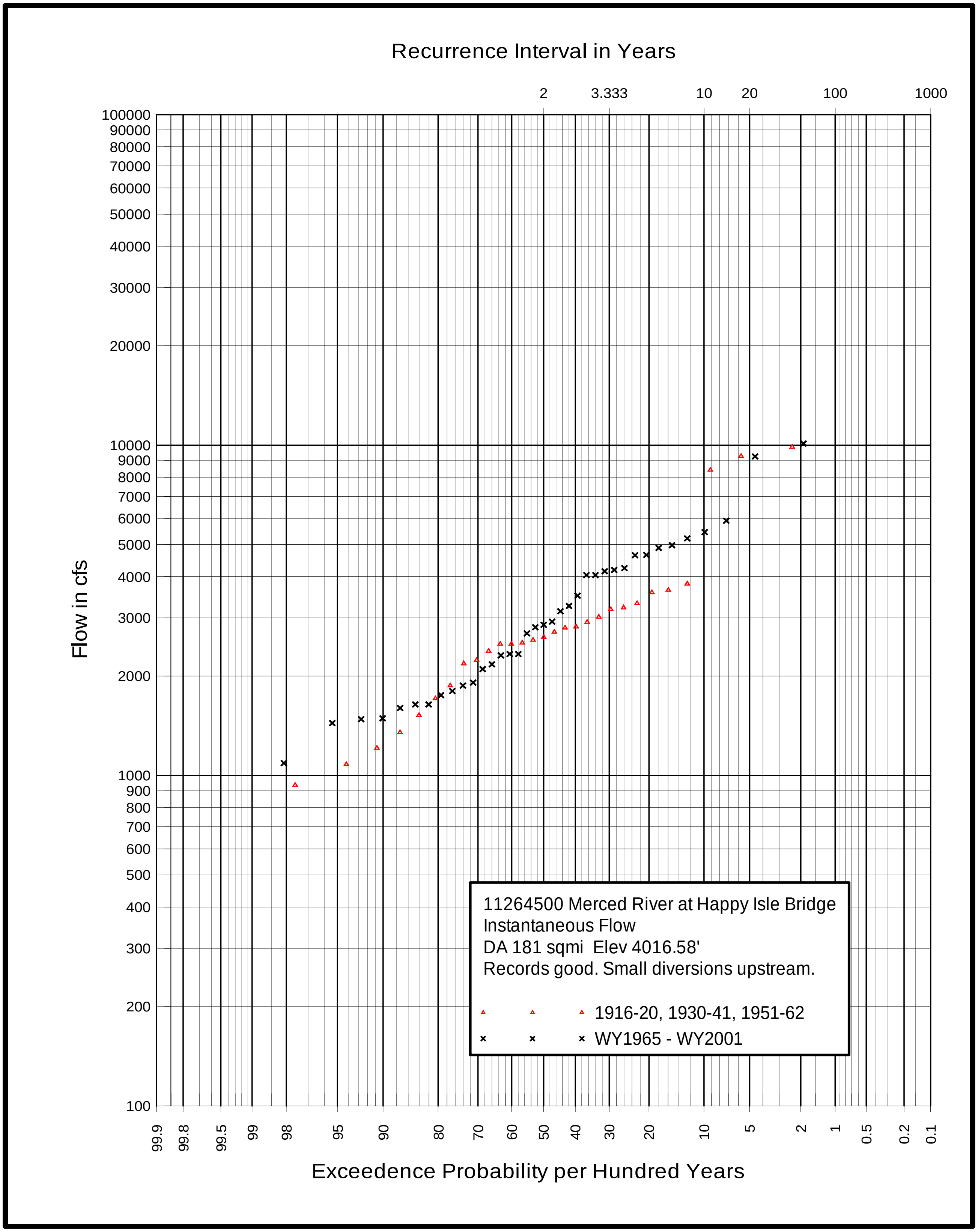
Recurrence Interval in Years
2
3.333
10
20
100
1000
Flow in cfs
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probability per Hundred Years
11317000 Middle Fork Mokelumne R at West Point
Instantaneous Flow
DA 68.4 sqmi Elev 2450'
Records good. Flow regulated by Middle Fork R, capacity 1,740 af and several small diversions upstream.
WY1912 to WY2001
WY1922 to WY1959
WY1964 to WY2001

