PCWA-L-214

Placer County Water Agency

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July 28, 2005

Mr. Takeshi Yamashita, Regional Engineer
FEDERAL ENERGY REGULATORY COMMISSION
901 Market Street, Suite 350
San Francisco, CA 94103-1778

Attention: Mr. John Onderdonk

RE: FERC Project No. 2079 - CA
Middle Fork American River Project
Addendum to the May 2004 PMF Determination
Hell Hole, Interbay, and Ralston Afterbay Dams

Dear Mr. Yamashita:

In response to your April 29, 2005 letter, our consultant Mead & Hunt has reevaluated their "May 2004 Probable Maximum Flood (PMF) Determination for Hell Hole, Interbay and Ralston Afterbay Dams" in the enclosed addendum dated July 2005. The May 2004 study was originally submitted to FERC by our letter dated July 6, 2004. Three copies of the July 2005 addendum, including CDs with HEC-1 input / output files and other documentation, are provided.

In the July 2005 addendum, Mead & Hunt addresses the items in your April 29, 2005 letter, and also considers recent findings from Mead & Hunt's supplement to their June 2003 LL Anderson Dam PMF study, which was submitted by our July 15, 2005 letter to FERC.

The changes in PMF flows and methods of analysis between the May 2004 study and the July 2005 addendum are summarized below:

Dam	PMF – May 2004 Study	PMF – July 2005 Addendum	Change in PMF flow
Hell Hole	85,800 cfs @ w.s. elev. 4647.1	98,600 cfs @ w.s. elev. 4648.9	+15%
Interbay	64,700 cfs @ w.s. elev. 2544.1	89,500 cfs @ w.s. elev. 2550.4	+38%
Ralston	276,200 cfs @ w.s. elev. 1200.4	314,900 cfs @ w.s. elev. 1204.0	+14%

- Use of the energy-budget snowmelt calculation
- Use of a wind sequence based on maximum observed wind speeds near Hell Hole Reservoir
- Rearrangement of the temporal sequence of precipitation by moving the peak increment later in the sequence
- Assumption that L.L. Anderson Dam, which controls about half the area tributary to Interbay Dam, is modified to pass the recently revised PMF with no increase in elevation or storage

Please call Jon Mattson or me at (530) 885-6917, or e-mail me at sjones@pcwa.net, if you have any questions.

Sincerely,

PLACER COUNTY WATER AGENCY

Stephen J. Jones

Stephen J. Jones
Power System Manager

Enclosure

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Addendum to the May 2004 *Probable Maximum Flood Determination*

(final)

Hell Hole, Interbay, and Ralston Afterbay Dams

FERC Project No. 2079

Report prepared by

MEAD & HUNT

www.meadhunt.com

July 2005

Table of Contents

Exhibits

Tables

1. Summary

This report documents supplemental analyses performed in response to the Federal Energy Regulatory Commission's (FERC) comments on the May 2004 *Probable Maximum Flood Determination, Hell Hole, Interbay, and Ralston Dams.* In that report (henceforth referred to as the "2004 report" or "2004 study") Mead & Hunt, Inc. described analyses undertaken to establish the Probable Maximum Flood (PMF) inflow and outflow hydrographs at three facilities of the Placer County Water Agency's (Water Agency) Middle Fork American River Project. Changes to the 2004 analysis consisted of (1) using an energy budget snowmelt calculation; (2) using a wind sequence based on maximum observed wind speeds near Hell Hole Reservoir; (3) re-arranging the temporal sequence of precipitation by moving the peak increment later in the sequence; and (4) assuming that L.L. Anderson Dam, which controls about half the area tributary to Interbay Dam, is modified to pass the recently revised PMF with no increase in elevation or storage.

Candidate floods occurring in March and November were considered. The all-season PMFs, which proved to be November events at all three dams, are listed in Table 1.

