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TRINITY RIVER BASIN
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*Trinity Dam
Operating Criteria
Trinity River Division
Central Valley Project - California*



JULY 1979

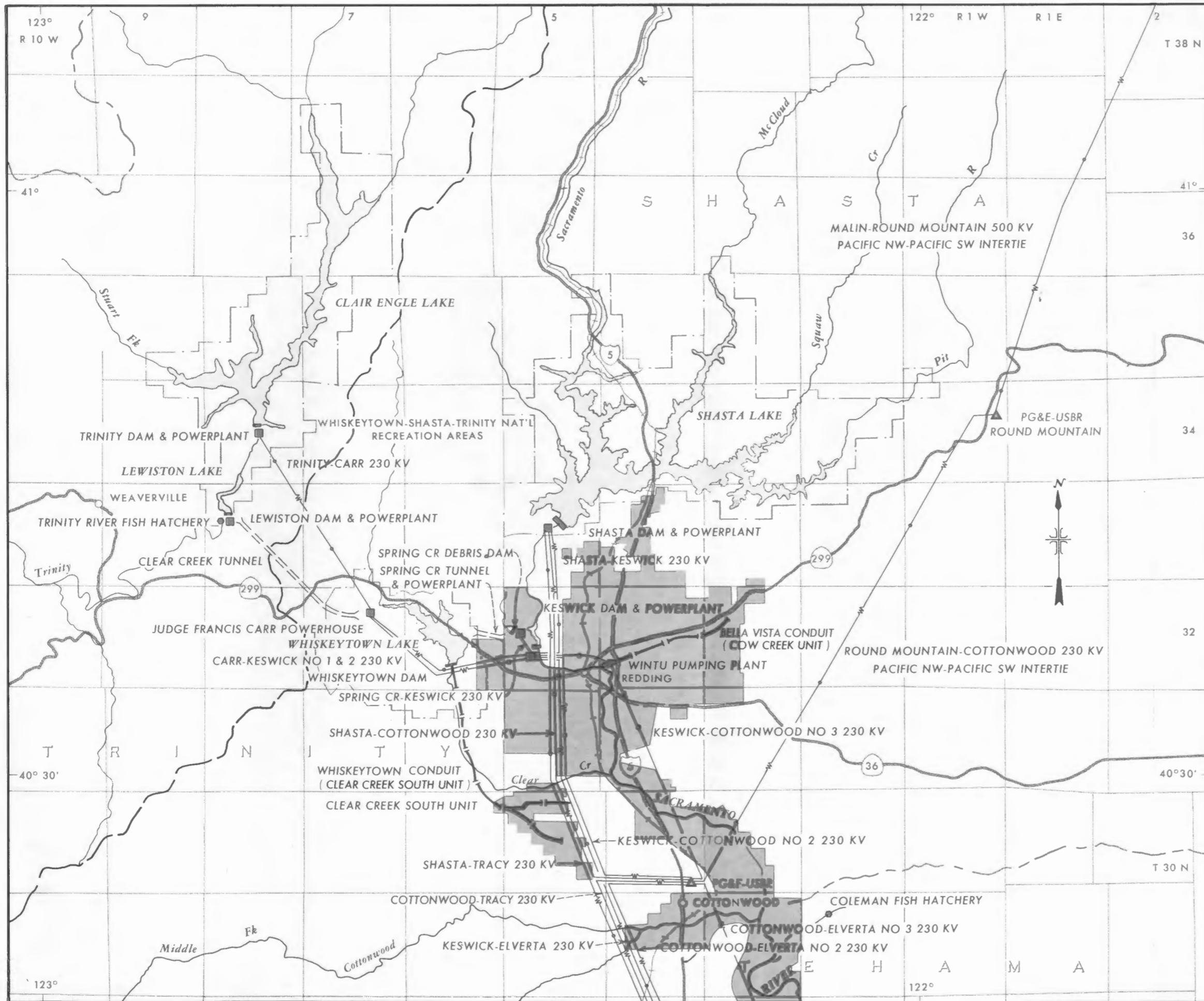
TRINITY RIVER DIVISION
CENTRAL VALLEY PROJECT
CALIFORNIA

Trinity Dam
Operating Criteria

Prepared for the
Trinity River Basin
Fish and Wildlife
Task Force

July 1979

United States
Department of the Interior
Bureau of Reclamation
Mid-Pacific Region



**BUREAU OF RECLAMATION
COMPLETED OR AUTHORIZED WORKS**

- DAM AND RESERVOIR
- TUNNEL
- CONDUIT
- TRANSMISSION LINE
- PUMPING PLANT
- POWERPLANT
- SUBSTATION
- FISH HATCHERY
- CENTRAL VALLEY BASIN BOUNDARY
- WATER SERVICE AREA

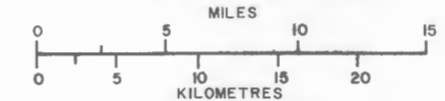
UNITED STATES
DEPARTMENT OF THE INTERIOR

**BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT
SHASTA AND TRINITY RIVER
DIVISIONS**

CALIFORNIA

MID-PACIFIC REGION

MAP NO. 214-208-4469



FEBRUARY 1977

FACTUAL DATA ON THE SHASTA AND TRINITY RIVER DIVISIONS

The Central Valley Project was authorized for construction in 1935. Shasta Dam, a part of Shasta Division, was one of the initial features included in the project. The Trinity River Division was authorized by Congress in 1955 and completed in 1964.

SHASTA DIVISION

SHASTA DAM AND SHASTA LAKE on the Sacramento River have a drainage area of 17 262 km² (6,665 sq. miles) and store a maximum of 5 614 810 x 103 m³ (4,552,000 acre-feet) of water. Floods are controlled and surplus winter runoff is stored for many uses including: irrigation in the Sacramento and San Joaquin Valleys, maintenance of navigation flows in the Sacramento River, conservation of fish life in the Sacramento River, protection of the Sacramento-San Joaquin Delta from intrusion of saline ocean water, provision of water for municipal and industrial use, and generation of hydroelectric energy. The dam is a curved concrete gravity structure, with a height of 183.5 m (602 ft.) and a crest length of 1 054.6 m (3,460 ft.).

SHASTA POWERPLANT is located just below Shasta Dam. Water from the dam is released through five 4.6-m-diameter (15-ft.-) penstocks leading to the five main generating units and two station service units. The total capacity of these units is 456,000 kW.

KESWICK DAM AND POWERPLANT are located on the Sacramento River 14.5 km (9 miles) downstream from Shasta Dam. The dam creates a 29 357 000-m³ (23,800-acre-foot) afterbay for Shasta Lake and Trinity River Division and smooths out the uneven water releases from the powerplants. The dam also has migratory fish trapping facilities operating in conjunction with the Coleman Fish Hatchery on Battle Creek 40.2 km (25 miles) downstream. Keswick Dam is a concrete gravity structure 48.5 m (157 ft.) high with a crest length of 318.8 m (1,046 ft.). The powerplant has three generating units with a total capacity of 75,000 kW.

TRINITY RIVER DIVISION

Surplus water from the Trinity River Basin is stored, regulated, and diverted through a system of dams, reservoirs, tunnels, and powerplants into the Sacramento River for use in water-deficient areas of the Central Valley Basin. Additional power generating capacity is also provided for northern and central California. In addition, Trinity River Division improves recreational opportunities and increases minimum flows in the Trinity River.

Trinity River water is stored in Clair Engle Lake behind Trinity Dam. Releases from this reservoir are utilized to generate 106,000 kW at Trinity and Lewiston Powerplants. Releases are regulated in Lewiston Lake 11.3 km (7 miles) downstream. Lewiston Dam regulates flows to meet the downstream requirements of the Trinity River Basin, including those of the Trinity River fishery. Water not needed in the Trinity River Basin is diverted by Lewiston Dam through the Clear Creek Tunnel to the 141,444-kW Judge Francis Carr Powerhouse and then into Whiskeytown Lake behind Whiskeytown Dam on Clear Creek, a tributary of the Sacramento River. From Whiskeytown Lake the water from Trinity River and surplus flows from Clear Creek flow through the Spring Creek Tunnel to the 150,000-kW Spring Creek Powerplant and discharge into existing Keswick Reservoir on the Sacramento River. Above Keswick Dam,

Trinity River water is combined with Sacramento River water to provide irrigation service to lands in Shasta County, to meet the ultimate requirements of the Sacramento Canals, and to help supply water to lands in the Delta-Mendota Canal service area, the San Luis Unit, and other areas of the Central Valley Project.

TRINITY DAM AND CLAIR ENGLE LAKE on the Trinity River have a drainage area of over 1 885 km² (728 sq. miles) of mountainous country and store a maximum of 3 019 000 000 m³ (2,448,000 acre-feet) of water. Flows are regulated and surplus water is stored for irrigation. The dam is an earthfill structure 164 m (538 ft.) high with a crest length of 746.8 m (2,450 ft.).

TRINITY POWERPLANT at Trinity Dam has two generators with a capacity of 105,600 kW.

LEWISTON DAM AND LAKE, about 11.3 km (7 miles) downstream from Trinity Dam, creates an afterbay to Trinity Powerplant and diverts water by means by Clear Creek Tunnel to Whiskeytown Lake. Lewiston Dam is an earthfill structure 27.7 m (91 ft.) high and 219 m (720 ft.) long, forming a reservoir capacity of 18 100 000 m³ (14,600 acre-feet).

LEWISTON POWERPLANT, using releases for the support of fish life and other downstream purposes in the Trinity River, has one station unit with a capacity of 350 kW.

TRINITY RIVER FISH HATCHERY. The Trinity River is one of California's most famous fishing streams. To maintain the salmon and the steelhead fisheries below Lewiston Dam, 4.3 m³/s (150 ft³/s) of water is released between December 1 and August 30 of each year. Releases are increased to 5.7 m³/s (200 ft³/s) during the period of September 1 to October 14, and to 7.1 m³/s (200 ft³/s) October 15 to November 14. Releases for the period November 15 to November 30 are set at 5.7 m³/s (200 ft³/s). The higher releases in the fall facilitate natural spawning. The Trinity River Fish Hatchery, with a capacity of about 40,000,000 eggs, is located immediately downstream from Lewiston Dam and compensates for upstream spawning area rendered inaccessible and unusable by the dams.

CLEAR CREEK TUNNEL, 5.33 m (17.5 ft.) in diameter and 17.4 km (10.8 miles) long, enables transfer of water from Lewiston Dam to the Judge Francis Carr Powerhouse and Whiskeytown Lake. A bypass is provided into Crystal Creek.

JUDGE FRANCIS CARR POWERHOUSE, located on Clear Creek, has two generators with a capacity of 141,444 kW.

WHISKEYTOWN DAM AND LAKE are located on Clear Creek. The dam provides regulation for Trinity River flows discharged from the Judge Francis Carr Powerhouse and regulates the runoff from the Clear Creek drainage area. The dam is an earthfill structure 86 m (282 ft.) high, with a main crest length of 685.8 m (2,250 ft.), and creates a reservoir with a capacity of 297 400 000 m³ (241,100 acre-feet).

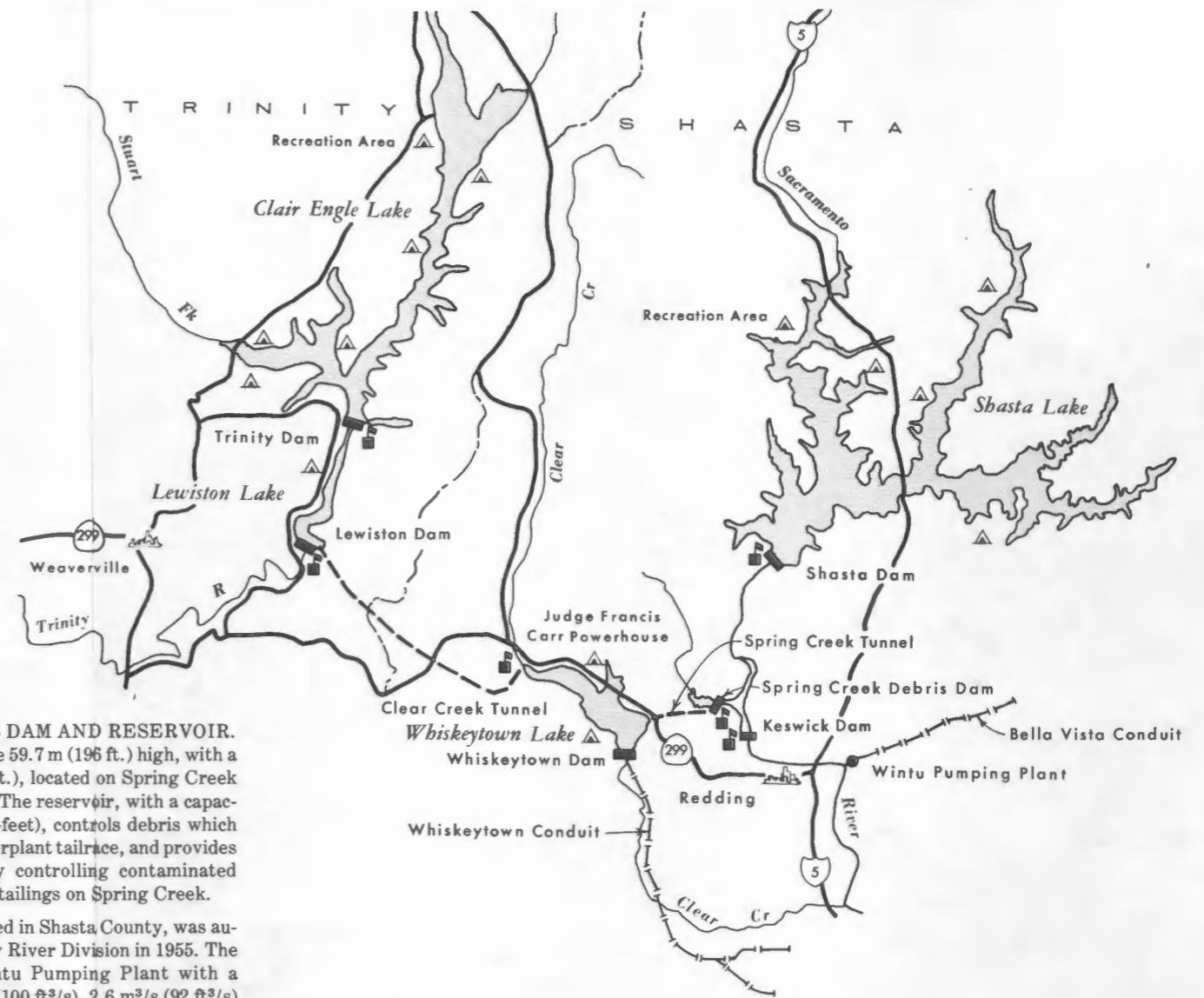
SPRING CREEK TUNNEL AND POWERPLANT. The tunnel diverts water from Whiskeytown Lake on Clear Creek, a tributary of the Sacramento River, to the Spring Creek Powerplant. The tunnel is 5.6 m (18.5 ft.) in diameter and about 3.9 km (2.4 miles) in length, including the 5.2-m-diameter (17-foot-) Rock Creek Siphon, 1 km (0.6 of a mile) in length. Spring Creek Powerplant is located on an arm of Spring Creek at Keswick Reservoir. It has two generators with a capacity of 150,000 kW.

SPRING CREEK DEBRIS DAM AND RESERVOIR. The dam is an earthfill structure 59.7 m (196 ft.) high, with a crest length of 347.5 m (1,140 ft.), located on Spring Creek above the powerplant tailrace. The reservoir, with a capacity of 7 240 000 m³ (5,870 acre-feet), controls debris which would otherwise enter the powerplant tailrace, and provides important fishery benefits by controlling contaminated runoff resulting from old mine tailings on Spring Creek.

