PAP-791

Maximum Controlled-Release Capacity from Trinity Dam - Central Valley Project. Trinity River Division, California

1998

by

Bitsy Cohen
Tony Wahl

DATE	PEER REVIEWER(S)	CODE
8/25/98	Dave Hinchliff Signature	D-8130
	Dave Hinchliff Printed Name	
Author initials	PEER REVIEW NOT REQUIRED	
Author Elisabeth A Cohen Tony L. Wahl		

D-8560 Wittler

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AUG 25 1998

MEMORANDUM

To: Area Manager, Northern California Area Office, Shasta Lake CA
Attention: Russell Smith, NC-300

From: Elisabeth A. Cohen, Waterways and Concrete Dams Group
Tony L. Wahl, Water Resources Research Laboratory

Subject: Maximum Controlled-Release Capacity from Trinity Dam - Central Valley Project, Trinity River Division, California

The Technical Service Center (TSC) has completed an analysis of the maximum controlled-flow release capacity from Trinity Dam. This analysis is based on a mathematical model of the combined operation of the river outlet works and powerplant, which use a shared tunnel and penstock system. The model was developed by the TSC and calibrated using data collected from two field tests conducted by Northern California Area Office staff on August 4 and August 6, 1998. The calibrated model predicts a maximum controlled-flow release of 13,750 ft^3/s at reservoir water surface elevation 2370 (crest of the uncontrolled spillway), which includes both the combined operation of the river outlet works and powerplant (using the high-head runners) and releases from the auxiliary outlet works system. The discharge capacity of the auxiliary outlet works, which is entirely separate from the river outlet works and powerplant, was not analyzed, but was assumed to be that shown on drawing 416-D-160.

Cavitation potential in the outlet works system was not analyzed. The increased discharge and reduced pressures caused by combined operations of the outlet works and powerplants do have the potential to create cavitating flow conditions. If prolonged combined operations of the river outlet works and powerplant occur in the future, we recommend that during such operations special attention be given to any abnormal noise levels that might indicate ongoing cavitation, and we recommend that the outlet works system be inspected for cavitation damage following those operations.

A revised controlled-flow release discharge curve is attached. The figure shows the river outlet works capacity under three different scenarios:

1) **River outlet works operating without powerplant** - This curve shows the discharge at 100 percent opening of the two hollow-jet valves, and indicates about 18 percent greater discharge than that shown on drawings 416-D-160 and 416-D-164. This increased discharge capacity was verified by the field test performed August 4, 1998.

2) **River outlet works in combination with powerplant (high-head runners)** - This curve shows the combined discharge when operating the hollow-jet valves at 100 percent opening and one or both turbines at full-gate, with the high-head runners installed. For reservoir

elevations below 2262, there will be insufficient head to operate the powerplant within the design head range for the high-head runners. Between elevation 2262 and 2290, there is only sufficient head to operate one turbine. Unit 1 should be operated in this case, since it has the most upstream connection to the outlet works penstock, and thus the most available head.

3) **River outlet works in combination with powerplant (low-head runners)** - This case is similar to (2), except that the low-head runners are installed in the powerplant. For reservoir elevations below 2213, there will be insufficient head to operate the powerplant within the design head range for the low-head runners. Between elevation 2213 and 2241, there is only sufficient head to operate one turbine. Again, unit 1 should be operated in this case, since it has the most upstream connection to the outlet works penstock, and thus the most available head. For reservoir elevations of 2332 and above, the combined operation of the outlet works and powerplant produces so much head loss that the low-head runners can still be used and will operate within their design net head range. However, the low-head runners are unlikely to be installed in the powerplant under these conditions, since they would operate at heads higher than their design range if the outlet works were not also operating. Thus, this portion of the discharge curve is shown as a dashed line. Note that the greatest release capacity is obtained by using the low-head runners in this range.

The release capacities described above and shown in the accompanying figure were determined using a mathematical model of the combined river outlet works and powerplant releases. The model computes friction and minor losses throughout the outlet works and powerplant tunnels, penstocks, and associated gates and valves. The net head on the turbines and hollow-jet outlet valves is determined by the model, and performance data for these components are used to determine the discharges. The initial analysis indicated significantly higher outlet works capacity than that shown on the design discharge curve in drawing 416-D-164. As a result, two field tests were performed, and assumed loss coefficients in the model were adjusted based on the results of the tests. Once the adjustments were made, the model was used to compute discharges for combined flows through the river outlet works and powerplant. The discharge curves show only the maximum release capacities; however, the model could be used to analyze other scenarios, such as partial opening of the hollow-jet valves or operation of the powerplant at conditions other than full-gate. The model is contained in a Lotus 1-2-3 spreadsheet, and can be provided to Regional or Area Office personnel upon request.

Two tests were performed to calibrate the model. On August 4, 1998, the river outlet works was operated at 60 percent and 100 percent valve openings. On August 6, 1998, the outlet works and powerplants were operated in combination with the river outlet works at 100 percent valve opening and the powerplant at near-full gate conditions, using the high-head runners. Pressures, reservoir levels, powerplant output, and other pertinent operational data were recorded. Discharge through the outlet works valves was determined using drawing 416-D-1084, and discharge through the powerplant was determined from tables in the SOP and from turbine performance curves on file in Denver. Discharges were not measured independently.