Table 1
All-Season Probable Maximum Flood

Dam	Drainage Area (square miles)	PMF Peak Inflow (cfs))	PMF Peak Outflow (cfs)	PMF Peak Reservoir Stage (cfs)
Hell Hole	113	102,500	98,600	4648.9
Interbay	89	89,500	89,500	2550.4
Ralston	425	315,000	314,900	1204.0

Relative to the 1994 study, the PMF peak flows increased by approximately 14 percent at Hell Hole and Ralston, and by 37 percent at Interbay. Much of the increase at Interbay is due to the substantial increase in assumed spill from L.L. Anderson Dam. The PMF as recomputed would overtop both Ralston and Interbay Dams by several feet, and would reach a level 1.0-foot below the lowest point in the crest of Hell Hole Dam.

2. Background for Revised Probable Maximum Flood Analyses

In May 2004, Mead & Hunt provided the report titled *Probable Maximum Flood Determination, Hell Hole, Interbay, and Ralston Afterbay Dams* to the Placer County Water Agency, which subsequently submitted the report to the FERC's San Francisco Regional office and to the California Department of Water Resources – Division of Dam Safety. The subject dams are part of the Water Agency's Middle Fork American River Project. The 2004 report concluded that the PMF would overtop the Interbay and Ralston Afterbay Dams by several feet. The 2004 PMF would peak about 2.8 feet below the minimum crest elevation of Hell Hole Dam.

The FERC commented on the study by letter dated April 29, 2005, requesting specific revisions to the report and also referring to comments made in a previous letter dated March 31, 2005, concerning the L.L. Anderson Dam. The L.L. Anderson Dam, located upstream of Interbay Dam, is also part of the Middle Fork Project. An addendum to the L.L. Anderson study was submitted to the FERC on July 15, 2005.

This report addresses comments in the April 29 and March 31, 2005, letters as follows:

- The energy budget melt equation has been used to compute snowmelt concurrent with the Probable Maximum Precipitation (PMP). Wind speeds concurrent with the PMS were derived from site-specific data from a wind gage near Hell Hole Dam.

- The temporal sequence of the PMP has been re-ordered to place the peak 6-hour increment between hours 37 and 42, and the peak 1-hour precipitation increment at hour 40. Temporal sequences of temperature and wind were also adjusted to follow the new PMP temporal pattern.

- The L.L. Anderson Dam has been modeled as if the dam were modified to pass the newly increased PMF at the current top-of-dam elevation of 5273.2 feet. Details of the future spillway rating curve are not available at this time.

- Sensitivity analyses have been performed on the loss function, unit hydrograph parameters, and wind speed assumptions.

- The FERC reviewer noted that the abbreviation "cfs" was incorrectly defined as "cubic feet per minute" in the 2004 report. All uses of "cfs" in the 2004 report and this report refer to cubic feet per second.

- Other editorial comments by the FERC concerning inconsistency in the use of decimal places in the 2004 report, have been noted. Every effort has been made to present numeric data consistently in this report.

With the exception of the changes noted above, the HEC-1 rainfall-runoff models used in the 2004 study were adopted for the present study. Each dam's PMF analysis was performed for the months of November and March. An all-season Probable Maximum Storm could occur in either of these months, but in the 2004 study, November proved to be the critical month due to higher temperatures concurrent with the storm. The use of the energy budget method in the present study added wind as a factor in snowmelt calculations, and depth of snowpack also became potentially critical because the energy budget calculation produces more melt than the degree-day method. Therefore, March events (for which Hydrometeorological Report No [HMR] 58 specifies a higher wind speed and snowpack depths are greater) were analyzed in addition to November events.

3. Temporal Sequence of Probable Maximum Storm

The application of procedures in HMR 58 for developing the PMP sequence was unchanged from the 2004 study, except for the temporal reordering of the increments of the storm. In the 2004 study, the peak increment of PMP rainfall was placed at hour 33 of a 72-hour sequence. The sequence of PMP rainfall has been rearranged for the present analysis so that the peak increment occurs at hour 40. The temporal patterns adopted for the Ralston Afterbay, Interbay, and Hell Hole basins are shown in Exhibit 1. Within each of these basins, the PMP was redistributed spatially among model subbasins based on the index PMP for each subbasin, as documented in the 2004 report.