COW CREEK UNIT, located in Shasta County, was authorized as a part of the Trinity River Division in 1955. The unit features consist of Wintu Pumping Plant with a maximum capacity of 2.8 m³/s (100 ft³/s), 2.6 m³/s (92 ft³/s) through the main conveyance, and a pressure system with branching pressure distribution lines. Each year about 8 370 000 m³ (23,000 acre-feet) of water can be lifted 90 m (295 ft.) from the Sacramento River by the Wintu Pumping Plant into the 12.9-km-long (8-mile-) Bella Vista Conduit. This supplemental supply, in combination with local ground water, will serve about 2 800 ha (6,800 acres) of irrigable land east of Redding.

CLEAR CREEK SOUTH UNIT, located in Shasta County, was authorized as a part of the Trinity River Division. The major feature is the 18.8-km-long (11.7-mile-) Whiskeytown Conduit which transports about 18 502 000 m³ (15,000 acre-feet) from Whiskeytown Lake to serve 1 800 ha (4,600 acres) of irrigable land west of Anderson.

THE TRANSMISSION SYSTEM consists of switchyards, high-voltage lines, and substations for delivery of power to project pumps and for wholesale disposal of excess power, with 1 841 km (1,144 miles) of 230-kV line. Backbone of the system consists of five 230-kV circuits; three circuits to Elverta Substation with a 230-kV connection between Folsom Powerplant and Elverta Substation, two circuits from Elverta to Tracy Switchyard, and two circuits from Shasta to the Tracy Switchyard. The system is connected to the northwest by the Malin-Round Mountain 500-kV line and the Round Mountain-Cottonwood 230-kV line, both units of the Pacific Northwest-Pacific Southwest Intertie, with 151.3 km (94 miles) of 500-kV line, and 57.7 km (34 miles) of 230-kV line.



RECREATION. The Whiskeytown-Shasta-Trinity National Recreation Area is administered by the United States Forest Service. Boating, fishing, swimming, water skiing, camping, hunting, and sightseeing are enjoyed by nearly a million tourists every year. Many resorts cater to the needs of the visitors to the area.

OTHER PROJECT FEATURES

In addition to the Shasta and Trinity River Divisions, the Central Valley Project includes a number of other divisions and units. These are the authorized Allen Camp Unit; the Sacramento Canals Unit, operating and under construction; the American River Division with operating Folsom and Sly Park Units, and the authorized Auburn-Folsom South Unit with Auburn Dam and Folsom South Canal in construction stage; Delta Division with the Delta Cross Channel which carries Sacramento River water across the river delta area, the Tracy Pumping Plant which lifts the water 60.0 m (197 ft.) into the Delta-Mendota Canal, and the Contra Costa Canal system; the Friant Division with Friant Dam on the San Joaquin River, and the Friant-Kern and Madera Canals which distribute San Joaquin River water from Friant Dam to agricultural areas to the north and south; the San Luis Unit, a joint Federal-State project; and the San Felipe Division, under construction.

CENTRAL VALLEY PROJECT MAPS

- Central Valley Project
Map No. 214-208-5133
- Central Valley Project, North Half
Map No. 214-208-4174
- Central Valley Project, South Half
Map No. 214-208-4175
- Central Valley Project, San Luis Unit
Map No. 214-208-5165
- Central Valley Project, Delta Division
Map No. 214-208-4177

Address all inquiries regarding additional information concerning this project to:

REGIONAL DIRECTOR, MID-PACIFIC REGION
BUREAU OF RECLAMATION
2800 COTTAGE WAY
SACRAMENTO, CALIFORNIA 95825

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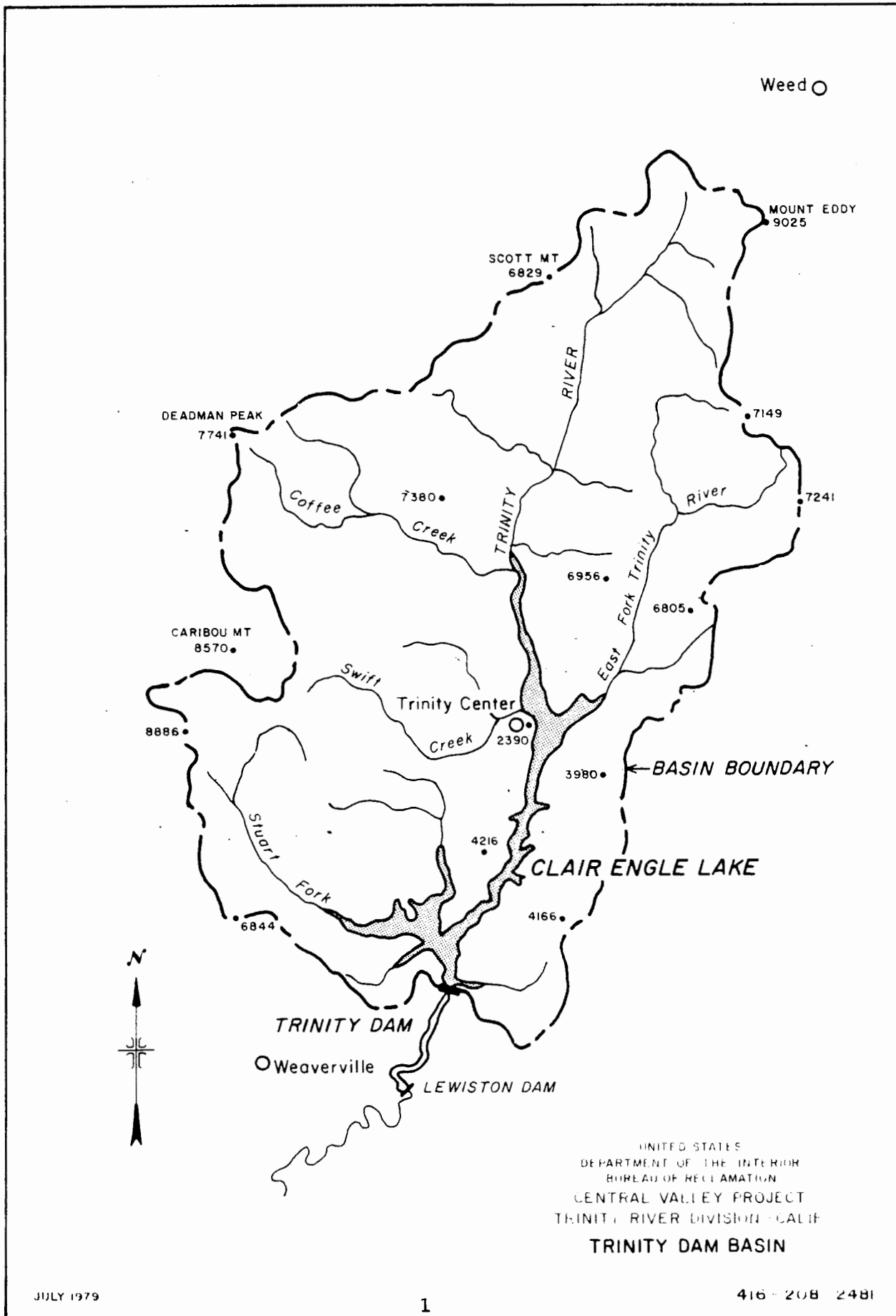
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UNITED STATES
 DEPARTMENT OF THE INTERIOR
 BUREAU OF RECLAMATION
 CENTRAL VALLEY PROJECT
 TRINITY RIVER DIVISION - CALIF
TRINITY DAM BASIN

INTRODUCTION

PURPOSE AND SCOPE

In January 1974 a storm of unusually severe intensity occurred over the Trinity River Basin, providing a computed peak inflow to Clair Engle Lake of about 103,000 cubic feet per second (ft^3/s). Previous storms had filled the reservoir nearly to the spillway crest. The combination of a nearly full reservoir and unexpectedly heavy inflow precipitated a review of the Trinity Dam Standard Project Flood by the Corps of Engineers and completion of the review of the Design Flood then underway by the U.S. Bureau of Reclamation. The results of the reviews by the Corps of Engineers and Bureau of Reclamation are found in Parts II and III of this document.

Inasmuch as passage by the dam of $60,000 \text{ ft}^3/\text{s}$ might be necessary under certain assumptions and with operating criteria then in force, the two reviews were based solely on the issue of structural safety for Trinity Dam. It was variously estimated that should it be necessary to pass $60,000 \text{ ft}^3/\text{s}$ by Trinity Dam, the dam would be overtopped for 10-12 hours with as much as $30,000 \text{ ft}^3/\text{s}$ flow. Should this occur, the dam would be threatened and might fail.

The storm of January 1974 in itself did not pose a threat to the structural integrity of Trinity Dam as not more than 14,400 ft^3/s was observed below Lewiston Reservoir at the Lewiston stream gage. This was just less than half of the designed outlet capacity for both Trinity and Lewiston Dams. Nevertheless it appeared the operating criteria should be modified.

Introduction

The main purpose of this document is to summarize the basic data available on the Trinity Dam operations.

During preparation of this document, the USBR E&R Center staff provided invaluable review, furnishing suggestions which are incorporated in it.

AUTHORIZING LEGISLATION

The Trinity River Division, Central Valley Project, was authorized August 12, 1955 by Public Law 84-386 (69 Stat. 719). The principal purpose of the legislation was to increase the supply of available water for irrigation and other purposes in the Central Valley of California. A copy of the legislation is appended to this report.

As interpreted from the authorizing Act, flood control was to be incidental to the normal operation of the project for fishery flows, recreation, irrigation needs, and power generation. Therefore, flood control storage in Clair Engle Lake was not an authorized function and no flood storage space was provided.

PRE-1974 OPERATIONS

Construction of Trinity Dam began in 1957. The dam was completed and storage of inflow to Clair Engle Lake commenced November 22, 1960. Construction of other unit features continued until all were completed in 1962. A description of the features is appended.

As authorized by Public Law 84-386 flood control was not included as a Trinity River Division function and pre-1974 Trinity Dam

Introduction

operating criteria did not provide for protection of the structural integrity of Trinity Dam. Therefore, the operating criteria provided for containment of all inflow except that released for Central Valley Project power generation, agriculture, fishery, municipal and industrial uses, Sacramento-San Joaquin River Delta salinity control, and downstream Trinity River fishery releases. This continued into late fall and winter, depending upon the available inflow to the reservoir, until the morning glory spillway invert elevation of 2,370 feet was reached. From the spillway crest up to the design maximum water surface elevation of 2,387 feet, inflow would spill uncontrolled to Lewiston Reservoir.

Trinity Dam spillway capacity at maximum lake water surface elevation is 22,500 ft³/s, the main outlet works provide an additional capacity of 7,200 ft³/s, for a maximum designed downstream release to Lewiston Reservoir of 29,700 ft³/s. The flow from these outlet works continues downstream to the Lewiston Reservoir contained by Lewiston Dam which has a spillway capacity of 30,000 ft³/s at maximum design elevation.

A feasibility inflow design flood study for the Trinity River Division features was prepared in 1951, with a subsequent revision for final designs completed in October 1955. The design flood resulting from the 1955 study had a peak inflow to Clair Engle Lake of 160,000 ft³/s with a corresponding 6-day volume of 489,000 acre-feet. The operating criteria utilized for Trinity Dam upon its closure in November 1960 were based on this design flood.

Introduction

Because flood control is not an authorized function of the Trinity River Division, Clair Engle Lake does not include storage capacity for this purpose. Inflow is released through Trinity Powerplant, or if the reservoir is full, it flows uncontrolled through the glory hole spillway to Lewiston Reservoir where it is diverted to the Sacramento River, as depicted on the plan profile (Drawing No. 416-208-410). The basic release schedule to the Trinity River from Lewiston Reservoir, with some minor exceptions, has been a fishery maintenance flow of 120,300 acre-feet annually as follows:

1963 to 1968

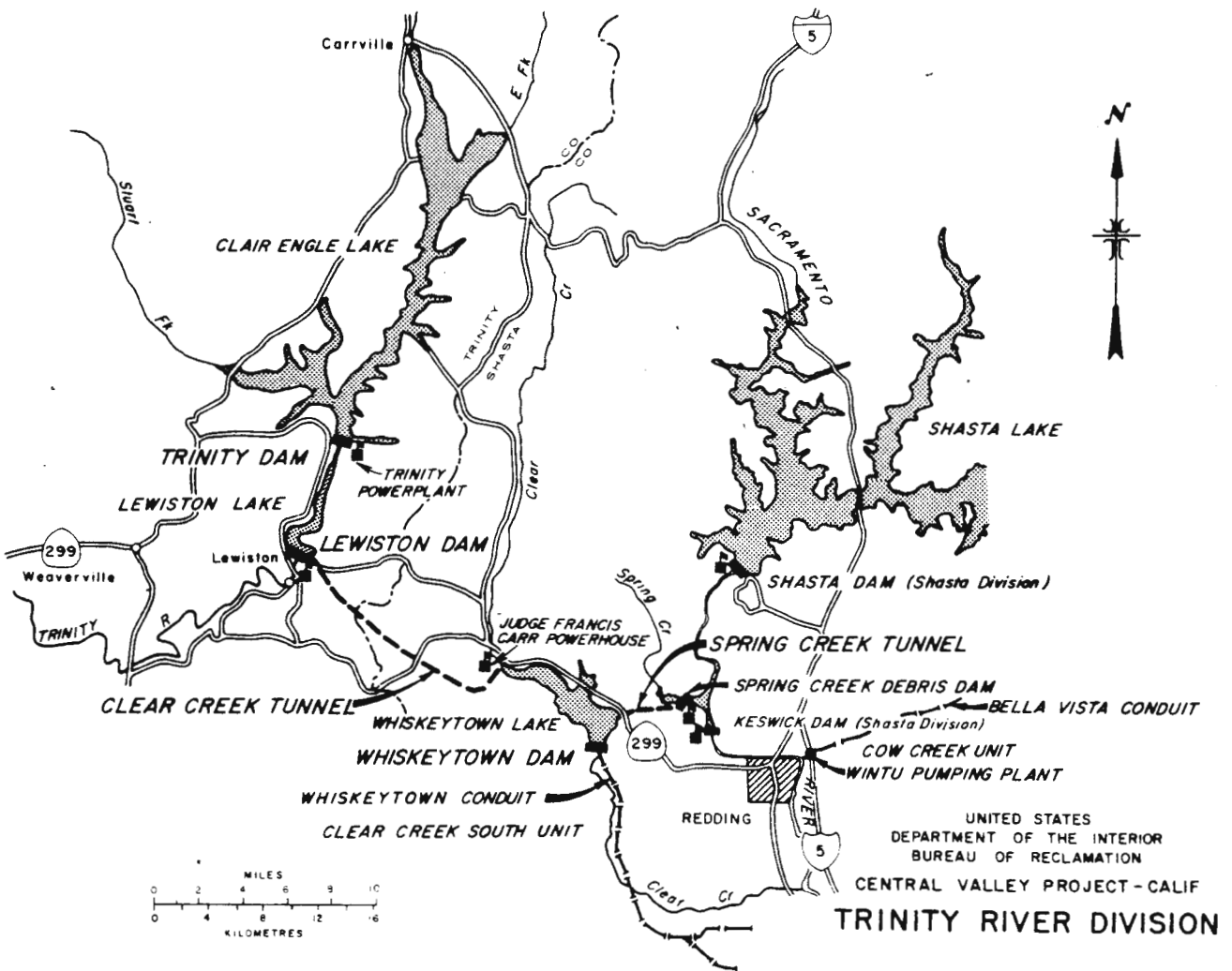
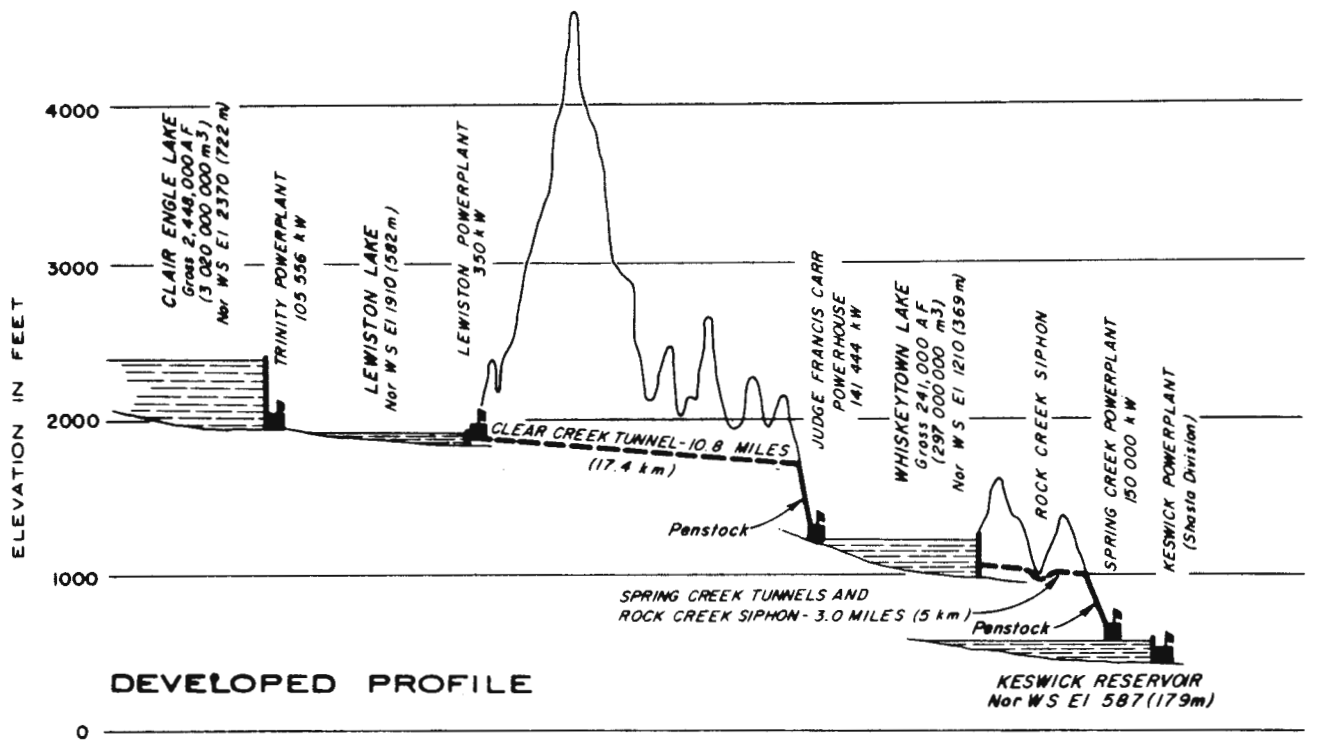
October 1 through October 31	--	200 ft ³ /s
November 1 through November 30	--	250 ft ³ /s
December 1 through December 31	--	200 ft ³ /s
January 1 through September 30	--	150 ft ³ /s