Figure 4-7



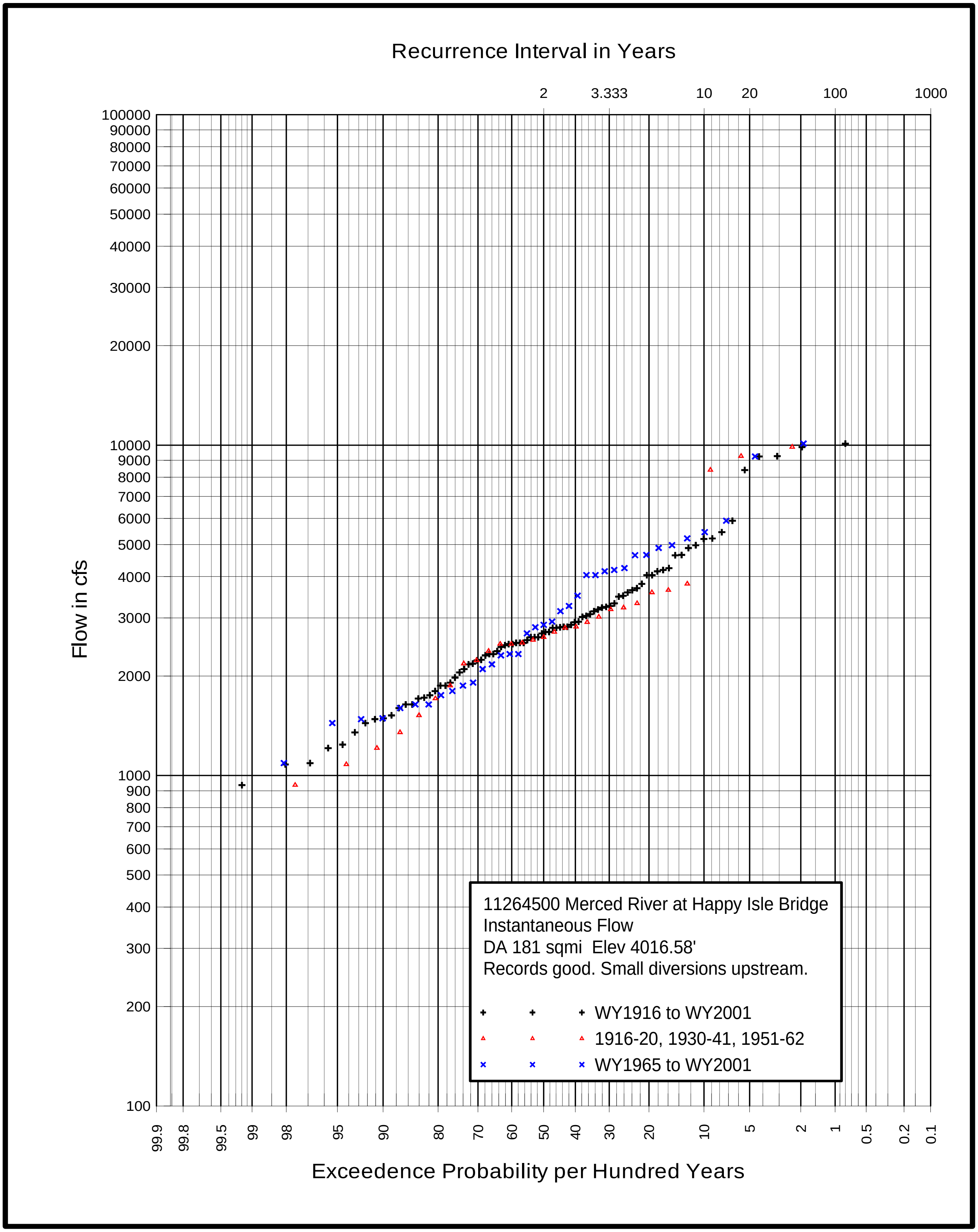
Recurrence Interval in Years
2
3.333
10
20
100
1000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
Flow in cfs
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probability per Hundred Years
11317000 Middle Fork Mokelumne R at West Point
Instantaneous Flow
DA 68.4 sqmi Elev 2450'
Records good. Flow regulated by Middle Fork R,
capacity 1,740 af and several small diversions upstream.
WY1912 to WY2001
WY1923 to WY1961
WY1963 to WY2001

