BEFORE THE STATE WATER RESOURCES CONTROL BOARD
WATER RIGHT PHASE OF THE BAY-DELTA ESTUARY PROCEEDINGS

Consideration of Interim Water Rights Actions pursuant to Water Code Sections 100 and 275 and the Public Trust Doctrine to Protect the San Francisco Bay/Sacramento-San Joaquin Delta Estuary

THE NEED FOR STANDARDS FOR MINIMUM
CARRYOVER STORAGE IN TRINITY RESERVOIR

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TESTIMONY
of
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EXHIBIT WRINT-TRICO-4

Submitted June 26, 1992

Testimony to the State Water Resources Control Board Regarding Carryover Storage in Trinity and Lewiston Reservoirs To Protect Public-interest Resources

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We have been asked to develop an approach to estimate the carryover storage in Trinity Reservoir which will meet instream-flow and temperature-control needs in 90 percent of all years. Carryover storage would help to ensure that out-of-basin demands for Trinity River water do not adversely affect the beneficial uses in the basin of origin. These out of-basin demands could include environmental

uses such as increased flows through the Bay Delta estuary or temperature control on the Sacramento River. In particular, the salmon and steelhead populations of the Trinity River require adequate instream flows and temperatures to allow spawning and rearing success, as well as outmigrant and spawner attraction flows. The net effect of minimum carryover standards for Trinity Reservoir and other upstream storage reservoirs would be to require that out-of-basin environmental needs be met out of allocations that would otherwise be available for consumptive uses, such as CVP contract deliveries.

Our analysis is based upon volumes of Trinity Reservoir storage required to sustain sufficiently cool flows during late summer and early fall in-the Trinity River. The following specific temperature objectives have been established by the Regional Water Quality Control Board:

Daily Average Not to Exceed	Period	River Reach
60° F	July 1 - Sept. 14	Lewiston Dam to Douglas City Bridge
56° F	Sept. 15 - Oct. 1	Lewiston Dam to Douglas City Bridge
56° F	Oct. 1 - Dec. 31	Lewiston Dam to confluence of North Fork Trinity River

Under fall 1991 conditions, water temperatures at North Fork were approximately 5 to 11 degrees Fahrenheit warmer than waters being released from Trinity Reservoir. Hence, a volume of water available for release with a temperature in the (estimated) range of 47° F to 49° F is needed to sustain cool releases from Trinity Reservoir in October.

We are approaching estimation of recommended carryover as a six-step process:

1. Establishing an objective of sustaining a cool pool within Trinity Reservoir on October 1.
2. Estimating the volume of cool water likely to be needed to sustain the October 1 through December 31 temperature objective.
3. Estimating the volume of water stored within Trinity Reservoir needed to sustain a cool stored pool from which the volume in item 2 can be drawn.
4. Computing estimated October 1 carryover storage for Trinity Reservoir based in part upon the sum of items 2 and 3.
5. Estimating carryover storage on May 1 from the October 1 carryover storage, plus required instream flows during May and June, estimated evaporation from Trinity Reservoir from May 1 to October 1, and releases of approximately 800 cfs from July 1 through September 30, as may be needed to sustain desired temperature regimes in Lewiston Reservoir (Table 1).
6. Adjusting the values in items 3 and 5 for effects of strings of consecutive years of subnormal inflow to Trinity Reservoir.

There are many ways to operate Trinity and Lewiston Reservoirs. Substantial year-to-year variability in daily air and water temperatures are also reported. Hence, the values to be derived are intended to be estimates, subject to revision and refinement by those with detailed knowledge of particulars of facilities and operations. Emphasis in our testimony is upon a process by which volumes of carryover storage needed to sustain water-quality properties needed to sustain water-quality properties fundamental to instream beneficial uses may be computed.

Water year 1991 is considered by Trinity County personnel to represent a year in which instream water temperature requirements for salmon fisheries in the Trinity River could just barely be met. We have used 1991, therefore, as a test case for estimating minimum carryover storage requirements for Trinity Reservoir in order to maintain salmon fisheries. Comparison of reservoir temperature distributions, storage volumes, inflows and outflows for many other years will be required in order to estimate how water year 1991 compares statistically with other years and, in particular, with the 90

percent exceedance criterion ("driest decile").