1969 to Present

October 15 through November 14	--	250 ft ³ /s
November 15 through November 30	--	200 ft ³ /s
December 1 through August 31	--	150 ft ³ /s
September 1 through October 14	--	200 ft ³ /s

The schedule is varied four times yearly, depending on the need to attract spawners or aid in outmigration of yearlings planted at the Lewiston Hatchery. The release schedule was modified slightly in 1968 to aid the fishery, but total outflow has remained the same.

In 1974, negotiations between the U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, and the California Department of Fish and Game resulted in an agreement for a 3-year experimental release of an additional 125,000 acre-feet annually to study the



Introduction

results of additional releases on the fishery. This provided a total downstream Trinity River flow below Lewiston Dam of 245,000 acre-feet annually. The Department agreed to monitor the experiment to determine if an improvement in the Trinity River fishery could be shown.

Experimental fishery releases in accord with this agreement were made in 1974 and 1975 but were suspended during the drought years 1976 and 1977. The third year releases were completed in 1978. However, at the request of the Trinity River Basin Fish and Wildlife Task Force, the Bureau has agreed to continue the experimental releases through 1979. Based on the April 1979 water supply forecast, the Bureau of Reclamation agreed to release 220,000 acre-feet to the Trinity River during the period April 1, 1979 through March 31, 1980. The Bureau further agreed to provide an additional 25,000 acre-feet for sediment studies for a total available release of up to 245,000 acre-feet for the period.

Incidental downstream protection is provided during any storm; however, the dam outlets were not constructed with the necessary capacity for quick reservoir evacuation to obtain flood storage space for a second major storm which rapidly follows the first. When the reservoir fills, uncontrolled flow through the glory hole spillway begins. Three situations when major inflows into Clair Engle Lake were regulated so that peak discharges to the Trinity River at Lewiston were significantly reduced were:

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<u>Date</u>	<u>Peak inflow into Clair Engle Lake</u>	<u>Maximum release from Lewiston Dam</u>
December 22, 1964	87,000 ft ³ /s	200 ft ³ /s
January 23, 1970	51,000 ft ³ /s	7,000 ft ³ /s
January 16, 1974	103,000 ft ³ /s	14,500 ft ³ /s

A resident of the area claimed that prior to construction of Trinity Dam, the Poker Bar area between Lewiston and Douglas City on the Trinity River, flooded periodically. During the floods of 1940 and 1955, peak discharges in the Trinity River at the town of Lewiston were 40,300 ft³/s and 72,000 ft³/s, respectively.

PART II

DEVELOPMENT OF 1975 DESIGN FLOOD DATA

Most of the Bureau of Reclamation data used in this part is quoted from two Bureau studies: (a) Nix, Parker W., "Inflow Spillway Design Flood Study for the Existing Trinity Dam," memorandum to Central Files, USBR Mid-Pacific Region, Sacramento, California, March 24, 1975, and; (b) Everson, Clarence E., "Revised Design Storm for Trinity Dam," memorandum to Head, Flood and Sedimentation Section, USBR E&R Center, Denver, Colorado, February 24, 1975. The Corps of Engineers data referred to herein is quoted from "Upper Trinity River Basin, Trinity County, California, Report on Standard Project Flood and Intermediate Regional Flood Determination" report dated September 1974. It was prepared by the U.S. Army Engineer District, San Francisco, California Corps of Engineers.

In developing the design flood it is assumed that storm rainfall will be augmented by melt water from an antecedent snow cover and decreased by infiltration and other losses. A unit hydrograph that is characteristic of the drainage area is then used to convert the resulting available water into a hydrograph of inflow to the lake. The following paragraphs describe the derivation of the Bureau of Reclamation's design flood and the Corps of Engineers' standard project flood.

Development of 1975 Design Flood Data

STORM CLIMATOLOGY

Most of the annual precipitation in northern California occurs from October to April. The months which normally have the most precipitation are December and January; the months of November and February are the next wettest months on the average; however, severe storms can occur as early as October and as late as March and April. The general process that underlies occurrence of storms along California's north coast is explained in the following paragraphs.

As the polar front reaches more southerly latitudes during the colder months, storm centers develop in part due to the temperature difference between the front and the warmer waters of the Pacific at subtropical and midlatitudes. These storms then move toward the coasts of California, Oregon, and Washington. They tend to slow down and intensify as they approach the continent. Three or more successive storms spaced a day or two apart are typical; the initial storm may become relatively stationary near the coast and be overtaken by a successive storm, which provides added energy and reinforcement of its intensity. These Pacific storms become heavily saturated with moisture due to long air trajectories over water. Cyclonic circulation may extend upward to 30,000 or 40,000 feet, with jetstream winds at these elevations exceeding 100 miles per hour around the southern periphery of the low-pressure region.

The converging of saturated air into the storm system causes it to rise due to differences in wind velocities; precipitation then

Development of 1975 Design Flood Data

results from this process. In addition, lifting of the saturated air, as it is transported upward and over mountains by the wind, accelerates and intensifies the precipitation process. Thus, orographic features and exposure to storm winds are important factors relative to precipitation patterns.

These storms generally affect large regions. Precipitation with varying degrees of intensity may persist for several days. A review of storms as they occurred above Trinity Dam indicates a tendency for the precipitation depth-duration curve to level off between 2 and 3 days. This may be followed 1 or 2 days later by a significant increase in depth-duration increments of precipitation.

Accumulations of considerable snow in the mountainous region of northern California often occur during early winter storms. Strong winds and temperatures much above normal in association with the more severe storms are typical. These above-normal temperatures often melt earlier snow accumulations and, when combined with severe precipitation, intensify storm effects.

PRECIPITATION AND STREAMFLOW RECORDS

The mean annual precipitation at Trinity Center Ranger Station is approximately 50 inches. This recording precipitation station in the center of the basin was in operation for 18 years through 1960. Six recorder gages are in operation outside and near the perimeter of the basin. The length of records range from 14 to 100 years, but published hourly readings prior to 1940 are not available. Also,

Development of 1975 Design Flood Data

there are eight nonrecording gages within the general area surrounding the drainage basin.

Runoff data for the Trinity River at Lewiston are available for 46 years prior to completion of Trinity Dam, which began storing water in 1960. Computed inflow data for Clair Engle Lake are available in the operation records from 1961 to date. These data and Trinity River releases below Lewiston are summarized for the years 1961 through 1978 on tables 1 and 2.

ANTECEDENT SNOWPACK

Snowfall is rather common at the lower elevations (below 3,500 feet) of the Trinity Basin; consequently, snowmelt will make a significant contribution to runoff. For the purpose of the USBR study, the antecedent snowpack is assumed to have a basin-wide average water content equivalent to 5.5 inches. The assumed initial densities and corresponding snow depths for each elevation zone are as follows:

<u>Elevation zone</u>	<u>Density</u>	<u>Initial snow on ground (inches)</u>	<u>Area (mi²)</u>	<u>Percent of basin</u>
Below 3,000	18.5	29.72	158.5	22.9
3,000-4,000	16.5	33.33	159.2	23.0
4,000-5,000	15.5	35.49	116.9	16.9
5,000-6,000	14.5	37.93	140.5	20.3
Above 6,000	11.0	50.74	<u>116.9</u>	<u>16.9</u>
		Total	692.0	100.0

Development of 1975 Design Flood Data

RECORDED FLOODS OF UNUSUAL SEVERITY

A review of Trinity River runoff records shows major flood events occurring during the calendar years 1862, 1926, 1928, 1937, 1940, 1941, 1948, 1950, 1955, 1958, 1960, 1963, 1964, 1972, and 1974. Of these recorded floods, that of December 1955 is generally accorded as having inflicted the most damage to Trinity County. That flood virtually isolated portions of Trinity County with bridges and/or their approaches destroyed at Lewiston, Douglas City, Junction City, Big Bar, Hawkins Bar, and Willow Creek.

Trinity Dam was completed in 1960 and was thus not a factor in preventing downstream flood damage during the severe storm of December 16-27, 1955. However, a comparison of the unadjusted storms on table 3 shows the December 18-24, 1964, storm was even more severe for the first 96 hours. Runoff from the 1964 storm was completely contained by Clair Engle Reservoir. Even though total storm inflow for the January 1974 storm was less than that of 1964, the January 16, 1974, inflow was not entirely contained because the reservoir was near full.

STANDARD PROJECT FLOOD

Following the 1974 flood, Trinity County Supervisors requested a Flood Plain Information Report be prepared for them by the U.S. Army Corps of Engineers. The Laytonville storm center of the December 20-23, 1964, storm was used by the Corps to derive a new Trinity Dam Standard Project Storm (SPS) for the report. The SPS augmented by

Table 3

COMPARISON OF UNADJUSTED STORMS FOR TRINITY DAM
Precipitation Depth - Duration Values (inches)

Duration (hours)	26 Jan- 4 Feb 1915	7-10 Dec 1939	28 Nov- 4 Dec 1941	23-30 Oct 1950	16-27 Dec 1955	18-24 Dec 1964	12-18 Jan 1974	USBR
								Transposed Laytonville Center 19-28 Dec 1964 ^{1/}
6	1.80	2.57	2.38	2.78	3.71	2.83	2.30	3.78
12	3.31	4.17	4.34	3.87	5.98	5.11	4.44	6.70
18	4.67	5.29	6.09	5.26	7.31	6.85	6.33	9.55
24	5.92	6.65	7.03	6.40	7.99	8.90	7.45	12.48
36	7.34	9.37	7.18	8.36	9.35	11.50	9.47	16.82
48	8.72	11.22	7.45	11.44	10.43	14.25	10.95	21.00
60	9.91	11.95	7.45	12.75	11.47	15.64	12.77	22.49
72	10.61	12.07	7.58	13.30	12.96	16.07	12.96	23.70
84	11.10		9.51	14.88	14.93	16.96	13.39	24.55
96	11.55		9.74	14.94	17.00	17.26	14.29	25.36
120	12.20		10.10	16.78	20.21	18.33	15.20	26.84
144	12.94		10.37	16.99	22.57	19.04	16.23	27.13

^{1/} Without adjustment for increased height of inflow barrier.

Development of 1975 Design Flood Data

snowmelt and depleted by infiltration losses was applied to their unit hydrograph, resulting in their new Standard Project Flood (SPF) having a peak of 202,000 ft³/s and a 5-day volume of 710,000 acre-feet. A glossary of Corps of Engineers flood terminology is shown in the Appendixes to this report.

Based on their flood hydrology, the Corps concluded that, in the event of an SPF occurring when Clair Engle Lake was full, the dam would be overtopped for about 2 days. Lewiston Reservoir would experience a peak inflow of 61,000 ft³/s during the SPF. Since Lewiston Reservoir has little storage available, the SPF outflow would approximate 61,000 ft³/s and cause the dam to be overtopped by about 6.5 feet.

These determinations were based on the assumption that the water level in Clair Engle Lake would be at the spillway crest elevation at the beginning of the SPF, which under past operating procedures was reasonable.

The Corps subsequently published their findings in the April 1976 document titled, "Flood Plain Information, Trinity River, Lewiston Lake to Junction City, Trinity County, California." This report provides a comprehensive discussion of both the 1974 flood damages and an evaluation of potential future flood occurrences. Included are extensive overflow limit maps for both a Standard Project Flood and an Intermediate Regional Flood.

Development of 1975 Design Flood Data

LAYTONVILLE STORM CENTER

Severe precipitation occurred in the Coastal Ranges about 100 miles south-southwest of Trinity Dam during the December 1964 storm. This storm, a record for the area, was in the vicinity of Laytonville, California, and is referred to as the Laytonville storm center. The same storm also produced record precipitation over the drainage area above Trinity Dam. Considering the meteorological aspects of the storm situation and the fact that record precipitation amounts occurred in both areas, it is conceivable that variation in precipitation for the two areas is due mostly to topographic differences, and thereby reflects differences in probable maximum precipitation.

Because of significant differences in topography, Bureau of Reclamation hydrologists considered transportation of the Laytonville storm center to the Trinity Dam drainage basin questionable. Nevertheless it was examined in detail during the 1975 USBR design storm studies.

The Laytonville area is in the Coastal Ranges with relatively direct exposure and in close proximity to moist air inflow from the coastal waters. The orientation of the range is essentially southeast to northwest in this area. Elevations range from about 1,000 to 6,175 feet (Big Signal Peak) within the Trinity Dam Basin outline placed over the area of the storm center. However, elevations over most of the area thus defined are less than 4,000 feet. The Trinity Dam Basin is farther inland, with a south-southwest to north-northeast

Development of 1975 Design Flood Data

orientation. A mountainous region with elevations exceeding 5,000 feet are located between the basin and the coast. Elevations in the Clair Engle reservoir watershed range from 2,370 to 9,025 feet, with a substantial part above 7,000 feet.

For the Laytonville storm center analysis, an outline of the Trinity Dam Basin was placed over the area to include the most severe positioning with respect to isopercentile values. To get to the best positioning, a rotation of 72 degrees was required. In effect, this was a transposition and fitting of the severe part of the isopercentile pattern to the Trinity Dam Basin. The transposed isopercentile values were multiplied by mean annual precipitation to determine the transposed storm precipitation pattern.

From this pattern an average value of storm precipitation for the basin was determined. It was distributed by recorder data for Laytonville and Potter Valley Powerhouse weighted by means of Thiessen polygons with the storm dewpoint located at San Francisco. The location used for maximum storm dewpoint for Trinity Dam area corresponded to that of San Francisco for the Laytonville area. The inflow barrier was estimated for the maximum dewpoint location. The resulting moisture adjustment was determined to be 0.98.