4. Snowmelt during the Probable Maximum Flood

For the present study, all snowmelt calculations were carried out using the energy budget routine in the HEC-1 model. This change required the addition of wind speed sequences to the precipitation and temperature sequences already adopted for earlier degree-day calculations. A dew point sequence is also required by the model, which for periods of rain can be assumed to be equal to the temperature sequence.

The wind sequence adopted for development of the PMF was the same as that used in the July 2005 *L.L. Anderson Dam PMF Study Addendum.* This sequence is an envelope based on the maximum 3-day wind sequence in the record at the U.S. Forest Service's Hell Hole climate station. This sequence occurred in November 2002 in conjunction with about 1.1 inch of rain. A comparison of the Hell Hole data, the wind speeds derived from Appendix A of HMR 58, and what little is known about wind speeds during significant storms indicates that an envelope derived from observed site-specific wind speeds at Hell Hole is an appropriate and conservative treatment of wind during the PMS. The same wind sequence was used in simulating March and November floods.

The Hell Hole climate station is situated on an exposed ridge at an elevation of 5,240 feet. Considering that the majority of the basin has less direct wind exposure than the climate station, the wind speed envelope based directly on the Hell Hole record was adopted for the French Meadows (L.L. Anderson), Loon Lake, Lower Hell Hole, and Duncan Canyon subbasins. To account for elevation differences, winds in the Upper Hell Hole subbasin were adjusted upward, and winds in the Middle Rubicon, Lower Rubicon, Long Canyon, Stumpy Meadows, and Lower Middle Fork subbasin were adjusted down. The adjustment factors were derived from the elevation-wind speed relationships presented in Appendix A of HMR 58. Pertinent pages of the 2004 report showing the location, size, and elevation of each of the model subbasins are reproduced as Exhibit 2. The wind sequence for each subbasin group is plotted in Exhibit 3, along with the maximum recorded wind sequence that was the basis for the model sequence. (*Note:* wind speeds entered in the HEC-1 model are adjusted upward by a factor of approximately 1.3, because the HEC-1 input structure calls for wind speeds at 50 feet above the ground, while both the Forest Service data and HMR 58 values are presented for near-surface elevations.) The electronic spreadsheet used for wind calculations is included with this report on CD.

Table 2 lists the peak 24-hour wind speeds assumed for each subbasin group. In the sequence as derived from the Hell Hole record, the wind speed is steady throughout the peak 24 hours. Also shown are the peak 24-hour and 1-hour wind speeds from HMR 58. The HMR 58, 24-hour value is actually less than the 24-hour wind derived from the Hell Hole record, but the peak 1-hour interval is much more. An energy-budget melt analysis using HMR 58 wind speeds was performed as a sensitivity analysis, as described in Table 2.

Table 2
Maximum 24-Hour Wind Speeds
Used in PMF Simulations
(based on records at Hell Hole climate station)

Subbasins	Mean Elevation (feet)	Maximum 24-Hour Wind Speed, Based on Hell Hole Record (miles per hour)	Maximum 24-Hour Wind Speed for November, From HMR 58 (miles per hour)	Maximum 1-Hour Wind Speed for November, From HMR 58 (miles per hour)
Upper Hell Hole	7,000	46	42	64
French Meadows, Duncan Canyon, Loon Lake, Lower Hell Hole	5,000 - 6,500	40	38	57
Middle Rubicon, Lower Rubicon, Long Canyon, Stumpy Meadows	4,000 - 5,000	36	33	53
Lower Middle Fork	3,500	31	29	46

The elevation-snowpack relationships at the outset of the PMS were adopted from the 2004 study. These represented a 100-year snowpack for March and the maximum recorded snowpack for November, as November snow records are not adequate to construct a 100-year frequency curve.

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5. Probable Maximum Flood Simulation

HEC-1 Input and Output files for all cases run are included with this report on CD. Table 3 lists the computed peak PMF inflows, outflows, and stages for March and November. November again proved to be the controlling case, as was the case in the 2004 study. The increase in potential temperatures in November, relative to March, more than compensated for the decrease in available snowpack.