Our approach is to estimate the size of the warm water pool and of the cold water pool in the reservoir on October I of the year of interest, using temperature versus depth profiles near Trinity Dam. The warm water pool is assumed to be unusable for river temperature control and is therefore part of carryover storage. Of the cold water pool, that volume below the effective inlet elevation of the powerhouse bypass is inaccessible and is also considered part of carryover. We have also assumed no water-quality constraints in the cold pool, although limited available data show summer turbidities of 10 to 20 NTU in the hypolimnion.

The remaining cold water pool is considered to be part of a resource that was not expended in the year of interest. The remaining cold water could have been used, but was not, and so is not part of the necessary carryover pool.

To the October 1 carryover pool must be added additional cold water that would be needed to regulate river temperatures for the remainder of the warm season, commonly, early November, plus an operational flexibility ("safety buffer") volume to reduce chances that the bypass will draw on warm water as the thermocline level approaches the effective intake level and to reduce the risk of a premature turnover in the reservoir.

Selection of Trinity Reservoir Release Temperature

The boundaries of warm water and cold water pools in the reservoir are drawn at a particular temperature, set at the maximum release temperature needed to achieve downstream water temperature objectives. From the fall 1990 and 1991 records of Trinity River temperatures at that point and of Lewiston release temperatures, we estimated that Lewiston releases should be about 6 to 7 F cooler than the desired 56 F at Douglas City.

From the Jones & Stokes temperature model of Lewiston Reservoir (Brown and others, 1992), we estimated that releases from Trinity Reservoir warm by about 1 to 1.5° F as they traverse Lewiston Reservoir at 800 cfs, such that Trinity releases should be about 7 to 8° F cooler than the desired temperature at Douglas City. Therefore, we selected 49° F as the target release temperature from Trinity, and as the boundary temperature between warm and cool pool within the reservoir.

This temperature may be expected to vary within a range of several degrees depending upon seasonal temperatures, release rates and other factors. The effects of different release temperatures on carryover needs can be explored in future work.

Estimation of Warm and Cool Pool Volumes

We used measured temperature versus depth profiles for Trinity Reservoir near the dam to locate the depth to the 49° F isotherm on or about October 1, 1991, using data developed by U.S. Fish and Wildlife Service staff (Smith, 1991). For comparison, we also used data from the U.S. Bureau of Reclamation (Rowell, 1979) Trinity Dam Multilevel Outlet Evaluation for 1964, 1974 and 1975 (the only other data readily available to us). We noted the elevations of the 49° isotherm and the water surface on or about October 1 and used these to estimate the cold water storage volumes and the total storage volumes. Warm water storage volume was calculated by difference.

Year	Elevation of 49° F Isotherm (ft MSL)	Elevation of Water Surface (ft MSL)	Cool Water Storage (taf)	Total Storage (taf)	Warm Water Storage (taf)
1991	2068	2211	89	670	581
1964	2208	2308	639	1559	920
1974	2233	2343	821	2030	1209

1975	2247	2344	930	2045	1115

Estimate of Minimum Carryover Storage

Minimum carryover storage for regulation of downstream river temperatures is composed of the unusable or inaccessible water on October 1, plus additional cold water needed to regulate river temperatures until the end of the warm season, and a safety buffer volume to reduce chances that the bypass will draw from the warm water pool as the thermocline elevation drops to near the effective level of withdrawal.

Suitable carryover storage for October 1, 1991 conditions can be approximated by summing the estimated volumes of:

a.	Warm pool	581,000 ac. ft.
b.	Unavailable or dead pool	23,000 ac. ft.
c.	Reserve for required Oct.-Dec. temp	53,000 ac. ft.
d.	Operational safety buffer rec.	100,000 ac. ft.
	Total:	757,000 ac. ft.