Figure 4-8



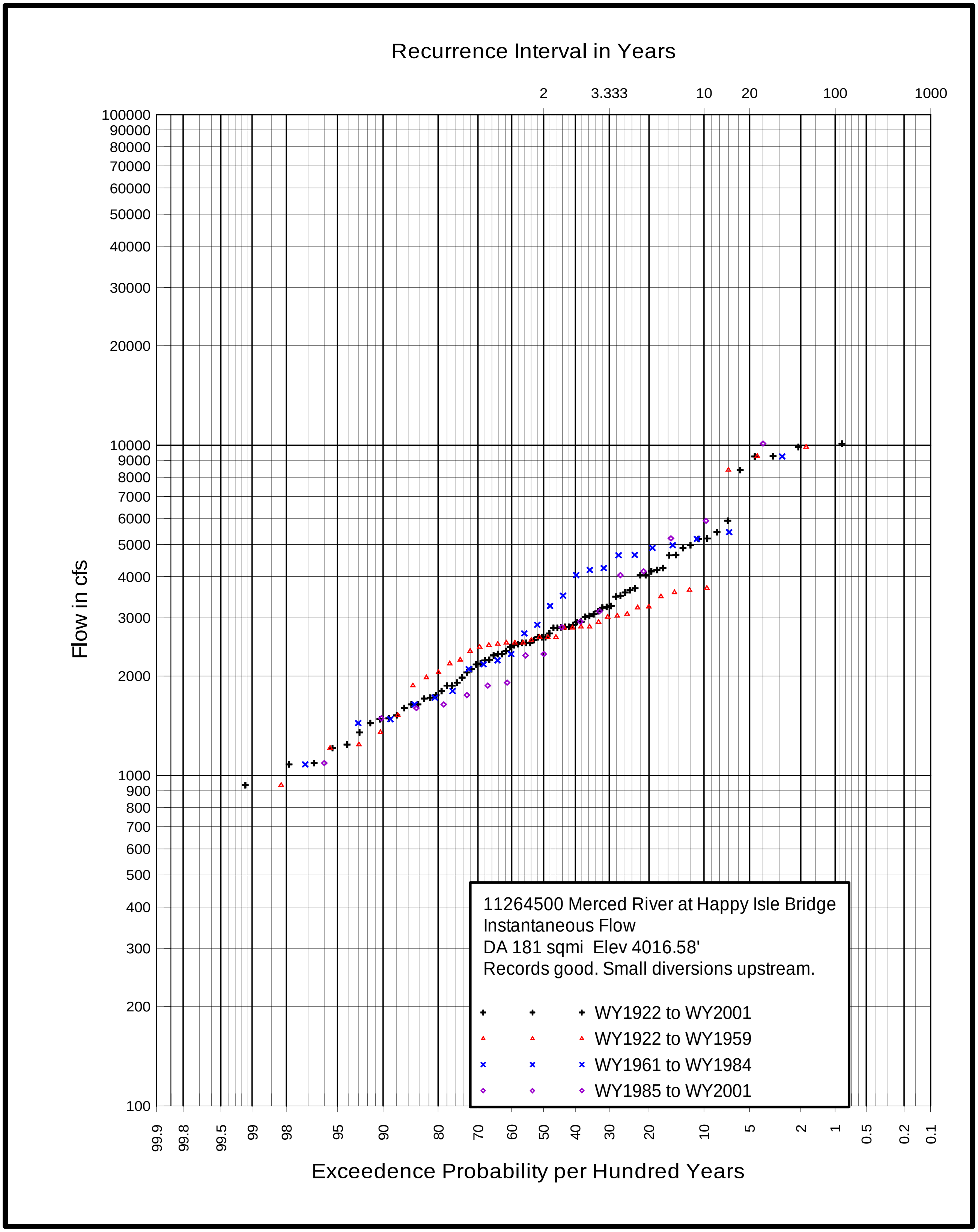
Recurrence Interval in Years
2
3.333
10
20
100
1000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
Flow in cfs
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probability per Hundred Years
11264500 Merced River at Happy Isle Bridge
Instantaneous Flow
DA 181 sqmi Elev 4016.58'
Records good. Small diversions upstream.
1916-20, 1930-41, 1951-62
WY1965 - WY2001

Figure 4-9



Recurrence Interval in Years
2
3.333
10
20
100
1000
Flow in cfs
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probability per Hundred Years
11264500 Merced River at Happy Isle Bridge
Instantaneous Flow
DA 181 sqmi Elev 4016.58'
Records good. Small diversions upstream.
WY1916 to WY2001
1916-20, 1930-41, 1951-62
WY1965 to WY2001