Table 3
Computed PMF Peak Inflows, Outflows, and Stages

Dam	Month	Peak PMF Inflow (cfs)	Peak PMF Outflow (cfs)	Peak Reservoir Stage (feet)	Feet Above (-) or Below (+) Top of Dam
Hell Hole	March	97,000	93,100	4648.5	1.4
	November	**102,500**	**98,600**	**4648.9**	**1.0**
Interbay	March	77,200	76,100	2547.0	-8.7
	November	**89,500**	**89,500**	**2551.2**	**-12.9**
Ralston Afterbay	March	303,200	303,100	1202.8	- 13.8
	November	**315,000**	**314,900**	**1204.0**	**-15.0**

The controlling (November) PMF outflow is 15-percent higher than the 2004 estimate at Hell Hole; 14-percent higher at Ralston, and 37-percent higher at Interbay. At Hell Hole and Ralston, the increase can be attributed almost entirely to the change in snowmelt methodology. The comparatively large increase at Interbay, relative to the 2004 study, is also due to the assumed increase in spillway capacity (with no increase in storage) at L.L. Anderson Dam.

6. Sensitivity Analysis

Using the November PMF model as the base case, we tested the sensitivity of the model results to changes in unit hydrograph parameters, loss rates, and snowmelt wind speeds. The snow-covered ground loss rate (LM in the HEC-1 input listing) was the parameter tested because snow cover persists throughout the simulation.

Table 4 compares the peak outflows at each dam under each sensitivity scenario.