To achieve this value, May 1, 1991 carryover would have needed to be greater by 290,000 acre feet (Table 1), for a total of 1,047,000 acre feet, without supplemental exports to the Sacramento River system. Both carryover estimates are based upon assumptions which may underestimate or overestimate actual needs. Our assumptions regarding 49 degree water in Trinity Reservoir being sufficient to sustain 56 degree maximum water temperatures at North Fork after September 30, adequate refilling the following winter (no string of dry years), and no operational or water-quality constraints affecting availability of the cool waters within Trinity Reservoir may lead to underestimates of actual carryover needs. Overestimates may be effected by not considering effects of temperature-control structures in Lewiston Reservoir. Once refinements addressing these assumptions can be made, it is likely that carryover storage on the order of 900,000 acre feet or slightly more may be needed to meet Trinity River requirements.

Out-of-Basin Considerations

Minimum carryover storage for Trinity Reservoir, depending upon the subsequent water year type, will determine Trinity exports to the Sacramento River basin (and/or the Bay-Delta estuary) -the following year. in the event of a driest decile water year, exports would be the minimum amount available that is not necessary for meeting Trinity River instream flow and temperature requirements. The low refill probability of Trinity Reservoir, as compared to Shasta Reservoir is indicative of limitations on exports during driest decile water years with low carryover from preceding years. For example, at 50 percent capacity (2,276,000 af), Shasta's refill probability is 36 percent. Trinity Reservoir, at 50 percent capacity (1,225,000 af), has a refill potential of 15 percent (USBR, Interim CVP-OCAP). Therefore, some buffer must be added for Trinity carryover, or exports to the Sacramento River will be severely constrained during consecutive years of low runoff, a period when those exports would be needed most by the CVP and the Bay-Delta estuary.

A further constraint on exports to the Sacramento River basin is the lack of temperature control structures in Whiskeytown Reservoir. Trinity watershed exports to the Sacramento River basin during the critical July - September period are limited because Trinity water is significantly warmed as it is transported through Whiskeytown. Trinity exports during the July - September period severely constrain the ability to meet temperature objectives for winter-run chinook salmon, especially during consecutive dry years such as the current drought.

In Table C-1 of a report submitted to the SWRCB on May 29, 1992, USBR modelers predicted that Spring Creek power plant discharges would be 11.5 degrees F warmer than combined Shasta Dam releases during the month of July. In August, the temperature differential rose to 12.8 degrees. Similar differentials probably prevail in September, although simulations for mean September temperatures through the Spring Creek power plant were not developed. Therefore, in order for Trinity River instream releases from Lewiston Dam to attain the desired 49 degrees, while maintaining desired temperatures in the Sacramento River, Spring Creek power plant releases should be virtually eliminated while Trinity River instream flow releases are increased to approximately 800 cfs, according to USBR's temperature model. The Russ Brown temperature model predicts that instream flow releases must increase to approximately 700 cfs. However, instream flow needs of the Trinity River fishery during that period are only 300-500 cfs (USFWS).

Therefore, instream flow needs in excess of that amount could be exported, if temperature control structures were installed in Whiskeytown. Water Right Orders 90-05 and 91-01 do not require actual installation of water temperature control structures in Whiskeytown. Therefore, assumptions in establishing an interim minimum pool for Trinity Reservoir should assume limitations on Trinity exports during July, August and September.

An alternative operational scenario to maximize Trinity exports while maintaining Trinity River instream flow and temperature needs would be to virtually drain Whiskeytown by July 1, and refill it with Trinity exports through September. That operational alternative would provide necessary Trinity River instream flows and temperatures without increasing Trinity instream flows above those necessary for fish habitat. However, the impacts to Shasta County's recreational economy would be significant, and USBR has committed to maintain Whiskeytown within 20,000 af of capacity during the summer season.

We understand that USBR is in the process of installing two temperature curtains in Lewiston Reservoir. The curtains may assist in maintaining desirable temperatures at the Trinity River hatchery, as well as Lewiston Dam and Clear Creek tunnel releases. However, the extent of effectiveness will not be known until the curtains are constructed and operational.

Another factor which could significantly increase the amount of Trinity carryover storage is whether or not powerhouse bypasses occur. In the event powerhouse bypasses are not assumed in calculations for minimal pool, Trinity Reservoir carryover will need to be significantly greater.