The overall result of the tests was to confirm the higher discharge capacities that were being predicted with the model (higher discharge than shown on drawings 416-D-160 and 416-D-164). The tests also assisted in the calibration of loss coefficients in the model associated with the combined operation of the outlet works and powerplant. It was not possible to perfectly tune the model to match all of the test results. Some possible reasons for remaining differences between the calibrated model and the results of the tests include nonconstant or nonlinear variation of loss coefficients during combined flow operations, random errors in pressure measurements and other test data, potential for bias in pressure measurements due to imperfect pressure taps and piezometer connections, and uncertainty in discharge determinations. The model was calibrated to more closely fit the test results from the 60 percent operation of the outlet works, since the lower flowrate during this test would minimize the magnitude of some of the potential errors. This causes the model to underpredict the observed pressure at the outlet works valves during the tests at 100 percent valve opening. Thus, the discharge from these valves is also underpredicted. Summaries of the model predictions and comparisons to the test observations are given in table 1. The differences between the predicted combined powerplant and outlet works flows and the estimated discharges during the field tests range from +1.6 percent to -4.6 percent.

The powerplant and river outlet works at Trinity Dam have not typically been operated in combination in the past, and methods for determining discharge have not considered the effects of combined operation. If combined operations become more prevalent in the future, discharges can be estimated as follows:

- Discharge through the river outlet works hollow-jet valves should be determined using drawing 416-D-1084 and the pressure readings from the two gauges attached to the 3-inch fill/bypass piping going around the ring-follower guard gates. These gages are located in the outlet works control house at elevation 1929.87, and are shown on drawing 416-D-300.

- Powerplant discharge can be determined by noting the reduction of pressure caused at the turbine penstock pressure gauges (under the penstocks at elev. 1896.75, tapped off near the butterfly valves) when the outlet works is placed into operation. This reduction of pressure can be used to determine an effective lake elevation, and the existing tables in the powerplant SOP can then be used to estimate the discharge. This technique was used for the August 6, 1998, test. Alternately, the pressure gauges can be used to determine the net head across the turbines, and discharge can be determined from the turbine characteristic curves.

We trust the information provided in this memorandum will meet your needs for the completion of the Trinity EIS. The information also needs to be included in the SOP and the drawing updated at the next opportunity. If additional details or assistance are necessary, please contact Tony Wahl at (303) 445-2155 or Bitsy Cohen at (303) 445-3247.

Elizabeth A Cohen
Tony L. Wahl

Copy to persons on next page

cc: Regional Director, Sacramento CA, Attention: MP-200 (Solbos)
Area Manager, Shasta Lake CA, Attention: NC-650 (Poore)

bc: D-8130 (Cohen, Hinchliff)
D-8313 (Prizio)
D-8420
D-8470
D-8560 (Wahl, Wittler)✓

WBR:TWahl/BCohen:fr:8/24/98:445-2155
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TABLE 1. — Comparison of key parameters from field tests and predictive model. The dual values (where shown) are recorded from both the upstream and downstream branches for the turbines and the outlet works or as incorporated into the model. There are both hollow-jet valves and ring-follower gates at the downstream end of the outlet works.

Test Scenario: 60 percent opening of river outlet works (hollow-jet valves) at reservoir elevation 2365.6. Powerplant turbines at speed-no-load.