Table 4
Results of Sensitivity Analysis

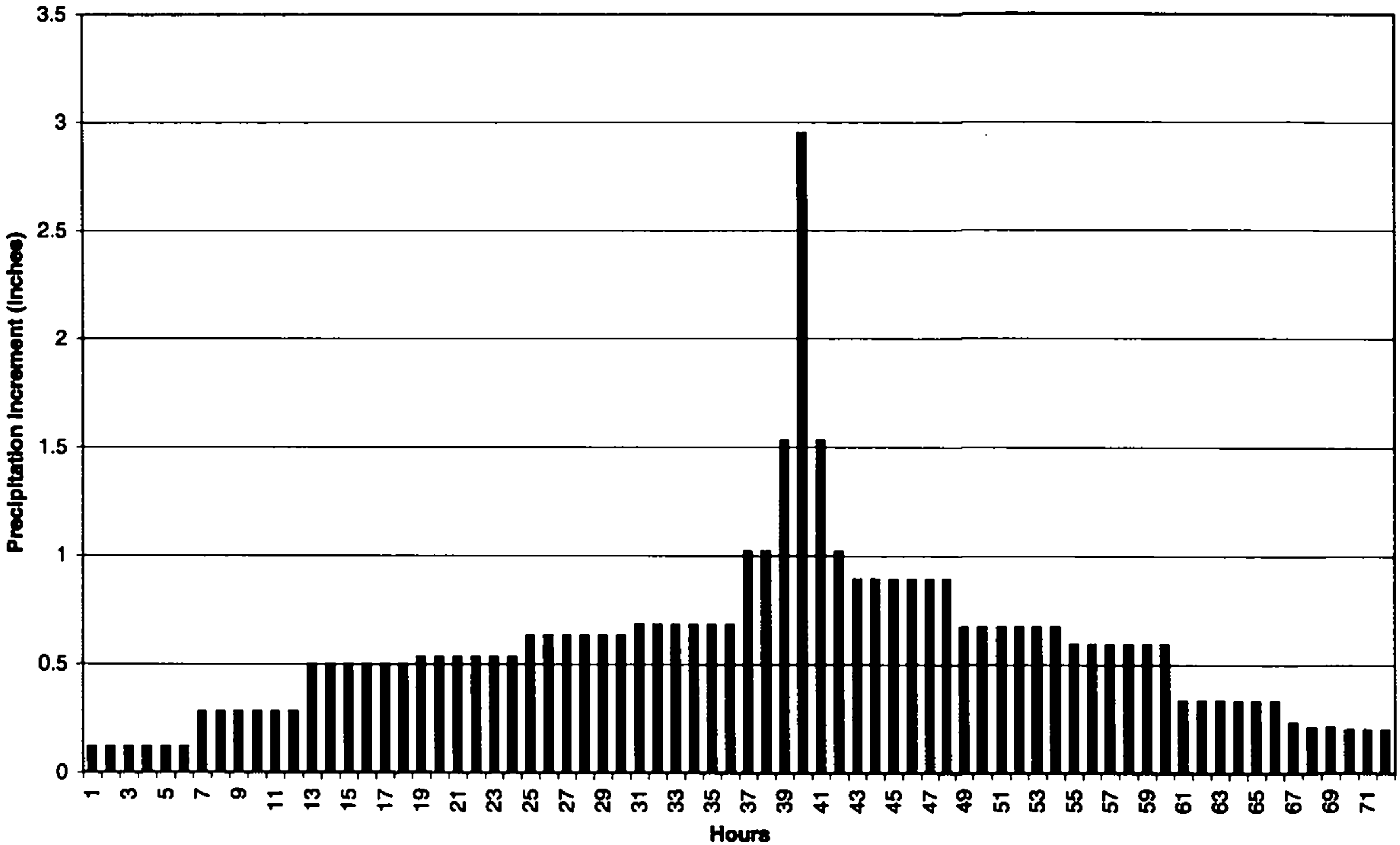
Dam	Model Input Parameter Tested	Change in Parameter	Peak Outflow (cfs)	Base Case Peak Outflow (cfs)
Hell Hole	Loss rate for snow-covered ground	- 0.02 inch per hour to 0.01 inch per hour	99,900	98,600
		+ 0.02 inch per hour to 0.05 inch per hour	97,200	98,600
	Unit Hydrograph time of concentration T_c and R	- 25 percent in each subbasin	105,600	98,600
		+ 25 percent in each subbasin	93,100	98,600
	Snowmelt Wind	Sequence derived from HMR 58	100,300	98,600
Interbay	Loss rate for snow-covered ground	- 0.02 inch per hour to 0.01 inch per hour	89,900	89,500
		+ 0.02 inch per hour to 0.05 inch per hour	86,300	89,500
	Unit Hydrograph T_c and R	- 25 percent in each subbasin	94,500	89,500
		+ 25 percent in each subbasin	82,900	89,500
	Snowmelt Wind	Sequence derived from HMR 58	90,600	89,500
Ralston Afterbay	Loss rate for snow-covered ground	- 0.02 inch per hour to 0.01 inch per hour	318,400	314,900
		+ 0.02 inch per hour to 0.05 inch per hour	311,400	314,900
	Unit Hydrograph T_c and R	- 25 percent in each subbasin	336,900	314,900
		+ 25 percent in each subbasin	298,300	314,900
	Snowmelt Wind	Sequence derived from HMR 58	319,900	314,900

The most influential change in the sensitivity analysis proved to be a change in the unit hydrograph t_c and storage coefficient. Reducing these two parameters together by 25 percent led to an increase of approximately 7 percent in the peak outflow. In the case of Ralston Afterbay and Interbay Dam, such a change leads to a relatively small increase in the already substantial overtopping. At Hell Hole, the resulting peak outflow of 105,600 cfs would just reach the minimum dam crest elevation, compared to the base case in which 1-foot of freeboard exists.