The following comparison of the USBR Laytonville transposed storm study with the 1975 revised design storm indicates there would be no significant effect on the revised design storm values as

Development of 1975 Design Flood Data

derived from in-place storms. The 1975 USBR revised design storm at 96 hours duration, however, is about 16 percent more severe than the SPS developed by the Corps of Engineers.

<u>Duration (hours)</u>	1975 Revised design storm (in)	USBR Transposed and adjusted Laytonville center of December 1964 storm (in)	Ratio of design storm to Laytonville center (percent)
12	8.65	6.57	132
24	13.30	12.23	109
48	19.75	20.58	96
72	23.76	23.23	102
96	26.67	24.85	107
120	29.13	26.30	111
144	31.21	26.59	117

1975 REVISED DESIGN STORM

The revised design storm for Trinity Dam is based on envelopment of the moisture maximized precipitation depth-duration values for the December 1964 and December 1955 storms.

Severe storms of record over the drainage area above Trinity Dam were analyzed in this study. These storms include:

Jan. 26 - Feb. 4, 1915
 Dec. 7 - 11, 1939
 Nov. 28 - Dec. 4, 1941
 Oct. 24 - 29, 1950
 Dec. 15 - 27, 1955
 Dec. 18 - 24, 1964
 Jan. 12 - 18, 1974

The isopercentile technique was used in derivation of the storm precipitation because of the mountainous character of the drainage area above Trinity Dam. This is a standardized technique used in

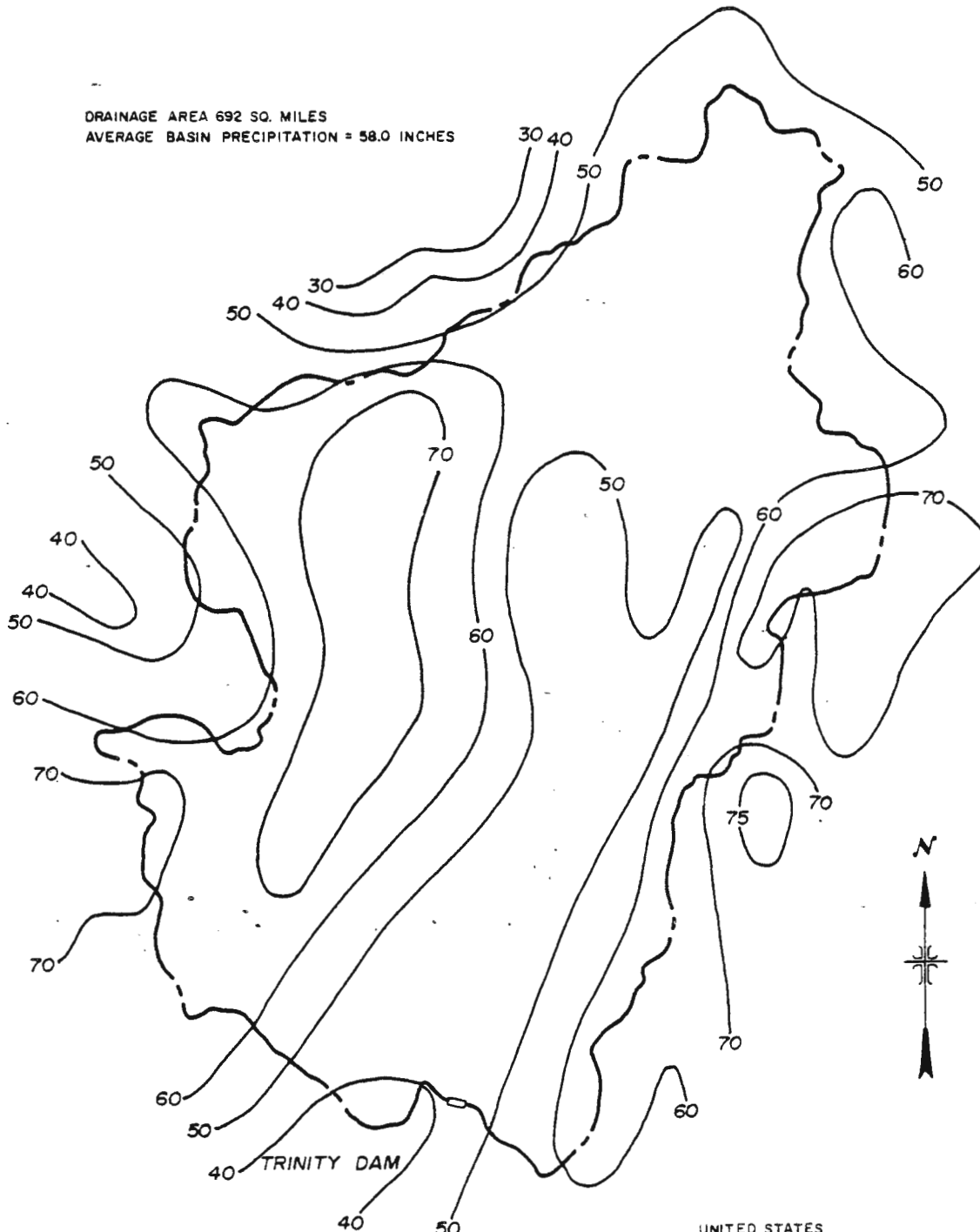
Development of 1975 Design Flood Data

development of storm patterns in mountainous regions to provide for topographic influences on precipitation. By this technique observed storm precipitation values are converted to percent of mean annual precipitation. These percent values, plotted on a map which includes the basin outline, are analyzed for lines of equal percentages of mean annual precipitation, using linear interpolation between observation points. The isopercentile map is then placed over a map of mean annual precipitation, and by multiplication a grid of storm values is determined. The storm pattern is drawn to the gridded values, producing an isohyetal map. The isohyetal maps of the storms are shown in Appendix B.

This procedure provides the most reasonable allowance for topographic effects on precipitation patterns. Several mean annual precipitation patterns are available for the area with reasonably good agreement among them. The mean annual precipitation pattern used for this study and shown on plate 2 is taken from the average seasonal isohyetal map of upper northern California, Department of Water Resources, State of California, 1958. Values of mean annual precipitation range from 40 inches near the dam to 70 inches in the west and also along the eastern border.

The storm patterns were planimetered to obtain average values of storm precipitation over the drainage area. Recorder station hourly data weighted by means of Thiessen polygons were used to distribute the basin average of total storm precipitation. The

DRAINAGE AREA 692 SQ. MILES
AVERAGE BASIN PRECIPITATION = 58.0 INCHES



UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT
TRINITY RIVER DIVISION - CALIF
MEAN ANNUAL PRECIPITATION
AT TRINITY DAM
PERIOD OF RECORD 1905-06 TO 1954-55

All figures in inches

Development of 1975 Design Flood Data

storm precipitation depth-duration values were adjusted for maximum moisture potential by choosing a representative dewpoint for the inflow moist air and determining the maximum dewpoint to be expected for the same location. Highest persisting 12-hour dewpoints (reduced pseudo-adiabatically to sea level) apply in each instance, with the date of maximum dewpoint within 15 days of the storm date. Saturated air and a pseudo-adiabatic lapse rate from the surface to about 40,000 feet is assumed for both the observed and adjusted storms. The precipitable water (predicated upon this assumption) is determined for the layer between the height of the moist air inflow barrier and 40,000 feet, using the storm dewpoint and maximum dewpoint as indices. The ratio of the maximum dewpoint to the storm dewpoint is the moisture adjustment or storm maximization factor. Table 4 lists the depth-duration values as derived in this manner for each of the storms analyzed. The December 1955 December 1964 storms provide the most severe combination of precipitation depth-duration values. Envelopment of values for these two storms establishes the revised Design Storm which is listed on table 4. Values derived by the USBR transposition of the Laytonville, California storm center which occurred during the December 1964 storm are included in table 4 for reference and comparative purposes.

COMPARATIVE DESIGN STORMS

Design storms are compared in table 5. Comparisons with the design storms for Eltapom, Helena, Pilot Ridge, Ironside Mountain, and

Table 4

COMPARISON OF MOISTURE ADJUSTED STORMS FOR TRINITY DAM
(Precipitation Depth - Duration Values)

	Storm							USBR	1975 Revised design storm
	26 Jan- 4 Feb 1915	7-10 Dec 1939	28 Nov- 4 Dec 1941	23-30 Oct 1950	16-27 Dec 1955	18-24 Dec 1964	12-18 Jan 1974	Transposed Laytonville Center 19-28 Dec 1964	
Moisture adjust- ment	1.83	1.45	1.45	1.55	1.38	1.38	1.47		
Duration (hours)									
6	3.29	3.73	3.45	4.31	5.12	3.90	3.39	3.70	5.12
12	6.06	6.05	6.29	6.00	8.26	7.05	6.52	6.57	8.65
18	8.55	7.67	8.83	8.15	10.08	9.45	9.30	9.36	11.20
24	10.83	9.64	10.19	9.92	11.02	12.29	10.95	12.23	13.30
36	13.43	13.59	10.41	12.96	12.91	15.87	13.91	16.48	16.82
48	15.96	16.27	10.80	17.73	14.40	19.65	16.10	20.58	19.75
60	18.14	17.33	10.80	19.76	15.82	21.53	18.78	22.04	22.00
72	19.42	17.50	10.99	20.62	17.88	22.18	19.05	23.23	23.76
84	20.31		13.79	23.06	20.60	23.40	19.69	24.06	25.28
96	21.14		14.12	23.16	23.46	23.82	21.00	24.85	26.67
120	22.33		14.65	26.01	27.89	25.30	22.34	26.30	29.13
144	23.68		15.04	26.33	31.15	26.28	23.87	26.59	31.21

Table 5

COMPARATIVE DESIGN STORMS
Precipitation Depth - Duration Values (inches)

Duration (hours)	1974	Previous design storm for Trinity Damsite 685 mi ² (Dated Sep 16, 1955)	PMP from HMR 36 Trinity Dam 692 mi ²	Corps	Design storm for Eltapom Damsite 784 mi ² (Dated Feb 18, 1966)	Design storm for Helena Damsite 608 mi ² (Dated Feb 18, 1966)	Design storm for Pilot Ridge Damsite 210 mi ² (Dated Feb 18, 1966)	Design storm for Ironsides Mountain Damsite 249 mi ² (Dated Feb 18, 1966)	Design storm for English Ridge Damsite 486 mi ² (Dated May 3, 1965)	USBR
	Revised design storm for Trinity Dam 692 mi ²			of Eng SPS for Trinity Dam (in report (Dated Sep 1974)						Laytonville, Center of Dec 1964 adjusted storm trans- posed to Trinity Dam 692 mi ²
1	.96	.95	1.04		.78	.77	.90	1.03	1.13	.99
3	2.73	2.60	2.82		1.99	1.96	2.40	2.85	2.57	2.10
6	5.12	4.40	5.22		3.62	3.55	4.50	5.49	4.38	3.70
12	8.65	6.90	9.86		6.58	6.41	8.18	10.27	8.01	6.57
18	11.20	8.50	13.47		9.49	9.02	11.84	14.57	11.00	9.36
24	13.30	10.00	16.61		12.11	10.75	15.06	17.11	13.78	12.23
36	16.82	12.50	21.85		16.10	14.08	19.92	21.05	19.03	16.48
48	19.75	14.80	25.93		19.70	17.15	24.45	24.58	24.17	20.58
60	22.00	16.50	29.16		21.46	18.88	26.79	27.40	26.28	22.04
72	23.76	17.60	31.70	20.70	22.53	19.80	28.13	28.94	27.58	23.23
84	25.28				23.49	20.52	29.25	29.87	28.53	24.06
96	26.67			23.00	24.33	21.24	30.33	30.64	29.40	24.85
120	29.13				25.91	22.52	32.29	32.08	30.98	25.30
144	31.21									26.59
168	32.01									27.38
180	32.23									27.91
Critical storms	Dec 1964 Dec 1955	Dec 1939 Nov-Dec 1941			Dec 1964	Dec 1964 Dec 1955 Nov-Dec 1941	Dec 1964 Dec 1955	Dec 1964	Dec 1964 Dec 1937	

Development of 1975 Design Flood Data

English Ridge damsites are in reasonably good agreement. Values based on Hydrometeorological Report (HMR) No. 36 agree closely for the short durations, but increase to about one-third larger beyond 48 hours. However, the tendency for a leveling off of precipitation depth-duration curves between 2 and 3 days for observed storms (as mentioned in the discussion of storm climatology) does not appear to be reflected sufficiently in the HMR 36 values. The revised design storm exceeds the Corps of Engineers Standard Project Storm by 16 percent at 96 hours duration; which is considered reasonable. The transposed and maximized values for the Laytonville center of the December 1964 storm is included for convenience of comparison; although not used in derivation of the revised design storm, they do not contradict the revised design storm values.

The Revised Design Storm Depth-Duration Values for Trinity Dam are shown on tables 4 and 5. No restrictions were placed on the distribution of design precipitation with time. Six-hour increments from the depth-duration values were rearranged into a time sequence which was similar to that observed in historical storms and which would assure the most severe effect of the distribution from snowmelt. The 6-hour periods for 120 hours of the storm were rearranged in the following order of rank (largest increment, 5.12 inches, is ranked number 1): 18, 14, 11, 5, 4, 1, 2, 3, 6, 7, 8, 9, 10, 12, 13, 15, 16, 17, 19, and 20. Since snowmelt and runoff were computed by elevation bands, the basin-average precipitation was distributed to

Development of 1975 Design Flood Data

the elevation bands on the basis of the elevation distribution observed in the December 1939 storm pattern. The ratios of the elevation-band precipitation to the basin-average precipitation for the five elevation zones, starting with the lowest zone, were 0.79, 0.94, 1.08, 1.13, and 1.15. The USBR Rain-on-Snow water budget analysis was used to determine the drainage from the snowpack during each 6-hour period on each elevation zone. Infiltration and other losses of 0.13-inch per hour were then subtracted. Water excesses from all the elevation zones were accumulated into basin-average values. Table 6 summarizes the results of the computations of the water excesses.

Lag time and unit hydrograph selection was made from the results of trial reproductions of a number of flood events on the Trinity River. The adopted 6-hour unit hydrograph has a lag time of 12 hours and a peak discharge of 26,250 ft³/s at time 12 hours. This unit hydrograph was applied to the water excesses from the Rain-on-Snow analysis. After the addition of a 1,000 ft³/s base flow, the resulting inflow Design Flood (which is shown on Plate 3) has a peak of 286,000 ft³/s and a 5-day volume of 816,000 acre-feet.