Figure 4-10



Recurrence Interval in Years
2
3.333
10
20
100
1000
Flow in cfs
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probability per Hundred Years
11264500 Merced River at Happy Isle Bridge
Instantaneous Flow
DA 181 sqmi Elev 4016.58'
Records good. Small diversions upstream.
WY1922 to WY2001
WY1922 to WY1959
WY1961 to WY1984
WY1985 to WY2001

Figure 4-11

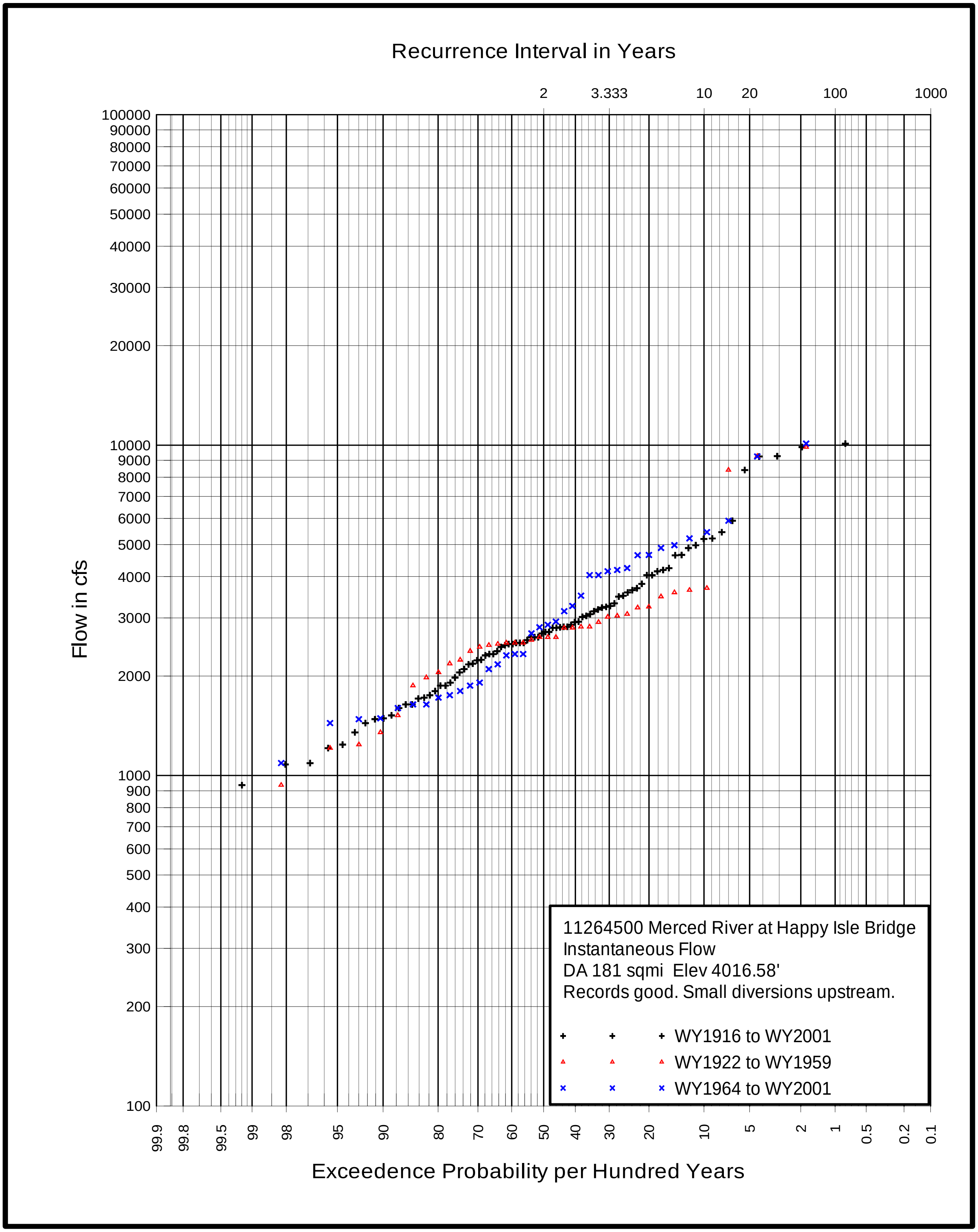