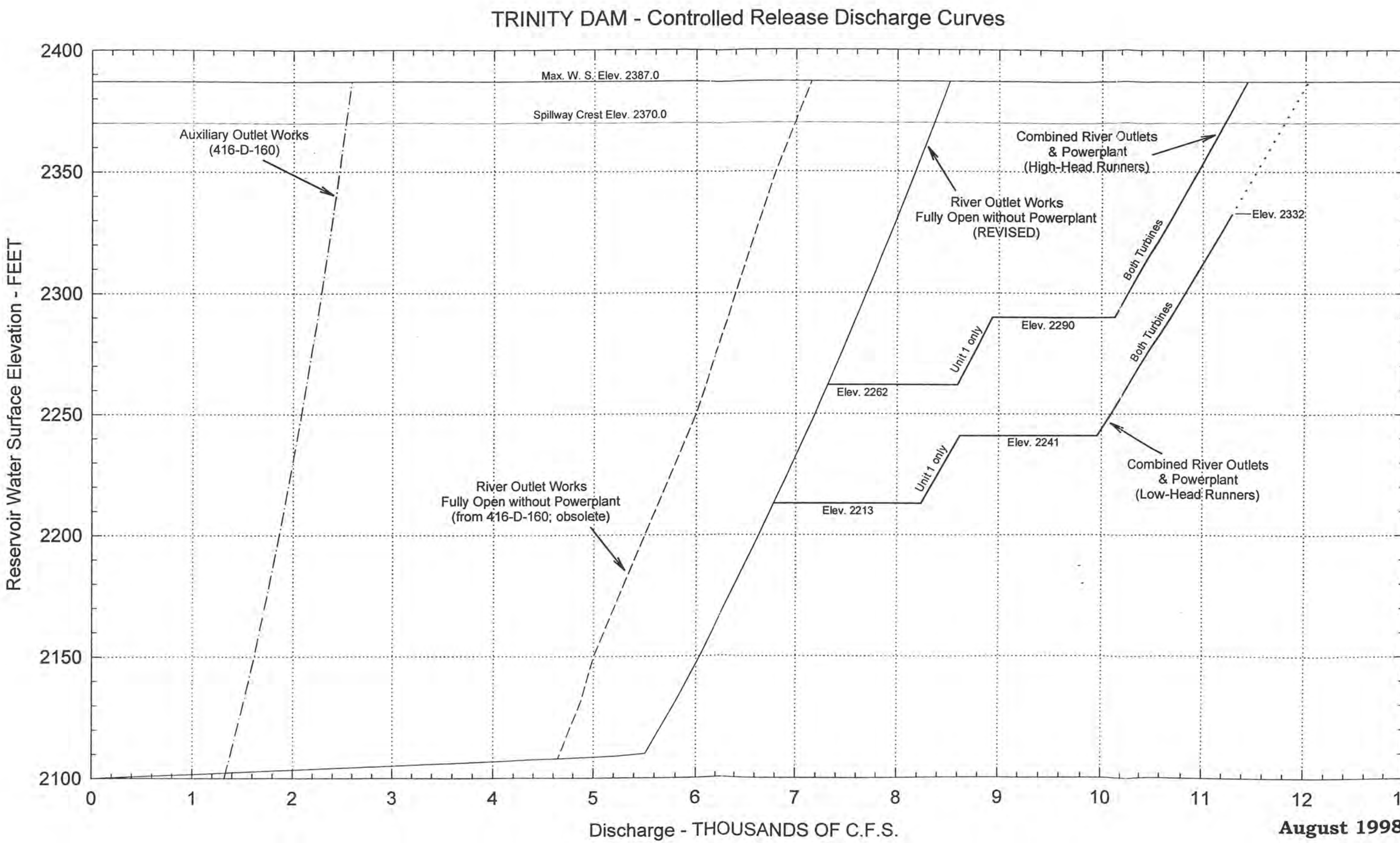
Parameter	Prediction by calibrated model	Observed value during August 4, 1998 test
Pressure at turbine gages	186 / 184.8 psi	165 / 175 psi
Pressure at gages on fill/bypass lines around ring-follower gates	124.5 psi	117 / 125 psi
Hollow-jet valve flow	2,960 cfs (each)	2,870 / 2,960 cfs
TOTAL OUTLET WORKS DISCHARGE	5,920 cfs	5,830 cfs

Test Scenario: 100 percent opening of river outlet works (hollow-jet valves) at reservoir elevation 2365.6. Powerplant turbines at speed-no-load.

Parameter	Prediction by calibrated model	Observed value during August 4, 1998 test
Pressure at turbine gages	170.5 / 168.1 psi	161 / Not Available
Pressure at gages on fill/bypass lines around ring-follower gates	63.8 psi	65 / 71 psi
Hollow-jet valve flow	4,140 cfs (each)	4,150 / 4,325 cfs
TOTAL OUTLET WORKS DISCHARGE	8,280 cfs	8,475 cfs

Test Scenario: 100 percent opening of river outlet works (hollow-jet valves) at reservoir elevation 2364.95. Turbine units 1 and 2 operating at 95 and 90 percent gate, respectively.

Parameter	Prediction by calibrated model	Observed value during August 6, 1998 test
Pressure at turbine gages	149.1 / 145.2 psi	140 / 147 psi
Turbine discharges	1,655 / 1,625 cfs 3,280 cfs (total)	3,370 cfs (total)
Pressure at gages on fill/bypass lines around ring-follower gates	56.7 psi	64 / 65 psi
Hollow-jet valve flow	3,935 cfs (each)	4,100 / 4,150 cfs
TOTAL OUTLET WORKS & POWERPLANT DISCHARGE	11,150 cfs	11,620 cfs



TRINITY DAM - Controlled Release Discharge Curves
Reservoir Water Surface Elevation - FEET
2400
2350
2300
2250
2200
2150
2100
Max. W. S. Elev. 2387.0
Spillway Crest Elev. 2370.0
Auxiliary Outlet Works (416-D-160)
Combined River Outlets & Powerplant (High-Head Runners)
River Outlet Works Fully Open without Powerplant (REVISED)
Elev. 2332
Both Turbines
Elev. 2290
Unit 1 only
Both Turbines
Elev. 2262
Elev. 2241
Unit 1 only
Combined River Outlets & Powerplant (Low-Head Runners)
River Outlet Works Fully Open without Powerplant (from 416-D-160; obsolete)
Elev. 2213
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Discharge - THOUSANDS OF C.F.S.
August 1998