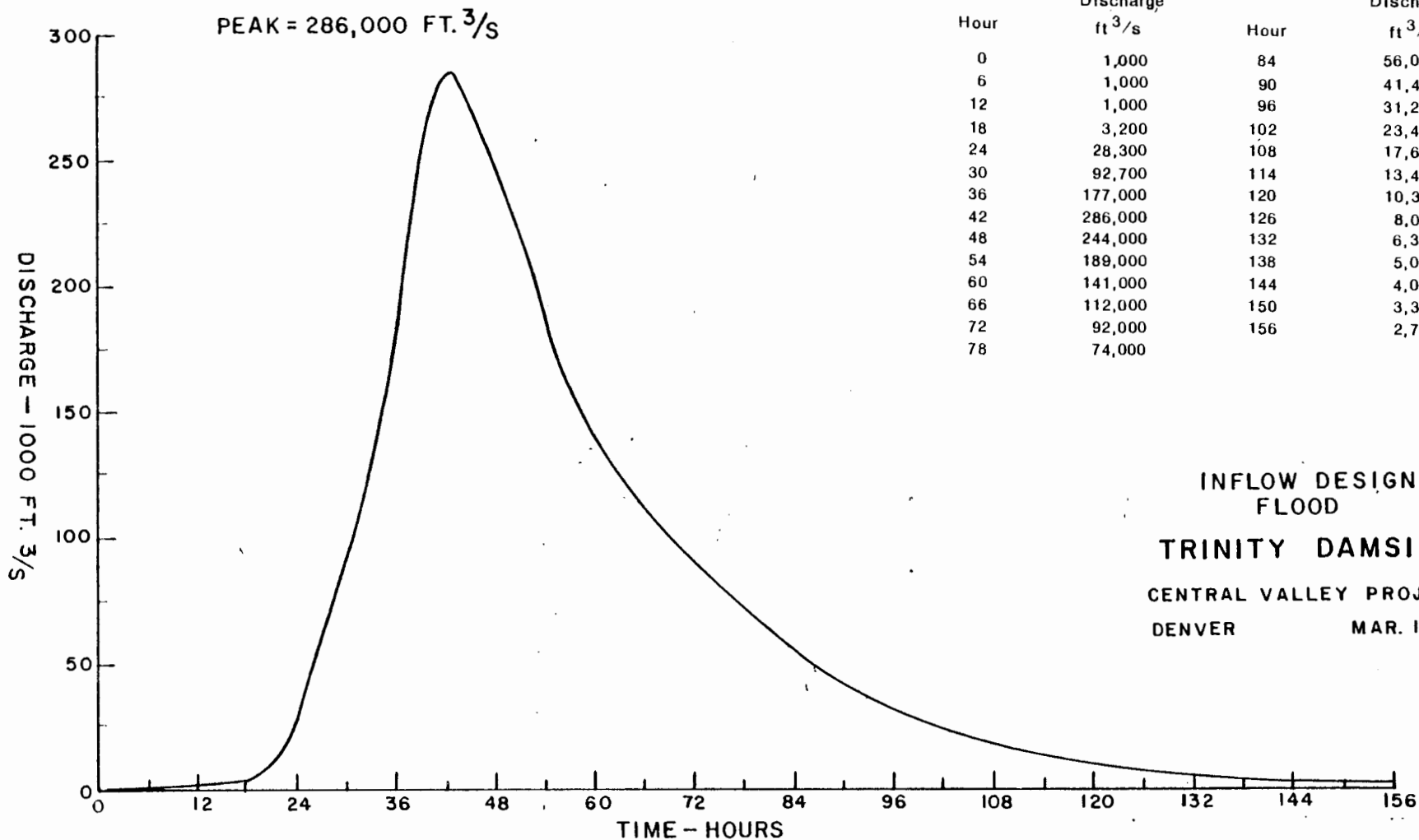
Table 6

Summary of results from Rain-on-Snow Analysis
for 120 hours of Design Storm

Characteristics	Elevation Zones					Total Basin
	<3,000	3-4,000	4-5,000	5-6,000	>6,000	
Area (mi ²)	158.5	159.2	116.9	140.5	116.9	692.0
Precipitation (inch)	22.93	27.24	31.33	32.84	33.44	29.13
Water Content of snowmelt (inch)	5.50	5.50	5.50	5.50	5.50	5.50
Losses (inch)	12.10	12.58	13.02	12.95	12.40	12.59
Water Excess (inch)	16.33	20.16	23.81	25.40	26.57	22.05

MAXIMUM 5-DAY VOLUME = 816,000

INSTANTANEOUS DISCHARGE



INFLOW DESIGN
FLOOD
TRINITY DAMSITE
CENTRAL VALLEY PROJECT
DENVER MAR. 1976

PART III

TRINITY DAM OPERATING CRITERIA

The 1955 design flood is compared in the following tabulation with the Corps of Engineers 1974 SPF and the USBR's 1975 design flood:

	<u>Peak inflow (ft³/s)</u>	<u>Volume (acre-feet)</u>
USBR 1955 design flood	160,000	489,000 (6 days)
Corps of Engineers 1974 SPF	202,000	710,000 (5 days)
USBR 1975 design flood	286,000	816,000 (5 days)

The 1975 design flood is the basis for the operating criteria utilized for Trinity Dam subsequent to 1974.

The January 1974 storm provided the highest inflow peak of record for the upper Trinity River Basin, with a peak inflow into Clair Engle Lake on January 16, 1974, of 103,000 ft³/s. Computed inflow to the lake was in excess of 6,000 ft³/s for a period of 8 days. The 5-day volume of inflow was about 340,000 acre-feet. Without Trinity Dam, the January 16 peak would have been a major disaster for the Trinity River flood plain, possibly destroying all structures within it. Extensive channel erosion would have occurred in areas now protected because of Trinity Dam. The "incidental flood control benefits" provided by Trinity Dam thus proved substantial. Floodwaters retained in Clair Engle Lake lowered the peak flood stage at the Lewiston Bridge by approximately 19 feet. Because of

Trinity Dam Operating Criteria

flows from intervening tributaries, the protection at Douglas City was not as great; however, without Trinity Dam, the January 1974 flood crest at Douglas City would have been almost 16 feet higher.

INTERIM OPERATIONS

The 15 years of Trinity River historical flood event data available at the time of the October 1955 design flood study showed the historical peak had occurred in 1940. That peak would have provided a Trinity River flow of 40,300 ft³/s at Lewiston. Thus, the design flood event of 160,000 ft³/s, or nearly four times the 1940 peak, appeared unlikely to be exceeded or even approached in volume or peak by subsequent floods. Ironically, the December 16-27, 1955 flood, which occurred subsequent to completion of the design flood study, had a peak inflow of 72,000 ft³/s, but the 1955 design flood was still considered adequate to provide a reasonable margin of safety. The December 1964 flood had a peak inflow of 87,000 ft³/s. Subsequently, plans were initiated to add Trinity Dam to the list of new flood studies being made under the Examination of Existing Dams Program. After the 1974 flood, the Trinity study was given priority. As January 1974 storm data were collated, it quickly became apparent that the peak inflow was 2-1/2 times as large as the historical 1940 peak event. This caused considerable concern to water operations managers who felt an inadequate margin of safety was provided by the design flood from which the Trinity Dam operating criteria had been determined.

Trinity Dam Operating Criteria

The Bureau of Reclamation reviewed the potential hazard to Trinity Dam based on the January 1974 flood hydrology. This review was made under the Safety of Dams program to obtain temporary operating criteria to prevent overtopping of Trinity and Lewiston Dams in the event a "maximum probable" storm should occur. Essentially, this temporary criteria required that storage in Clair Engle Lake be limited to a lower level during the flood season from November 1 to March 31. The initial temporary operating criteria were as follows:

INTERIM OPERATION CRITERIA, TRINITY DAM AND RESERVOIR

1. Reservoir storage during the period November 1 through March 1, will be maintained at or below 2,060,000 acre-feet by downstream releases through Trinity Powerplant and diversions to the Sacramento River via Clear Creek Tunnel to Judge Francis Carr Powerhouse at Whiskeytown Lake.
2. If the reservoir storage exceeds 2,060,000 acre-feet during the November 1 through March 1 period, water will be released to the Trinity River, not only through the Trinity Powerplant, but also through the auxiliary outlet works, which has a capacity of 2,500 ft³/s.
3. In the month of March the reservoir will be allowed to fill to a storage of 2,260,000 acre-feet before the auxiliary outlet works would be used to release up to 2,500 ft³/s.
4. If during the period November 1 through March 31 the reservoir reaches elevation 2370 (spillway crest), downstream releases will be increased to the maximum of 7,000 ft³/s.
5. The maximum spill from Trinity Dam could be as much as 30,000 ft³/s during a major storm occurrence in the Trinity River watershed above Clair Engle Lake.

PRESENT CRITERIA

In 1975 the interim criteria were modified further to increase dam safety while minimizing the impact of dam operations upon other

Trinity Dam Operating Criteria

project purposes. The modified criteria listed below are currently being used:

1. Draw Clair Engle Lake down to 1,850,000 acre-feet by November 1 of each year.
2. When lake storage is below 1,850,000 acre-feet, only power releases shall be made.
3. From November 1 to February 28 of each year, release up to 3,600 ft³/s through the powerplant at Trinity Dam to maintain lake storage at 1,850,000 acre-feet. These power releases shall be diverted through Judge Francis Carr and Spring Creek Powerplants to the Sacramento River.
4. From November 1 to February 28 of each year, release up to 6,000 ft³/s to Lewiston Reservoir when Clair Engle Lake storage exceeds 2,060,000 acre-feet. The maximum possible flow of 3,300 ft³/s shall be diverted to Judge Francis Carr Powerplant. The remainder will enter the Trinity River below Lewiston Dam.
5. From November 1 to March 31 of each year, release up to 7,000 ft³/s through the controlled outlets when the lake storage exceeds 2,448,000 acre-feet. Flows above 7,000 ft³/s would be discharged through the uncontrolled glory hole spillway.
6. From March 1 to March 31, releases from Clair Engle Lake shall not exceed 3,600 ft³/s, when lake storage is less than 2,260,000 acre-feet.
7. From March 1 to March 31 of each year, release up to 6,000 ft³/s, when lake storage exceeds 2,260,000 acre-feet.
8. Clair Engle Lake will be permitted to fill after March 31.

In order to assure reservoir filling in June, judicial appraisal of the type, depth and relative ripeness of the snowpack is essential. Powerplant releases are set at a level that will bring the reservoir near full with the projected inflow from the melting of the snowpack. The major objective is to minimize uncontrolled spills to the Trinity River.

Trinity Dam Operating Criteria

Throughout the year, normal releases are made to the Sacramento River through the system of powerplants which include Trinity, Judge Francis Carr, and Spring Creek, and to the Trinity River through Lewiston Powerplant. Of the 1.2 million acre-feet of historical long-term average inflow to Clair Engle Lake, approximately 1 million acre-feet is diverted from the Trinity River watershed to the Sacramento River at Keswick, producing over 1,500 kWh per acre-foot released. This interbasin transfer of water from the Trinity River to the Sacramento River augments the supply for meeting the multipurpose objectives of the Central Valley Project.

APPENDIXES

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TRINITY RIVER DIVISION, CENTRAL VALLEY PROJECT

An act to authorize the Secretary of the Interior to construct, operate, and maintain the Trinity River division, Central Valley project, California, under Federal reclamation laws. (Act of August 12, 1955, ch. 872, 69 Stat. 719)

[Sec. 1. Central Valley project, California—Trinity River division authorized.]—For the principal purpose of increasing the supply of water available for irrigation and other beneficial uses in the Central Valley of California, the Secretary of the Interior, acting pursuant to the Federal reclamation laws (Act of June 17, 1902, 32 Stat. 388, and Acts amendatory thereof or supplementary thereto), is authorized to construct, operate, and maintain, as an addition to and an integral part of the Central Valley project, California, the Trinity River division consisting of a major storage reservoir on the Trinity River with a capacity of two million five hundred thousand acre-feet, a conveyance system consisting of tunnels, dams, and appurtenant works to transport Trinity River water to the Sacramento River and provide, by means of storage as necessary, such control and conservation of Clear Creek flows as the Secretary determines proper to carry out the purposes of this Act, hydroelectric powerplants with a total generating capacity of approximately two hundred thirty-three thousand kilowatts, and such electric transmission facilities as may be required to deliver the output of said powerplants to other facilities of the Central Valley project and to furnish energy in Trinity County: *Provided*, That the Secretary is authorized and directed to continue to a conclusion the engineering studies and negotiations with any non-Federal agency with respect to proposals to purchase falling water and, not later than eighteen months from the date of enactment of this Act, report the results of such negotiations, including the terms of a proposed agreement, if any, that may be reached, together with his recommendations thereon, which agreement, if any, shall not become effective until approved by Congress. The works authorized to be constructed shall also include a conduit or canal extending from the most practicable point on the Sacramento River near Redding in an easterly direction to intersect with Cow Creek, with such pumping plants, regulatory reservoirs, and other appurtenant works as may be necessary to bring about maximum beneficial use of project water supplies in the area. (69 Stat. 719)

EXPLANATORY NOTES

Supplementary Provision: Increase in Generating Capacity. A provision in the Public Works Appropriation Act, 1956, 70 Stat. 478, enacted July 2, 1956, increases the generating capacity to approximately 400,000 kilowatts. The provision appears herein in chronological order.

Cross Reference, Storage Reservoir Named. The major storage reservoir on the Trinity River, referred to in the text, was

designated Clair Engle Lake by the Act of October 13, 1964, 78 Stat. 1093. The Act appears herein in chronological order.

Cross Reference, Central Valley Project, California. The Central Valley project, referred to in the text, was authorized by a finding of feasibility by the Secretary of the Interior, approved by the President on December 2, 1935. The project was reauthorized by section 2 of the Act of August 26,

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1937, 50 Stat. 850. The 1937 Act appears herein in chronological order. For references to other authorizations in the Central Valley project, California, see the explanatory notes following section 2 of the 1937 Act.

Sec. 2. [Integration and coordination with other features of Central Valley project—Fish and wildlife preservation and propagation.]—Subject to the provisions of this Act, the operation of the Trinity River division shall be integrated and coordinated, from both a financial and an operational standpoint, with the operation of other features of the Central Valley project, as presently authorized and as may in the future be authorized by Act of Congress, in such manner as will effectuate the fullest, most beneficial, and most economic utilization of the water resources hereby made available: *Provided*, That the Secretary is authorized and directed to adopt appropriate measures to insure the preservation and propagation of fish and wildlife, including, but not limited to, the maintenance of the flow of the Trinity River below the diversion point at not less than one hundred and fifty cubic feet per second for the months July through November and the flow of Clear Creek below the diversion point at not less than fifteen cubic feet per second unless the Secretary and the California Fish and Game Commission determine and agree that lesser flows would be adequate for maintenance of fish life and propagation thereof; the Secretary shall also allocate to the preservation and propagation of fish and wildlife, as provided in the Act of August 14, 1946 (60 Stat. 1080), an appropriate share of the costs of constructing the Trinity River development and of operating and maintaining the same, such costs to be non-reimbursable: *Provided further*, That not less than 50,000 acre-feet shall be released annually from the Trinity Reservoir and made available to Humboldt County and downstream water users. (69 Stat. 719)

EXPLANATORY NOTE

Reference in the Text. The Act of August 14, 1946 (60 Stat. 1080), referred to in the text, as amended is the Fish and Wildlife Coordination Act. The Act appears herein in chronological order.

Sec. 3. [Minimum basic facilities for health and safety—Lands for such facilities—Report to Congress on need for additional lands.]—The Secretary is authorized to investigate, plan, construct, operate, and maintain minimum basic facilities for access to, and for the maintenance of public health and safety and the protection of public property on, lands withdrawn or acquired for the development of the Trinity River division, to conserve the scenery and the natural, historic, and archeologic objects, and to provide for public use and enjoyment of the same and of the water areas created by these developments by such means as are consistent with their primary purposes. The Secretary is authorized to withdraw from entry or other disposition under the public land laws such public lands as are necessary for the construction, operation, and maintenance of said minimum basic facilities and for the other purposes specified in this section and to dispose of such lands to Federal, State, and local governmental agencies by lease, transfer, exchange, or conveyance upon such terms and conditions as will best promote their development and operation in the public interest. The Secretary is further authorized to investigate the need for acquiring other

August 12, 1955

TRINITY RIVER DIVISION, CENTRAL VALLEY 1237

lands for said purposes and to report thereon to the Committees on Interior and Insular Affairs of the Senate and House of Representatives, but no lands shall be acquired solely for any of these purposes other than access to project lands and the maintenance of public health and safety and the protection of public property thereon without further authorization by the Congress. All costs incurred pursuant to this section shall be nonreimbursable and nonreturnable (69 Stat. 720)

Sec. 4. [Sale and delivery of additional power available through construction of the division—Preference customers.]—Contracts for the sale and delivery of the additional electric energy available from the Central Valley project power system as a result of the construction of the plants herein authorized and their integration with that system shall be made in accordance with preferences expressed in the Federal reclamation laws: *Provided*, That a first preference, to the extent of 25 per centum of such additional energy, shall be given, under reclamation law, to preference customers in Trinity County, California, for use in that county, who are ready, able and willing, within twelve months after notice of availability by the Secretary, to enter into contracts for the energy: *Provided further*, That Trinity County preference customers may exercise their option on the same date in each successive fifth year providing written notice of their intention to use the energy is given to the Secretary not less than eighteen months prior to said date. (69 Stat. 720)

Sec. 5. [Payments to Trinity County, Calif.—Payments to public school districts.]—The Secretary is authorized to make payments, from construction appropriations, to Trinity County, California, of such additional costs of repairing, maintaining, and constructing county roads as are incurred by it during the period of actual construction of the Trinity River division and as are found by the Secretary to be properly attributable to and occasioned by said construction. The Secretary is further authorized and directed to pay to Trinity County annually an in-lieu tax payment out of the appropriations during construction and from the gross revenues of the project during operation an amount equal to the annual tax rate of the county applied to the value of the real property and improvements taken for project purposes in Trinity County, said value being determined as of the date such property and improvements are taken off the tax rolls. Payments to the public-school districts in the project area affected by construction activities shall be made pursuant to existing law. (69 Stat. 720)

NOTE OF OPINION

1. In-lieu tax payments

The authority to make in-lieu tax payments to Trinity County annually in an amount equal to "the annual tax rate of the county" applied to the value of real property and improvements taken for project

purposes, does not include amounts equivalent to the separate tax rates fixed by the various school districts in the county. Letter of Commissioner Dexheimer to Senator Knowland, January 5, 1959.