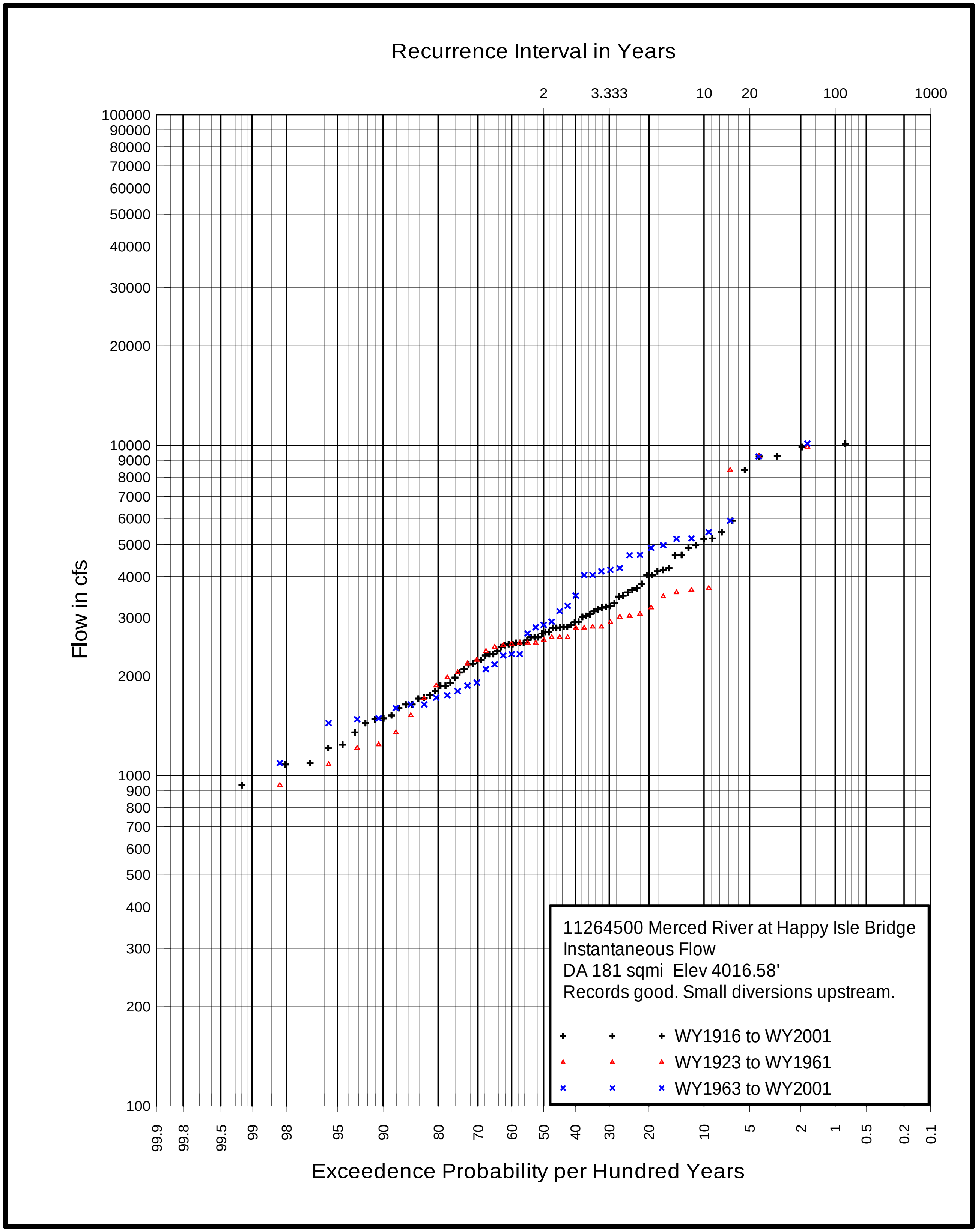

Recurrence Interval in Years
2
3.333
10
20
100
1000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
Flow in cfs
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probability per Hundred Years
11264500 Merced River at Happy Isle Bridge
Instantaneous Flow
DA 181 sqmi Elev 4016.58'
Records good. Small diversions upstream.
WY1916 to WY2001
WY1922 to WY1959
WY1964 to WY2001

