EXHIBIT ARWA-802

LOWER AMERICAN RIVER

FLOW MANAGEMENT STANDARD

Daily Flow Disaggregation

Modified Flow Management Standard

1 INTRODUCTION

This document provides a description of the methods used to generate a daily time series of release from Nimbus Dam, which is used as one input to the fisheries impact assessment described in the *Lower American River Biological Rationale, Development and Performance of the Modified Flow Management Standard* (Biological Rationale).

1.1 BACKGROUND

The Modified Flow Management Standard (Modified FMS) utilizes results from the CalSim II model to provide comparisons between various alternatives. The use of CalSim II is described in Technical Memorandum 2, entitled *Lower American River Modified Flow Management Standard - CalSim II Assumptions*. CalSim II results follow a monthly time step, which results in a dampening of variation around the mean value. For this reason, a flow disaggregation technique was developed to convert the monthly time step CalSim II flow result, into a daily flow time series, to be used in various fisheries impact assessments discussed in the Biological Rationale.

2 METHODS

2.1 GENERAL DESCRIPTION AND APPROACH

The disaggregation technique utilizes three modes of operation: minimum release requirement (MRR), call-driven releases[1], and flood operation releases. The fundamental premise is that the variability around the monthly average flow value is different when reservoir releases are governed by the various operational modes. When following the MRR, there is no variability compared to the monthly average. When following call-driven operations, there is small to moderate amount of variability compared to the monthly average. When following flood operations, if the monthly average is a large value, the variability can be quite high, while, if the monthly average is low, there is typically much lower variability.

For each operational mode, a pattern of daily flows is provided for the complete 82-year period covered by the CalSim II simulation. For any given month, the following steps occur when developing a daily flow time series:

1) The operational mode is determined for each month, and the corresponding daily flow pattern mode of operation is applied.
2) The daily values are scaled to match the same volume as provided by the CalSim II results for that month.

[1] Call driven releases occur when releases from Folsom Reservoir are required for Central Valley Project operational reasons other than minimum lower American River flow requirements or flood-control operations. For example, releases for maintenance of Delta water quality or for export from the Delta would be call-driven releases.

3) The daily values determined in step 2 are checked against the MRR, and increased as needed so that daily flows don't violate the MRR.
4) If a spring pulse is included for the given month and scenario (e.g., in the Modified FMS scenario), it is added.
5) All other non-MRR and non-spring pulse (if applicable) values are rescaled again to provide the same volume as the monthly average CalSim II results.
6) Step 5 is repeated several times to be sure the MRR is not violated as daily flows are rescaled to match the monthly average release volume.
7) A four-day linear transition from the third to last day of one month to the third day of the following month is applied to prevent an abrupt flow change from occurring.

2.2 Operational Mode Selection

Several CalSim II outputs are used to determine which of the three operational modes is applied to a given month. These monthly time series outputs include: flow release from Nimbus Dam, MRR, and end of month Folsom Reservoir storage. In addition, the maximum allowable volume of storage within Folsom Reservoir is also used as an input (but does not change between alternatives). If the release from Nimbus Dam is equal to the specified MRR for the month, then the minimum release requirement operations mode is selected for that month. If the end of month Folsom Reservoir storage is equal to the maximum allowable storage, then the flood operations mode is selected for that month. If the minimum release mode, nor the flood operations modes are selected, then the call-driven operations mode is selected.

2.3 Minimum Release Requirement Operations Pattern

The MRR flow pattern is determined by the monthly MRR for the specific alternative, as calculated by CalSim II. No daily variation is introduced to this pattern, it follows the monthly value calculated by CalSim II.

2.4 Call-Driven Operations Pattern

The call release operational pattern was developed through examination of historical Nimbus Dam release operations (as measured at the USGS American River at Fair Oaks gage) for periods when the system was not being operated for flood operations (see further explanation below). Observed flow data were analyzed for October 1, 1997 to September 30, 2012. Data prior to October 1, 1997 were not utilized as a change in operations is evident around this date (sub-monthly flow fluctuations are significantly reduced), presumably due to the listing of Central Valley steelhead. Data were first screened, and erroneous or absent periods were removed from the dataset analyzed.

The operational mode of each month within this record was determined and daily flow timeseries for all months identified as call-driven operations mode were isolated. The remaining daily timeseries were then subsampled by their calendar month, resulting in a set of potential daily flow patterns for each month (see Table 2-1). For example, 13 possible call release daily flow patterns were identified for the month of July, 8 possible call release patterns were identified for the month of January. Lastly, a random number generator was used to select a specific historical flow pattern for each month of the 82-year CalSim II simulation period, such that patterns were only applied to the same month (i.e., only patterns that historically occurred in October were used for October). This single pattern of daily flows reflecting call-driven release operations for the entire 82-year time period is then used for all scenarios that are disaggregated, such that the same call pattern is applied for a given month and year for all scenarios, assuming the scenario results in call-driven operations for that month.