Sec. 6. [Appropriation.]—There are hereby authorized to be appropriated for construction of the Trinity River division \$225,000,000, plus or minus such amounts, if any, as may be justified by reason of ordinary fluctuations in construction costs as indicated by engineering cost indexes applicable to the type of

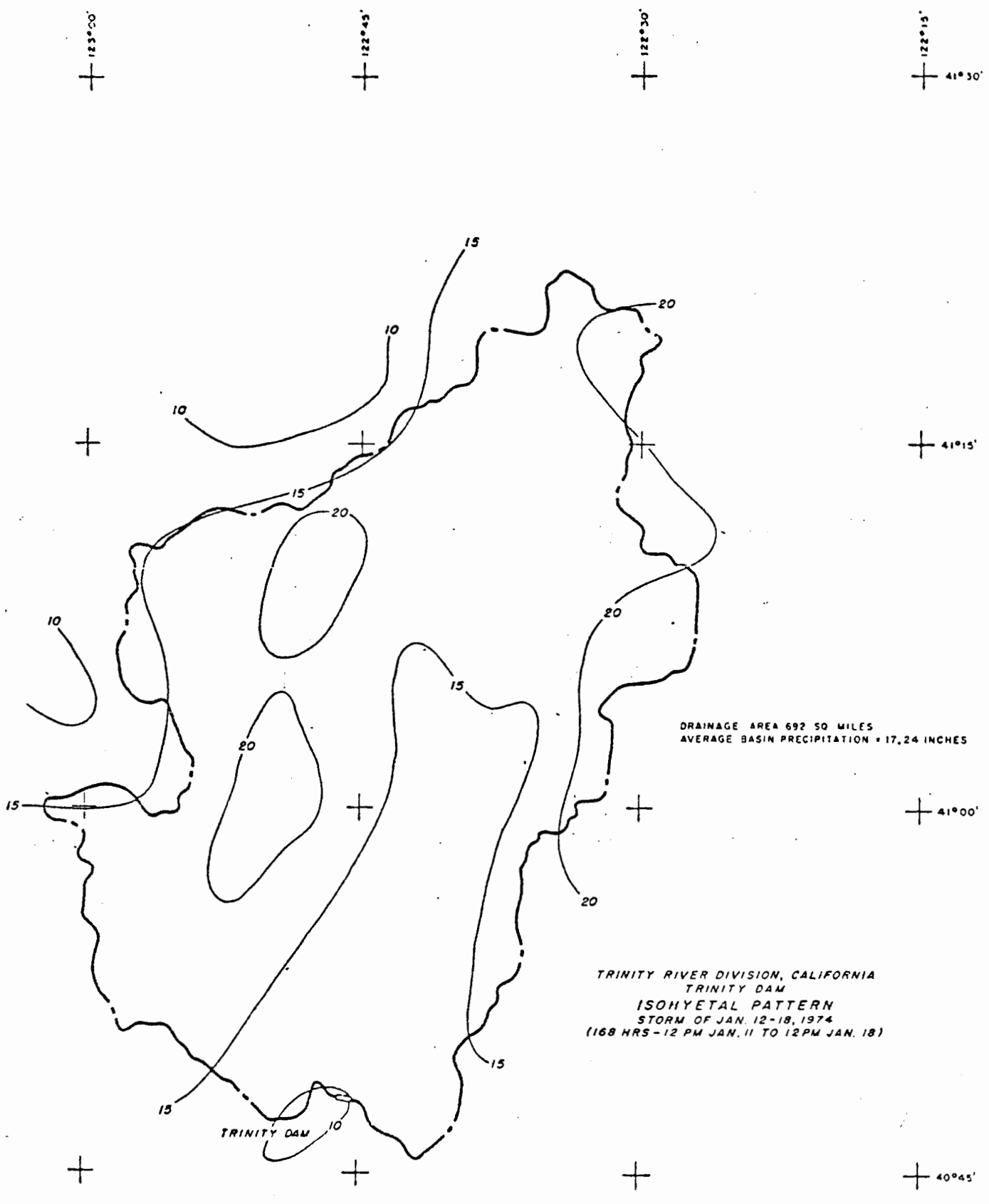
August 12, 1955

1238 TRINITY RIVER DIVISION, CENTRAL VALLEY

construction involved herein, and, in addition thereto, such sums as may be required to carry out the provisions of section 5 of this Act and to operate and maintain the said development. (69 Stat. 721)

EXPLANATORY NOTES

Not Codified. This Act is not codified in the U.S. Code. Law 386 in the 84th Congress. H.R. Rept. No. 602. S. Rept. No. 1154. H.R. Rept. No. 732 (on H. Res. 263).
Legislative History. H.R. 4663, Public



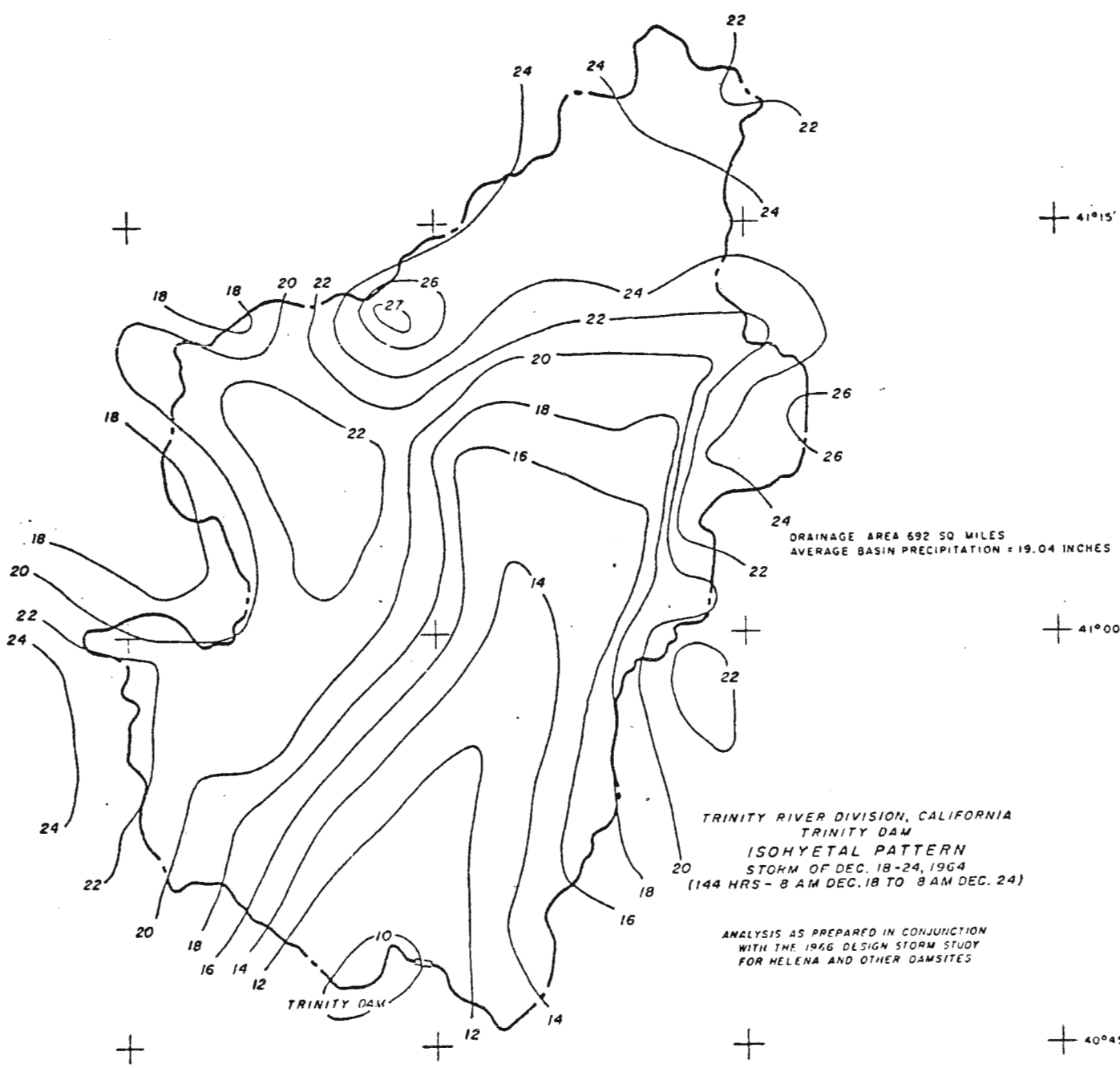
123°00' 122°45' 122°30' 122°15'

41°30'

41°15'

41°00'

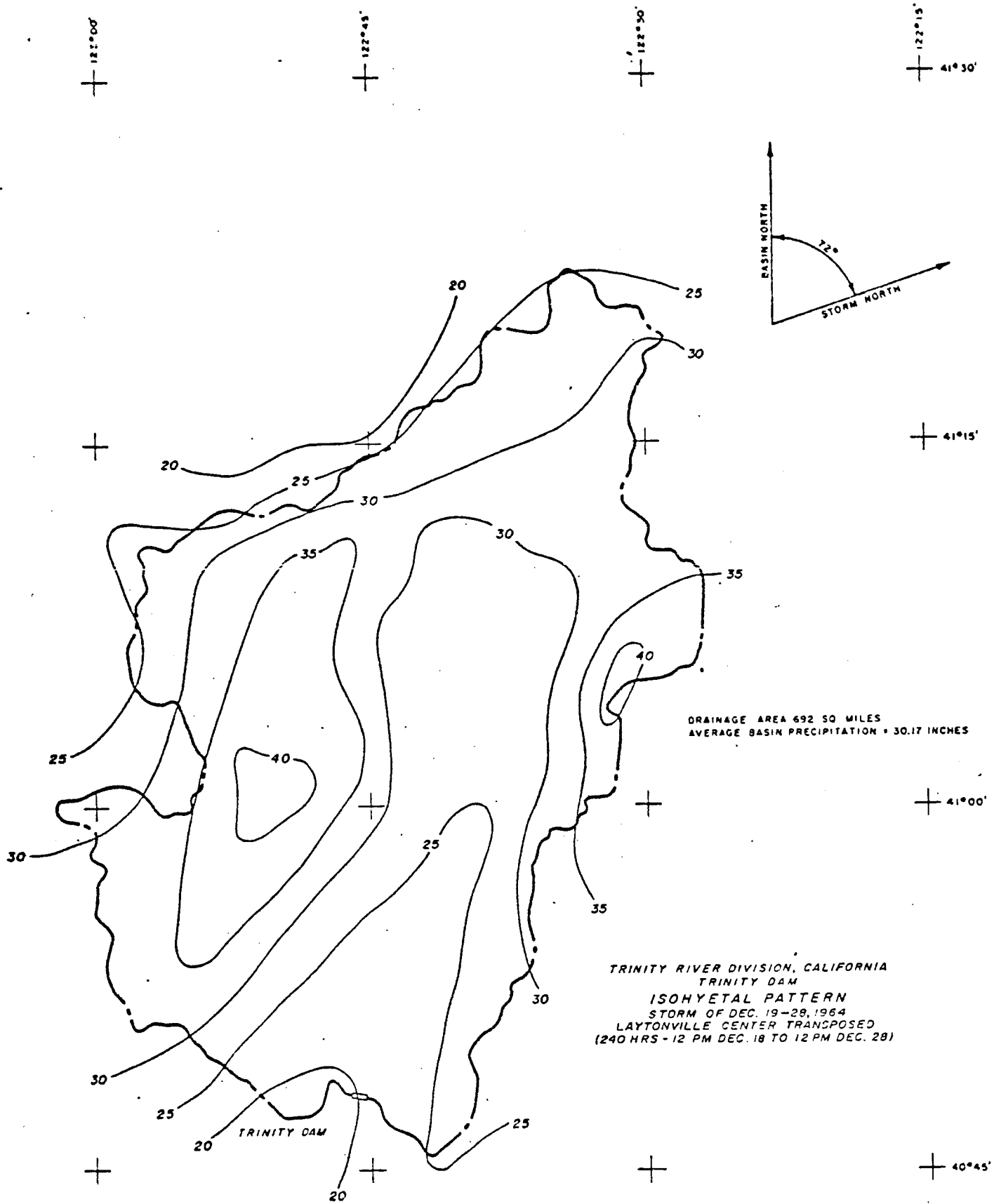
40°45'



DRAINAGE AREA 692 SQ MILES
AVERAGE BASIN PRECIPITATION = 19.04 INCHES

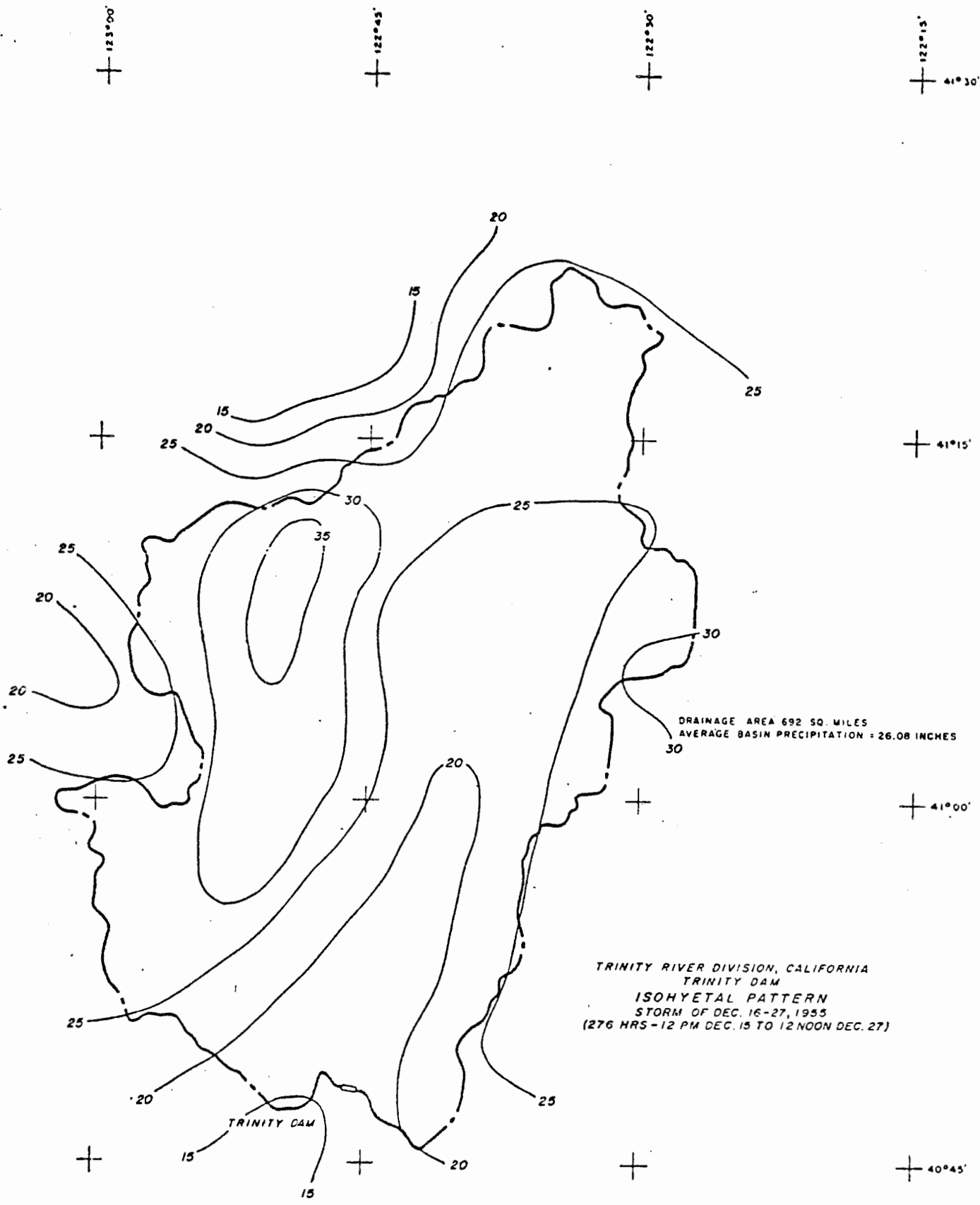
TRINITY RIVER DIVISION, CALIFORNIA
TRINITY DAM
ISOHYETAL PATTERN
STORM OF DEC. 18-24, 1964
(144 HRS - 8 AM DEC. 18 TO 8 AM DEC. 24)