Figure 4-12



Recurrence Interval in Years
2
3.333
10
20
100
1000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
Flow in cfs
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probability per Hundred Years
11264500 Merced River at Happy Isle Bridge
Instantaneous Flow
DA 181 sqmi Elev 4016.58'
Records good. Small diversions upstream.
WY1916 to WY2001
WY1923 to WY1961
WY1963 to WY2001

Figure 4-13

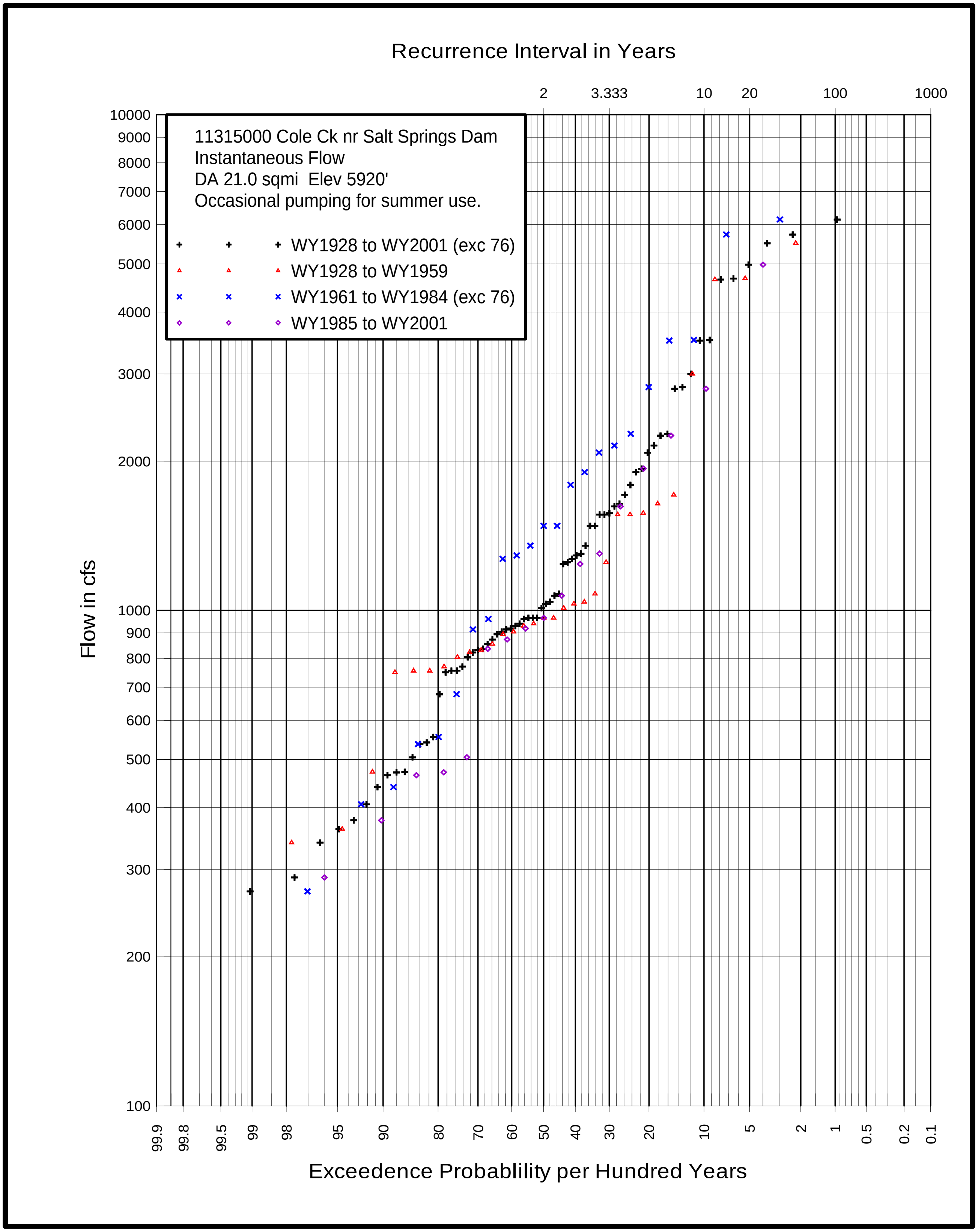
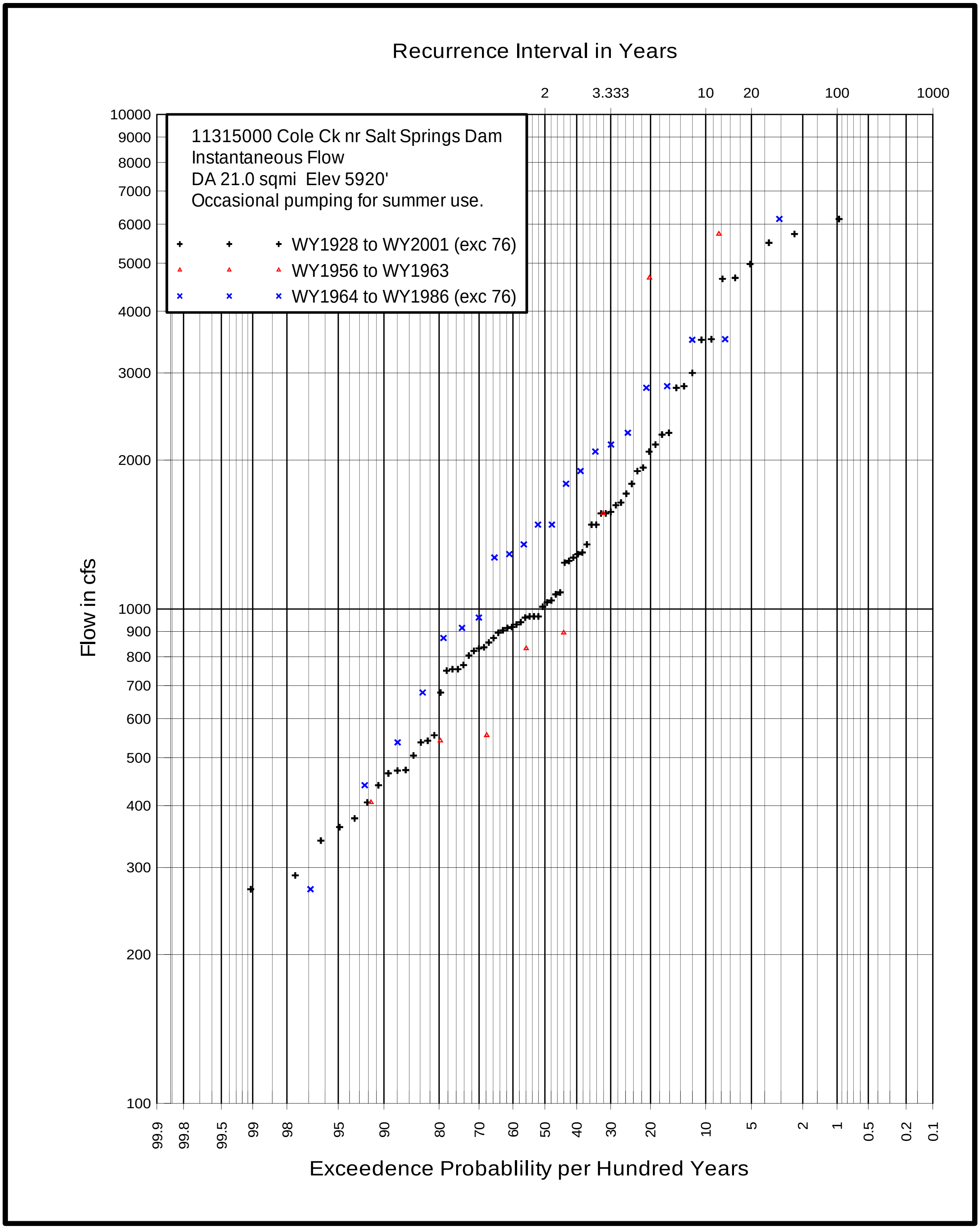