Table 2-1. Number of Call-Driven and Flood Patterns Used for Each Month in the Disaggregator

Month	No. of Monthly Call-Driven Patterns	No. of Monthly Flood Patterns
January	8	27
February	7	35
March	5	34
April	3	33
May	5	28
June	8	20
July	13	11
August	15	9
September	14	12
October	14	10
November	11	18
December	11	20

2.5 Flood Operations Pattern

The flood operations pattern was developed through examination of historical Nimbus Dam release operations (as measured at the USGS American River at Fair Oaks gage) and Army

Corps of Engineers monthly reservoir summary plots. Flood operations were determined/defined if the flood pool was encroached, or Folsom Reservoir storage was within 10 TAF of the allowable storage amount. In addition, periods when Nimbus Dam release exceeded 5,500 cfs (the maximum capacity of the Nimbus Dam Powerhouse) were also considered to be periods when the system was following flood operations. Observed flow data were analyzed for January 1, 1956 to July 31, 2012. This period was expanded beyond the period used to develop the call-driven operations pattern due to the low number of potential monthly flood patterns that were available in the October 1, 1997 to September 30, 2012 period. For example, using the October 1, 1997 to September 30, 2012 period, only two Decembers were found to be following flood operations. Once determined to be flood operations, the daily timeseries were then organized by their calendar month, resulting in a set of potential daily flow patterns for each month (see Table 2-1). Lastly, a random number generator was used to select a specific historical flow pattern for each month of the 82-year CalSim II simulation period, such that patterns were only applied to the same month (i.e., only patterns that historically occurred in October, were used for October). In select instances, to preserve the flood operations flow pattern that was observed historically (i.e., flood peaks that spanned two months), the actual flows that occurred in that year were selected to be the flood pattern, rather than relying upon the randomly selected monthly pattern. The resulting single pattern of daily flows reflecting flood release operations for the entire 82-year time period is then used for all scenarios that are disaggregated such that the same daily flood pattern is applied for a given month and year for all scenarios, assuming the scenario results in flood driven operations for that month.

2.6 SPRING PULSE

Regardless of the operational pattern determined, if a spring pulse release is triggered in the Modified FMS scenario, a pulse is overlain upon the underlying pattern. As described in greater detail in Technical Memorandum 1, entitled *Project Description – Lower American River Flow Management Standard*, the Modified FMS would provide a pulse flow event at some time during the period extending from March 15 to April 15 by supplementing normal operational releases from Folsom Dam under certain conditions when no such flow event has occurred between the preceding February 1 and March 1 time frame. Within the disaggregator, if triggered, the spring pulse flow is applied starting on March 15.

The pulse flow event would be provided only when the MRR from March 1 through March 31 ranged from 1,000 cfs to 1,500 cfs. The peak magnitude of the pulse flow would be three times the MRR base flows (pre-pulse flows), not to exceed a peak magnitude of 4,000 cfs. The pulse flow event would range in duration from 6 to 7.5 days, depending upon the initial MRR base flows (pre-pulse flows). There are no assumed restrictions on the rate of ramp-up from base flows to the peak of the pulse flow, which would last for 2 days. Pursuant to the ramp-down restrictions provided in the NMFS (2009) Operations Criteria and Plan (OCAP) Biological Opinion, flow reductions after the 2-day peak pulse flow will not exceed more than 500 cfs per day and not more than 100 cfs per hour. Consequently, if the peak pulse flow was 3,000 cfs, then the pulse flow event would extend 6 days, and, if the peak pulse flow was 4,000 cfs, then the pulse flow event could extend 7.5 days. The pulse flow would not occur if Nimbus Dam releases between February 1 and March 15 did not meet or exceed the maximum pulse flow rate for at least two days.

3 RESULTS

The dissagregator is applied to both the 2006 Flow Management Standard scenario and the Modified FMS scenario. For demonstration purposes, the results from three example water years, 1928, 1941, and 1944, from the 2006 Flow Management Standard scenario are provided in Figure 3-1.

The 1928 water year is comprised of five months that result in the MRR operations pattern, five months that utilize the call-driven operations pattern, and two months that utilize the flood operations pattern. In the MMR-driven months, no variability is shown. In the call-driven months, some variability is provided, but it varies by month and by the difference in magnitude between the monthly average flow and the MRR. October shows little variability from the monthly average flow, but June and July show greater variability, with June following MMR flows for the first half of the month. While the months of August and September follow the call-driven operation pattern, the monthly average flows are only slightly above the MRR, so the variability is almost completely muted by the scaling operation, making it much more similar to the MRR pattern. March and April follow the flood operations pattern with a significant flood peak occurring in March, but high and fairly consistent flows occurring in April

The 1941 water year is comprised of two months that results in the MRR operations pattern, one month that utilizes the call-driven operations pattern, and nine months that utilize the flood operations pattern. In the MMR-driven months, no variability is shown. In the call-driven month, very little variability is provided, because the monthly average flow is very close to the MRR for the month. Flood operations occur in nine months, with distinct flood peaks occurring in December and January, and elevated and varying flows occurring through June. Although July was determined to be a flood operations month due to the end of month storage, the monthly average flow is equal to the MRR, and as such no variability is provided.