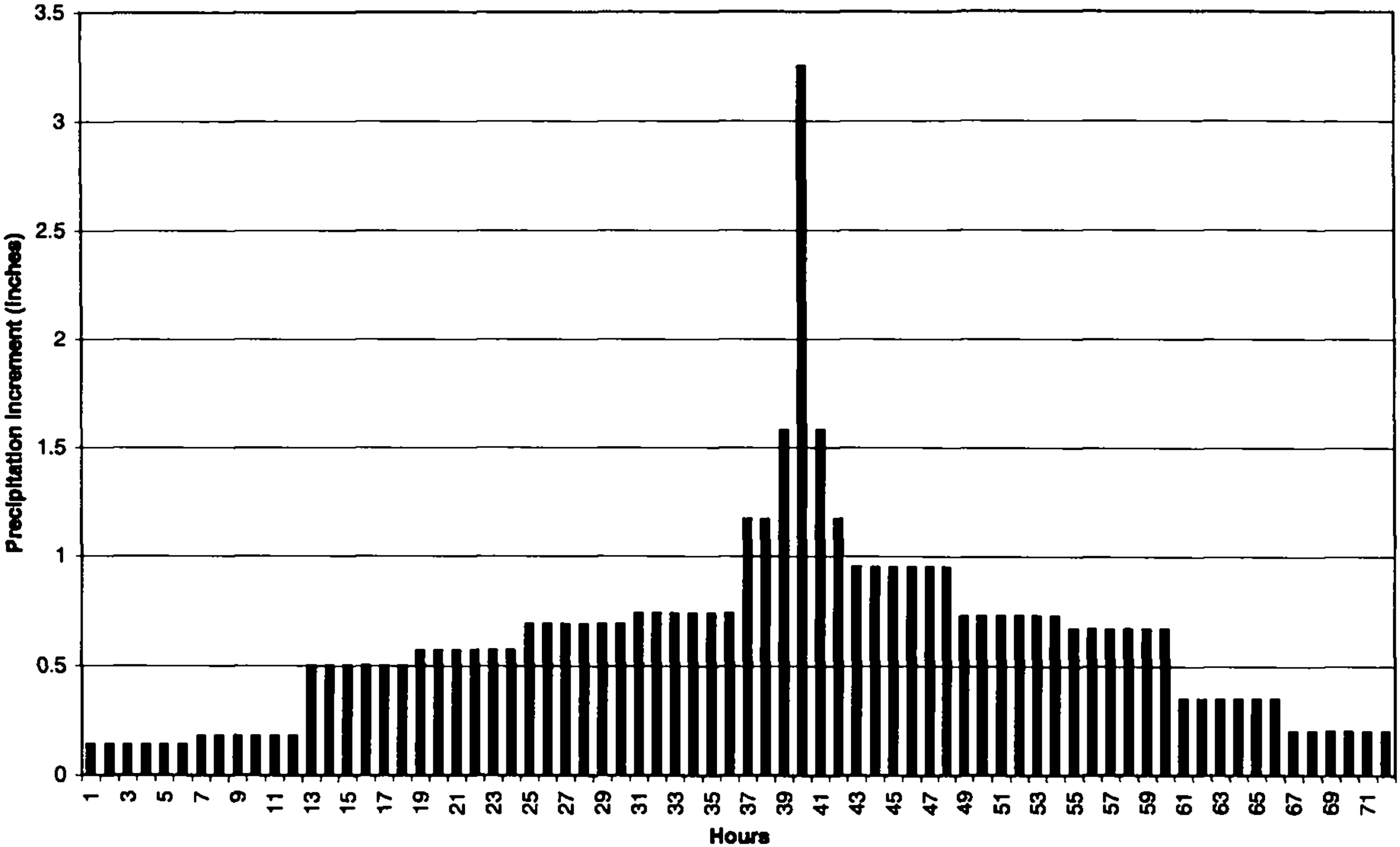
Exhibit 1: Probable Maximum Storm Temporal Sequences

(a) Rubicon River at Hell Hole Dam
(b) Middle Fork American River at Interbay Dam
(c) Middle Fork American River at Ralston Afterbay Dam