ANALYSIS AS PREPARED IN CONJUNCTION
WITH THE 1946 DESIGN STORM STUDY
FOR HELENA AND OTHER DAMSITES



DRAINAGE AREA 692 SQ MILES
 AVERAGE BASIN PRECIPITATION = 30.17 INCHES

TRINITY RIVER DIVISION, CALIFORNIA
 TRINITY DAM
 ISOHYETAL PATTERN
 STORM OF DEC. 19-28, 1964
 LAYTONVILLE CENTER TRANSPOSED
 (240 HRS - 12 PM DEC. 18 TO 12 PM DEC. 28)



123°00'

122°45'

122°30'

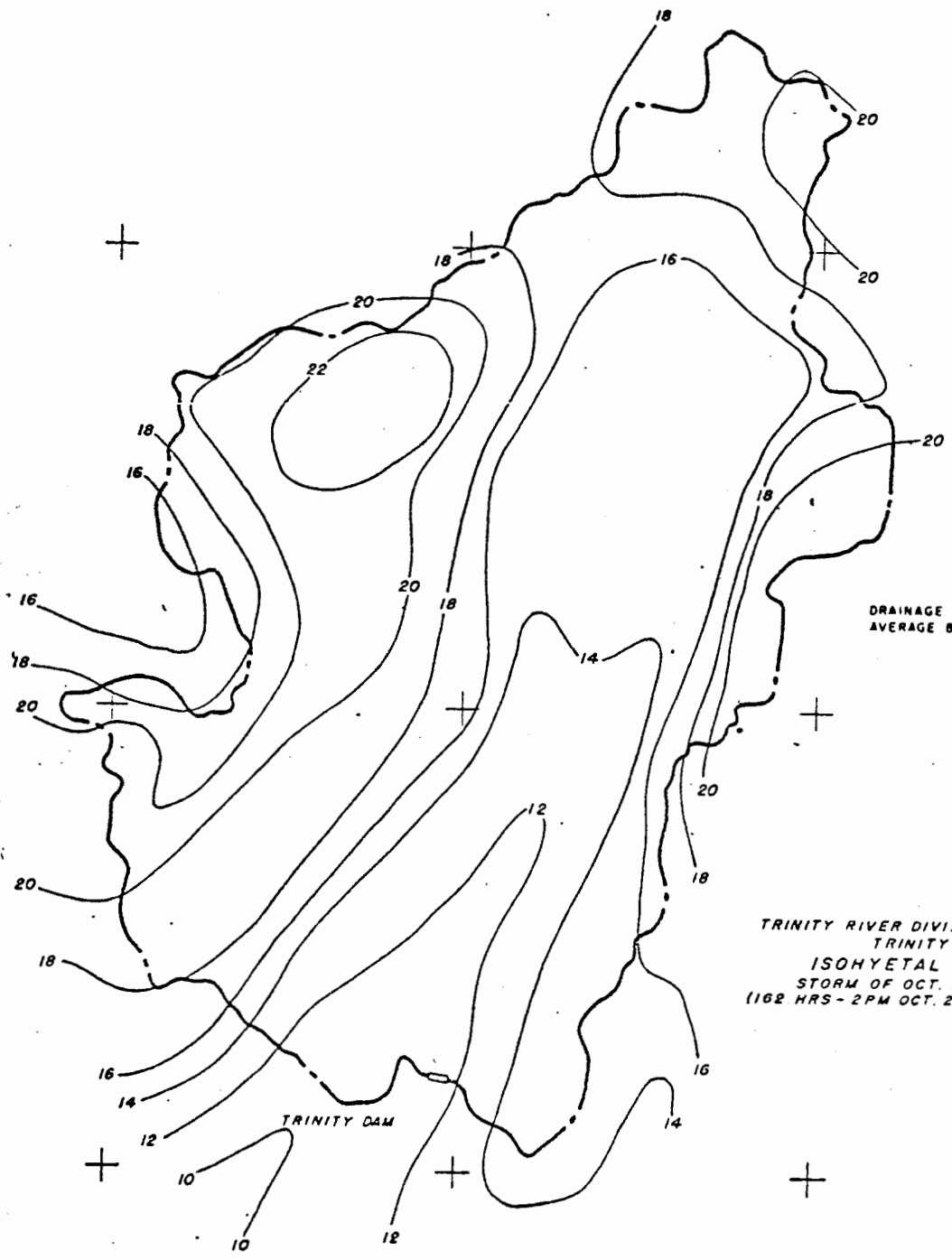
122°15' 41°30'

+

41°15'

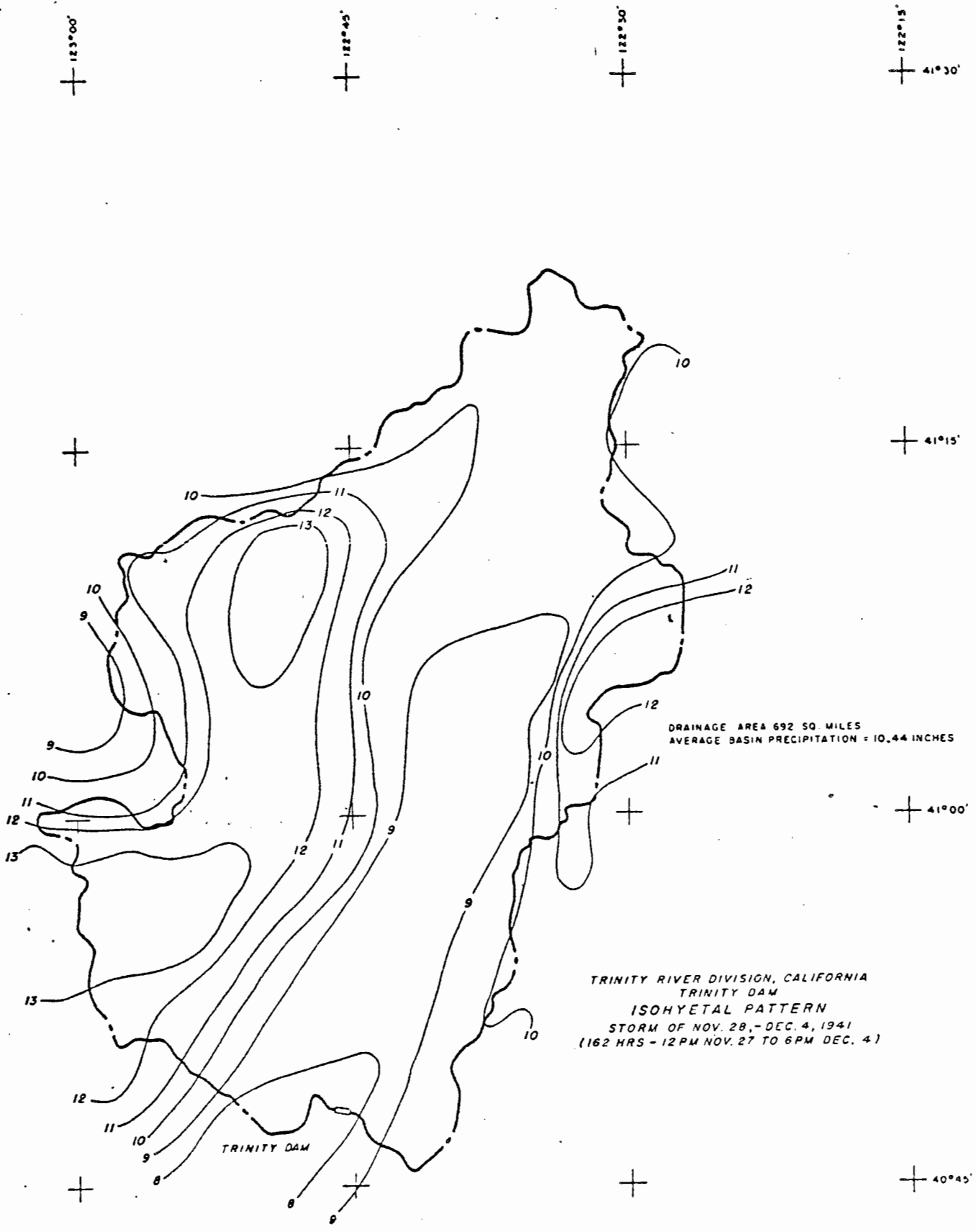
41°00'

40°45'

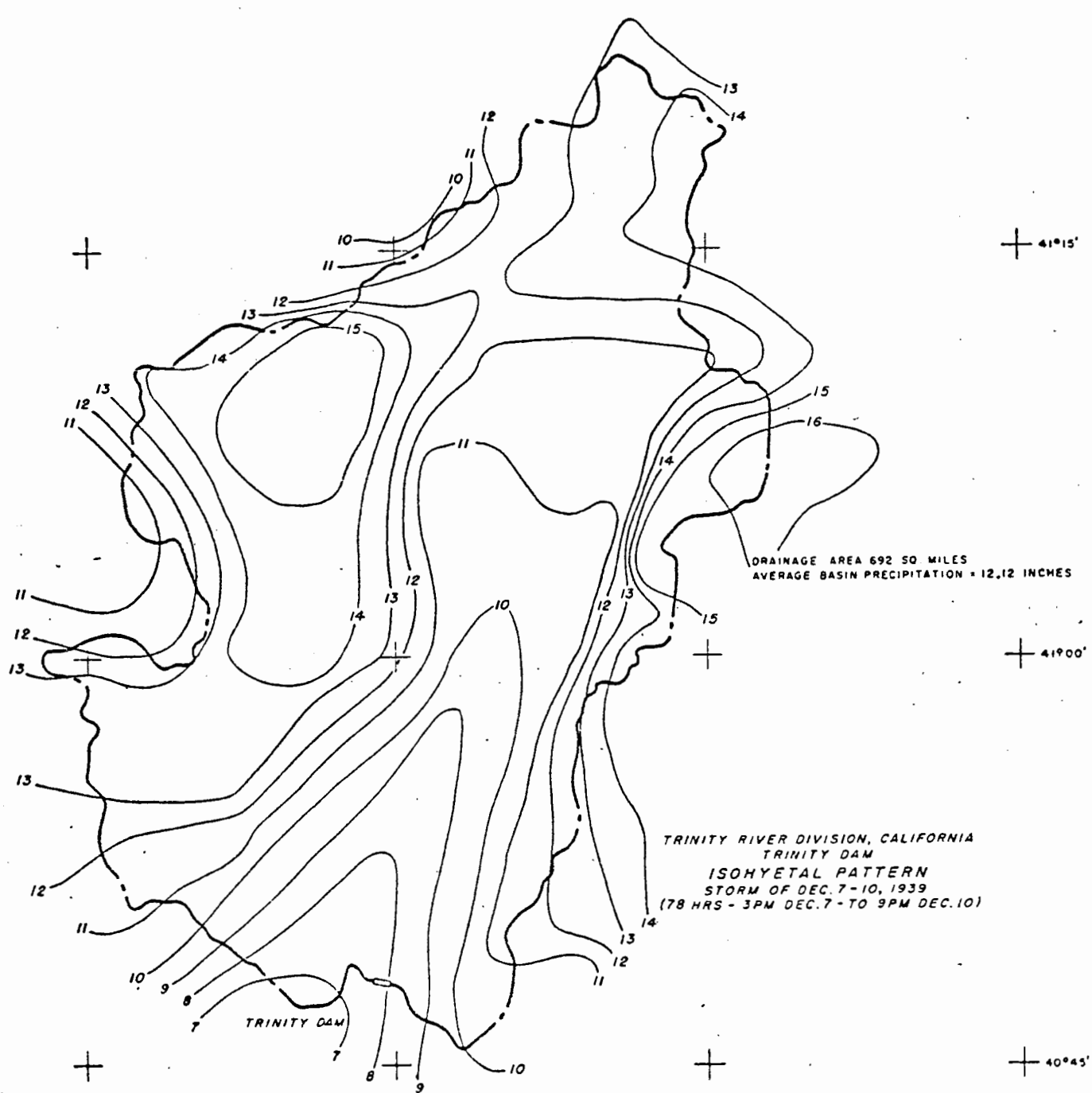


DRAINAGE AREA 692 SQ. MILES
AVERAGE BASIN PRECIPITATION 17.0 INCHES

TRINITY RIVER DIVISION, CALIFORNIA
TRINITY DAM
ISOHYETAL PATTERN
STORM OF OCT. 23-30, 1950
(162 HRS - 2 PM OCT. 23 TO 8 AM OCT. 30)



123°00' 122°45' 122°30' 122°15'



DRAINAGE AREA 692.50 MILES
AVERAGE BASIN PRECIPITATION = 12.12 INCHES

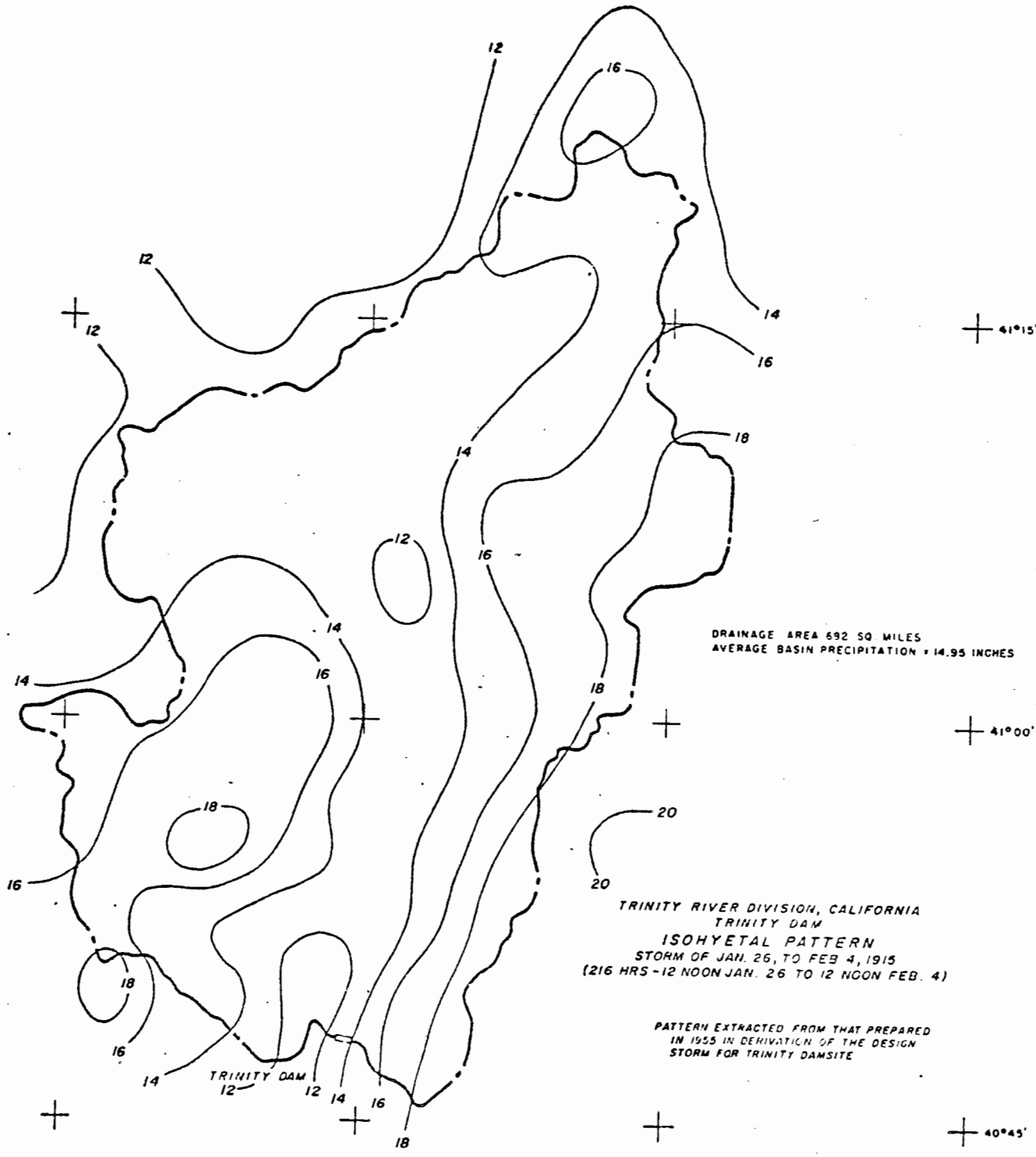
TRINITY RIVER DIVISION, CALIFORNIA
TRINITY DAM
ISOHYETAL PATTERN
STORM OF DEC. 7-10, 1939
(78 HRS - 3PM DEC. 7 - TO 9PM DEC. 10)

+ 123°00'

+ 122°45'

+ 122°30'

+ 122°15' 41°30'



TRINITY RIVER DIVISION
CENTRAL VALLEY PROJECT

(Excerpt from Fact Sheet, Bureau of Reclamation, May 1977.)