The 1944 water year is comprised of ten months that result in the MRR operations pattern, and two months that utilizes the call-driven operations pattern. In the MMR-driven months, no variability is shown. In the call-driven month, very little variability is provided, because the monthly average flow is very close to the MRR for those months. No flood operations occur during this month under the 2006 FMS scenario.

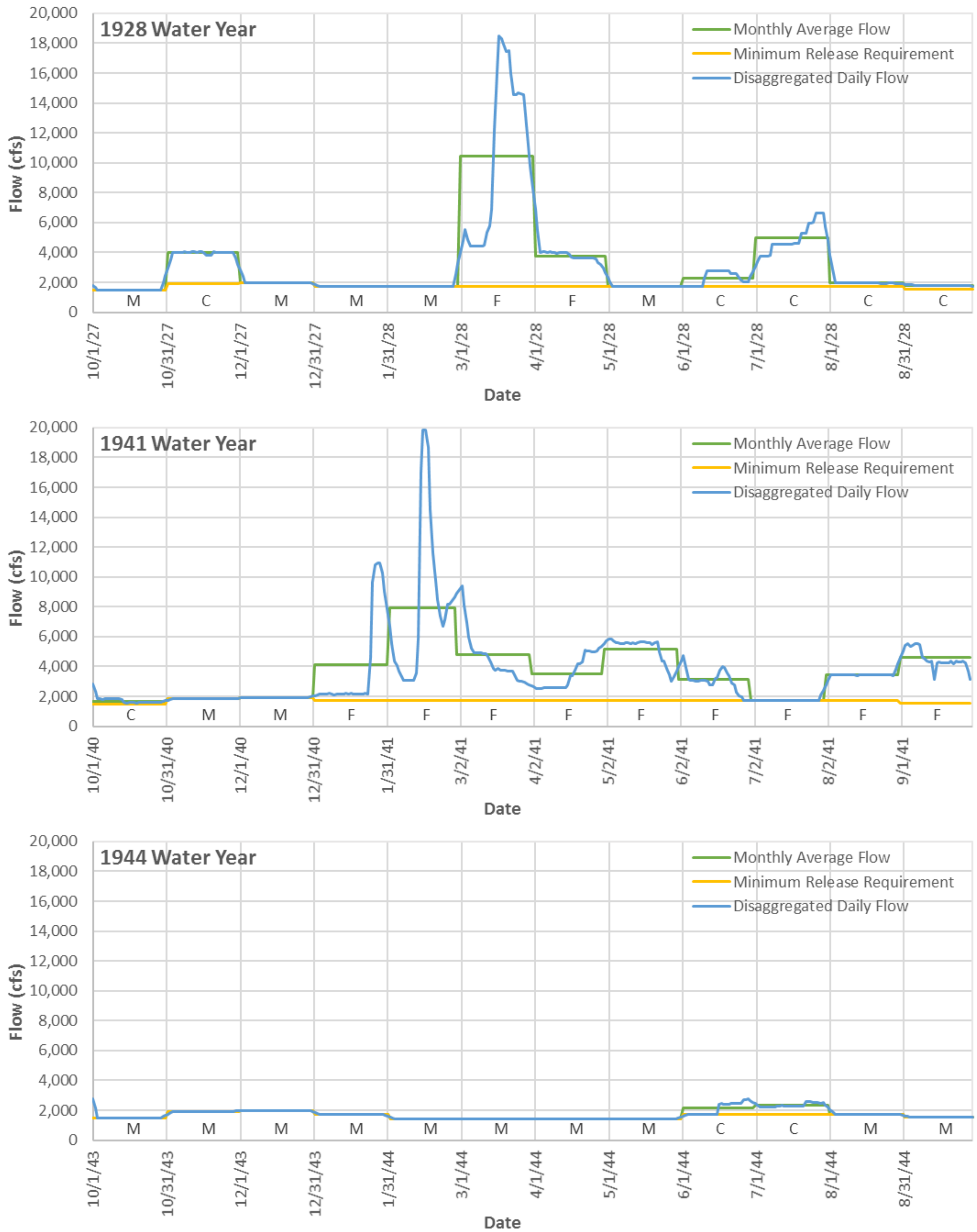

Figure 3-1. Monthly Average Flow, Disaggregated Daily Average Flow and Monthly Minimum Release Requirement for Three Example Water Years (1941, 1941, 1941). Monthly Operations Modes Are Also Shown: M - Minimum Release Requirement, C - Call-Driven, F - Flood