Sheet 1: Hell Hole Dam basin average PMP sequence



Sheet 2: Interbay Dam basin average PMP sequence



Sheet 3: Ralston Afterbay Dam basin average PMP sequence

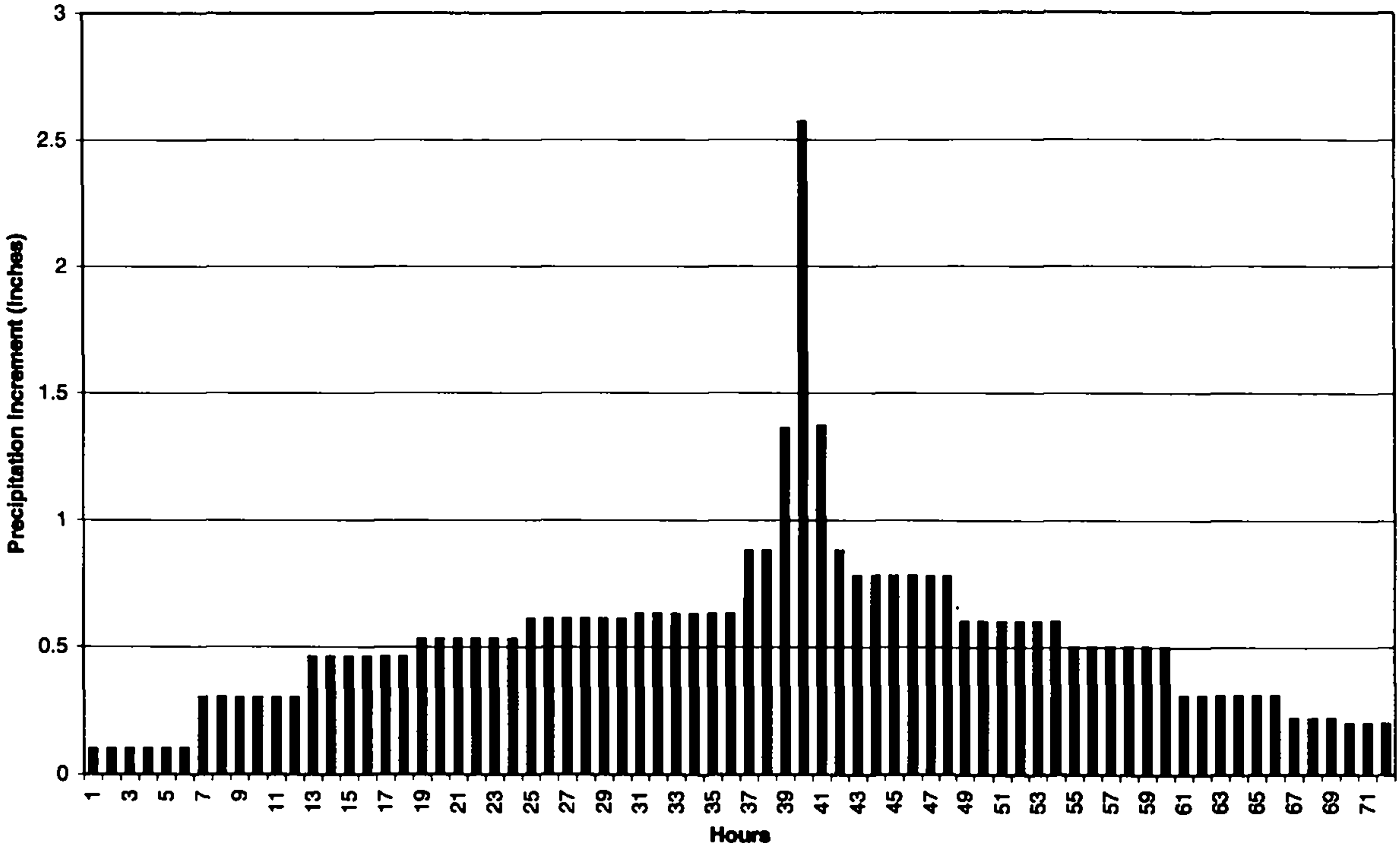


Exhibit 2. HEC-1 Model Subbasins

(Reproduced from 2004 Probable Maximum Flood Determination report)

2a: Subbasin areas and Elevations (2004 Table 3)

2b: Subbasin Map (2004 Exhibit 5)