References Cited

- Brown, R. T., Yates, G., and Field, J., 1992, Temperature modeling of Lewiston Lake with the BETTER two-dimensional reservoir flow mixing and heat exchange model: Jones & Stokes Associates, Inc., report to County of Trinity, Department of Transportation and Planning.

- Rowell, J. H., 1979, Mathematical model investigations: Trinity Dam multilevel outlet evaluation, Trinity River temperature prediction study: Trinity River Basin fish & Wildlife Task Force Interim Action Program report, U.S. Bureau of Reclamation (Sacramento, California), May 1979, 27 P. + 8 appendices.

- Smith J. G., 1991, Water temperature monitoring in Lewiston and Trinity Reservoirs (1990 through 1991): Memorandum of October 28, 1991 to Project Coordinator, Trinity River Fishery Resource Office, 1 P. + attachments.

- U.S. Bureau of Reclamation, 1992, Report on alternative operations of Shasta/Trinity Divisions for 1992 Sacramento River temperatures for salmon resources -Projected for the period June through December 1992: May 1992, 5 p. + 4 appendices.

- U.S. Fish and Wildlife Service, 1992, Trinity River Flows -- April 1, 1992 through March 31, 1993: Memorandum from Field Supervisor, Fish and Wildlife Enhancement Field Office (Sacramento) to Regional Direct, Mid-Pacific Region, U.S Bureau of Reclamation. May 15, 1992, 2 p.

Table 1. Monthly Releases and Losses Assumed in Composting Estimated Carryover Storage (a)

Month/Period, Driest-Decile Year	Mandated Instream Flows (b)	Flows Through Lewiston Reservoir for Temperature Control (800 cfs) (c)	Evaporation from Trinity Reservoir (d)	Total for Month or Period
May + June	117,100	---	9,500	126,600
July	---	49,000	7,300	56,300
August	---	49,000	6,000	55,000
September	---	47,500	4,200	51,700
May - September			Subtotal.	290,000
October	18,400 (e)	15,000 (f)	1,800	35,200
November	17,800 (e)	---	---	17,800
October - November			Subtotal.	53,000

- (a) All units in acre feet unless otherwise specified; values are rounded, and may not sum exactly.
- (b) Downstream migrant and sediment flushing flows specified in Lujan order.
- (c) Based on Bureau of Reclamation one-dimensional model.
- (d) From Bureau of Reclamation June 17, 1992 Forecast of Water Supply and Requirements for Clair Engle Lake; intended as a reasonable estimate only. Evaporation from Lewiston Reservoir and other losses considered below threshold of discrimination for this table.
- (e) 300 cfs for full month. Releases for December not debited, since cool-water storage needs are likely to be minimal.
- (f) We assume that an additional 500 cfs for 15 days may be needed to sustain the 300 cfs releases at 56 degrees F.

Note: All values subject to revision.

OPERATION OF LEWISTON DAM

Releases of water to the Trinity River pan be made through the hatchery, the power plant, the power plant bypass (river outlet works), or the spillway at Lewiston Dam. The Shasta O&M office provided the following release capacities and operational information for these structures:

Hatchery - 110 cfs
(110 cfs is for current facilities. It is estimated that increased releases of 120 to 150 cfs will be required when the new fishways are brought on line.)
Power Plant - 100 cfs
(The addition of a second proposed generator would utilize releases that are currently being made but are not being used to generate power.)
River Outlet Works (Power Plant Bypass)
320 cfs (power plant shut off)
220 cfs (power plant running)
Spillway -
(The radial gated spillway has a spillway crest elevation of 1874.5 feet. The top of the radial gates is elevation 1902 and the reservoir is normally operated to maintain a water surface elevation between 1900 and 1902.)

As indicated by these figures, releases exceeding 430 cfs have to be released over the spillway and would tend to draw water from the surface layer of Lewiston Lake. This may be a consideration for temperatures in the river at certain times of the year, as the temperature at the surface of the lake would be dependent on the stratification existing in Lewiston Lake at the time of release.

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