Recurrence Interval in Years
2
3.333
10
20
100
1000
11315000 Cole Ck nr Salt Springs Dam
Instantaneous Flow
DA 21.0 sqmi Elev 5920'
Occasional pumping for summer use.
WY1928 to WY2001 (exc 76)
WY1928 to WY1959
WY1961 to WY1984 (exc 76)
WY1985 to WY2001
Flow in cfs
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probablility per Hundred Years

Figure 4-14



Recurrence Interval in Years
2
3.333
10
20
100
1000
11315000 Cole Ck nr Salt Springs Dam
Instantaneous Flow
DA 21.0 sqmi Elev 5920'
Occasional pumping for summer use.
WY1928 to WY2001 (exc 76)
WY1956 to WY1963
WY1964 to WY1986 (exc 76)
Flow in cfs
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probablility per Hundred Years

Figure 4-15

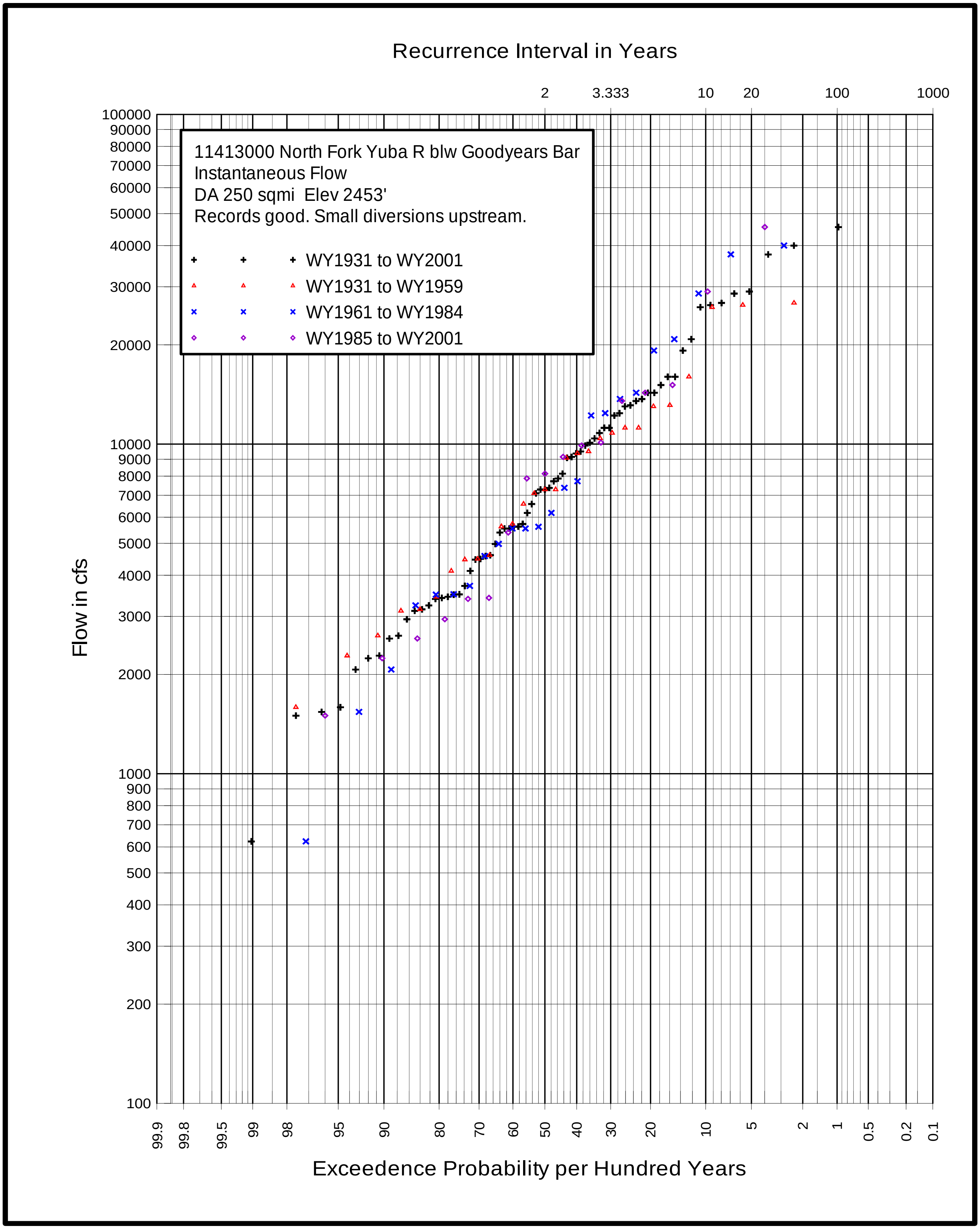

Recurrence Interval in Years
2
3.333
10
20
100
1000
11413000 North Fork Yuba R blw Goodyears Bar
Instantaneous Flow
DA 250 sqmi Elev 2453'
Records good. Small diversions upstream.
WY1931 to WY2001
WY1931 to WY1959
WY1961 to WY1984
WY1985 to WY2001
Flow in cfs
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
99.9
99.8
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Probability per Hundred Years

Figure 4-16