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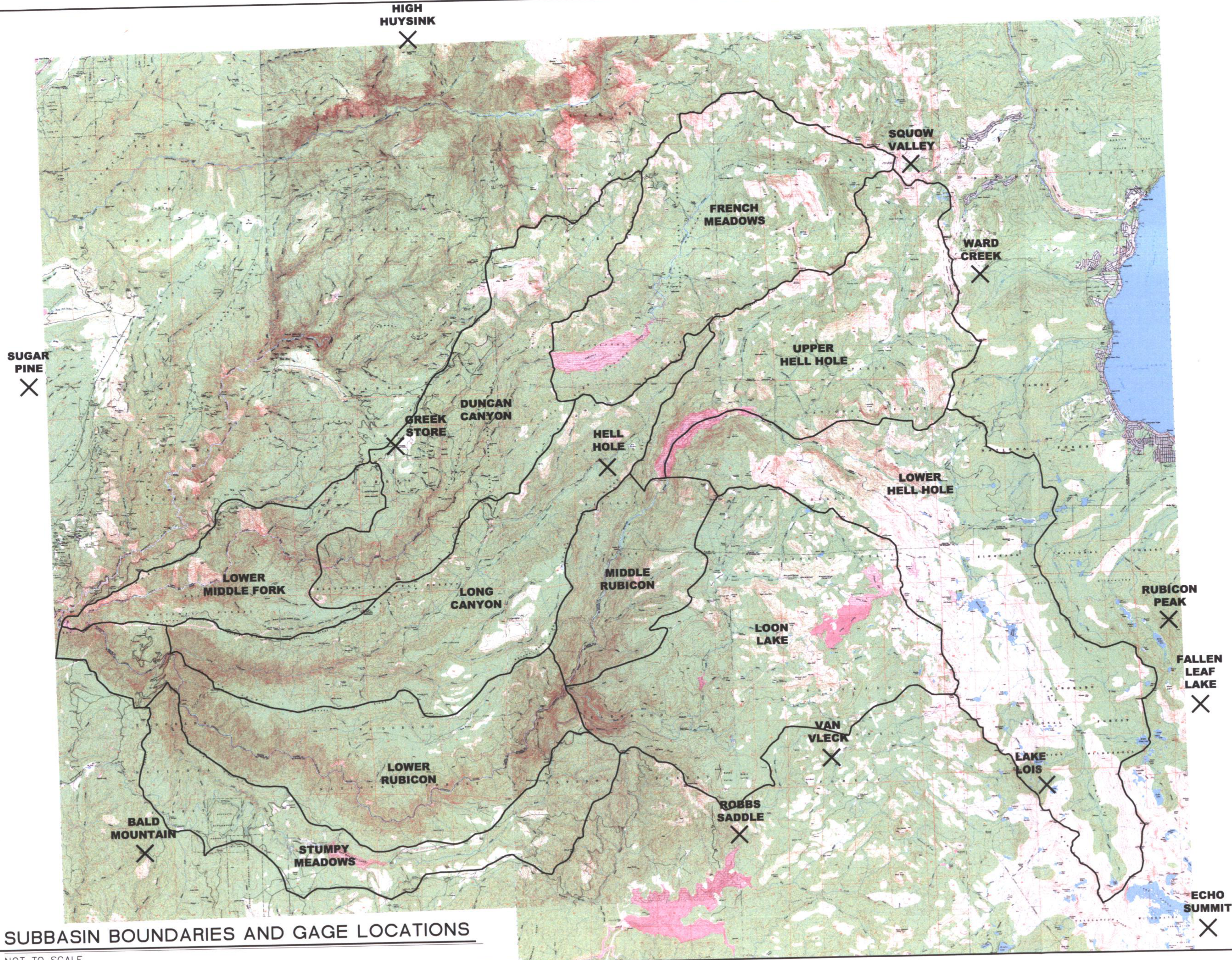

SUBBASIN BOUNDARIES AND GAGE LOCATIONS

NOT TO SCALE

EXHIBIT 5

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Exhibit 3. Wind Speed Distributions Based on Maximum Observed Wind Speeds at Hell Hole Climate Station

Exhibit 3: Hell Hole wind pattern and adopted wind sequences