PURPOSE

The Trinity River Division is a major unit of the Central Valley Project designed to provide water for irrigation, power, recreation, and fish and wildlife conservation. Surplus water from the Trinity River Basin is stored, regulated, and diverted through a system of reservoirs, dams, powerplants, tunnels, and conduits into water-deficient areas of the Central Valley Basin.

LOCATION

The Trinity River Division features are located in Trinity and Shasta Counties of California. At Lewiston Dam, the Trinity River is about 1,400 feet (430 meters (m)) high in elevation and 20 miles (32 kilometers (km)) west of the Sacramento River at Keswick Dam. (Refer to the developed profile and location map, Drawing No. 416-208-410, in Part I for an overview of unit features.)

PLAN

Trinity River water is stored in the 2,448,000-acre-foot (3 020 000 000 cubic meter (m³)) Clair Engle Lake behind Trinity Dam. Releases from this reservoir are utilized by a 105,600-kilowatt (kW) powerplant and reregulated in Lewiston Reservoir about 7 miles (11 km) downstream. Lewiston Dam with the 350-kW Lewiston Powerplant,

regulates flows to meet the downstream requirements of the Trinity River Basin, including the Trinity River Fish Hatchery and downstream fishery. Water from the Trinity River Basin is diverted by Lewiston Dam through the Clear Creek Tunnel to the 141,400-kW Judge Francis Carr Powerhouse and then into the 241,000 acre-foot (297 300 000 m³) Whiskeytown Lake behind Whiskeytown Dam on Clear Creek, a tributary of the Sacramento River. From Whiskeytown Lake, the Trinity River water and any Clear Creek flows above 15 ft³/s are diverted through the Spring Creek Tunnel to the 150,000-kW Spring Creek Powerplant where it discharges into Keswick Reservoir on the Sacramento River. The imported Trinity water supplements the Sacramento River flows for authorized Central Valley Project (CVP) multipurpose use.

MAIN FEATURES

The main features of the Trinity River Division are Trinity Dam, Clair Engle Lake, Trinity Powerplant, Lewiston Dam and Reservoir, Lewiston Powerplant, Clear Creek Tunnel and Judge Francis Carr Powerhouse, Whiskeytown Dam and Lake, Spring Creek Tunnels and Rock Creek Siphon, Spring Creek Powerplant, Spring Creek Debris Dam and Reservoir, Trinity River Fish Hatchery, Irrigation Development of Cow Creek and Clear Creek South Unit and the Power Transmission System.

TRINITY DAM, CLAIR ENGLE LAKE, AND TRINITY POWERPLANT

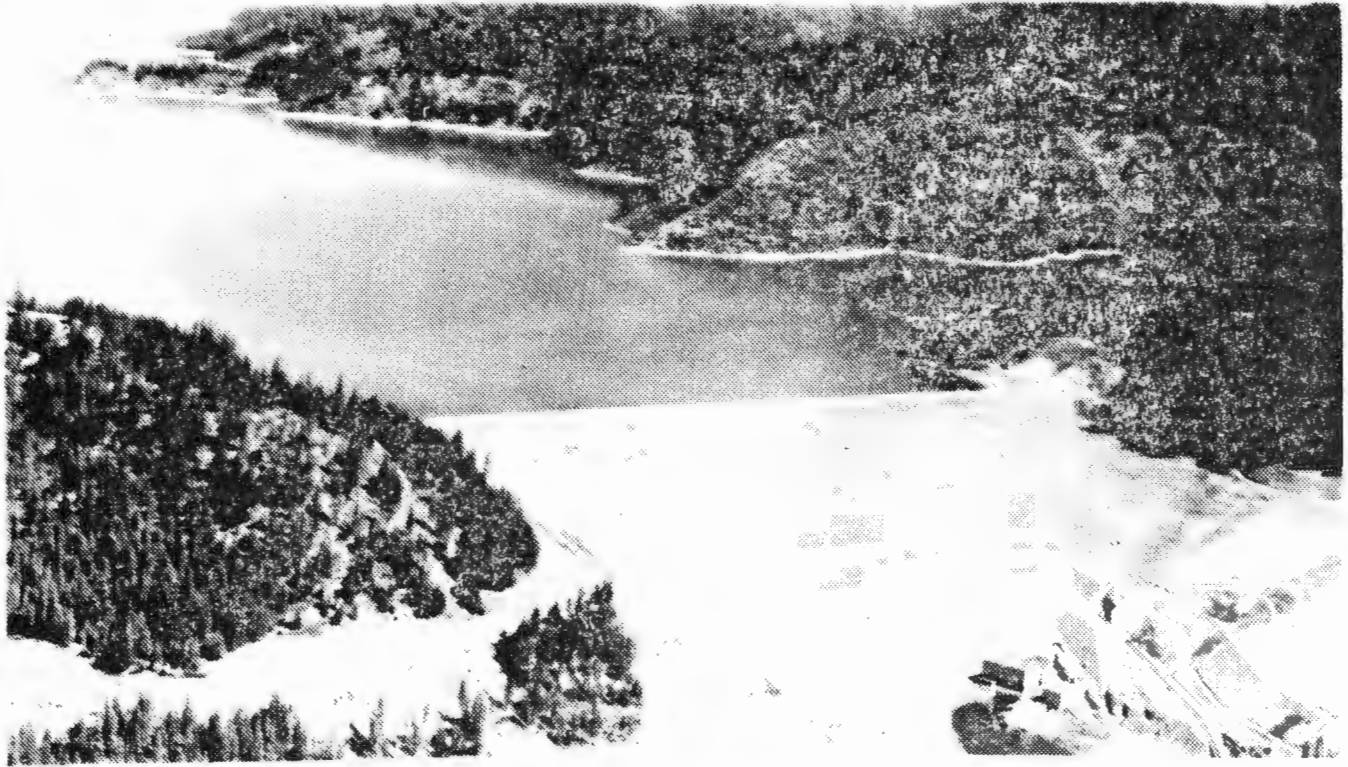
Trinity Dam

The dam and powerplant are located about 9 miles (14 km) upstream from the town of Lewiston on the Trinity River.

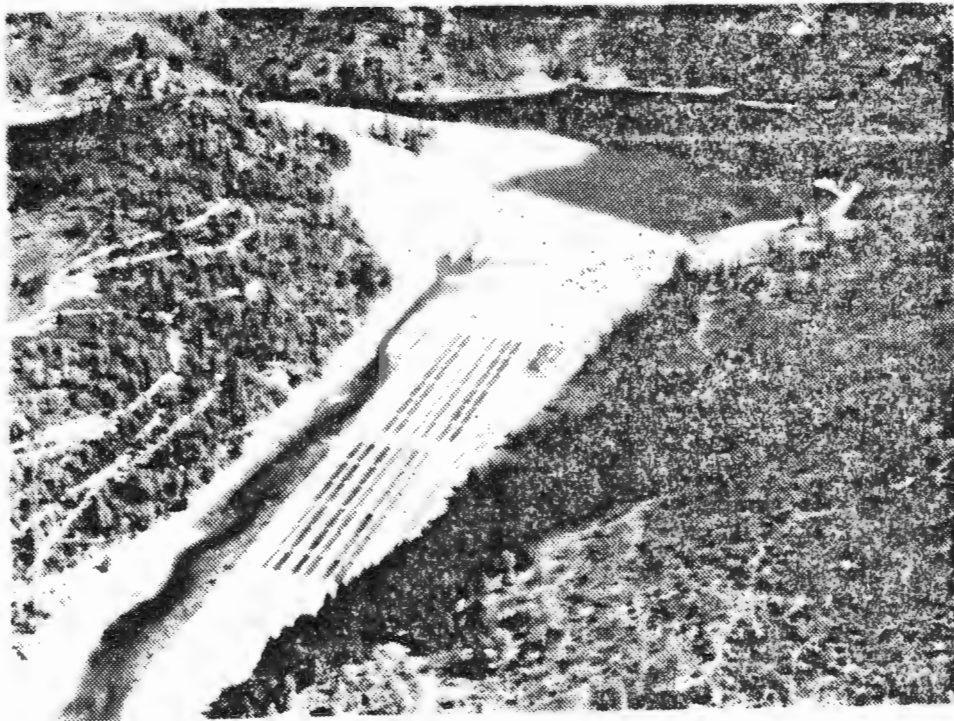
Type	Zoned earthfill
Structural	538 feet (164 m)
Lowest point in excavated foundation	El. 1,857 feet (566 m)
Height above streambed (at dam axis)	465 feet (142 m)
Crest elevation	2,395 feet (730 m)
Crest length	2,450 feet (747 m)
Crest width	40 feet (12 m)
Maximum base width	2,665 feet (812 m)
Volume of embankment	29,400,000 yd ³ (22 500 000 m ³)
Spillway, crest elevation	2,370 feet (722 m)
Type--morning glory, 54-foot (16.5-m) diameter with shaft leading to 20-foot (6.1-m) diameter tunnel	
Spillway capacity	22,500 ft ³ (637 m ³) (at W.S. el. 2387') per second
River outlet works capacity	7,200 ft ³ (204 m ³) (at W.S. el. 2387') per second
Auxiliary outlet works capacity	2,500 ft ³ (71 m ³) (at W.S. el. 2387') per second

Clair Engle Lake

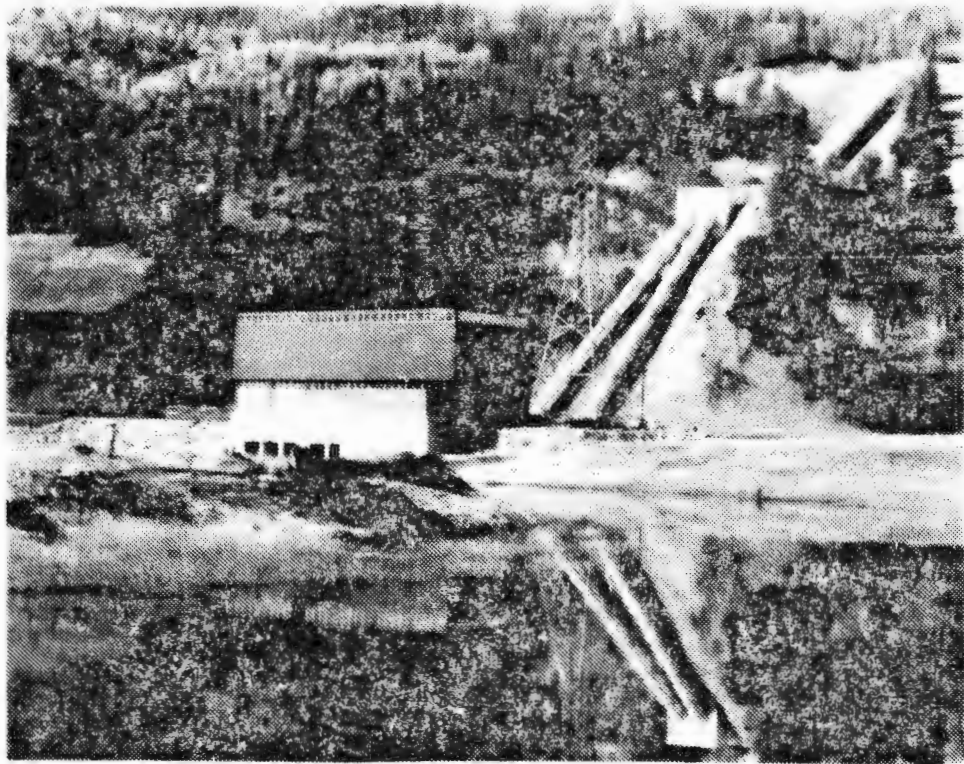
Normal water surface elevation (gross storage capacity)	2,370 feet (722 m)
Maximum water surface elevation	2,388.2 feet (729 m)
Gross storage capacity at El. 2370	2,448,000 acre-feet (3 019 600 000 m ³)
Active storage capacity	2,135,000 acre-feet (2 633 500 000 m ³)
Inactive and dead storage capacity	312,600 acre-feet (385 600 000 m ³)
Area at gross storage capacity	16,500 acres (6 680 hectares (ha))
Shoreline	145 miles (233 km)
Storage started	November 1960



Aerial view upstream of Trinity Dam and its reservoir, Clair Engle Lake, two of the main features of the Trinity River Division of the Central Valley Project, California.



Aerial view upstream of Lewiston Dam and Reservoir. Note Trinity River Fish Hatchery in the foreground.



General view of the penstocks carrying water to the Judge Francis Carr Powerhouse from the Trinity River. The body of water in the foreground is part of Whiskeytown Lake.



Aerial view upstream of Whiskeytown Dam and Lake. Note vehicular road traversing the earthfill dam across the lower central area of the photograph.

Trinity Powerplant

Number of units 2; normal operating
Each unit provided with inter- release 3,400 ft³/s
changeable high-head and low- (96 m³/s); maximum
head runners release 3,600 ft³/s
(102 m³/s)

Generator rating, each at
.95 P.F. 52,778 kilowatts (kW)

Turbine ratings at 426-foot head
(130 m) 85,000 horsepower (63 400 kW)
At 334-foot head (102 m) 70,000 horsepower (52 200 kW)

LEWISTON DAM, RESERVOIR, AND POWERPLANT

Lewiston Dam provides afterbay storage for reregulation of releases from Trinity Powerplant. It also serves to direct surplus Trinity River waters into Clear Creek Tunnel for transmountain diversion and to control releases for fish and other downstream requirements.

Lewiston Dam

Type Zoned earthfill
Structural height 91 feet (28 m)
Lowest point in excavated
foundation El. 1,819 feet (554 m)
Height above streambed
(at dam axis). 81 feet (25 m)
Crest elevation 1,910 feet (582 m)
Crest length 720 feet (219 m)
Crest width 25 feet (7.6 m)
Maximum base width 370 feet (113 m)
Volume of embankment 265,000 yd³
(203 000 m³)
Spillway, crest elevation 1,874 feet (571 m)
Type--gated chute with two 30 x 27.5-foot (9.1 x 8.4-m)
radial gates
Spillway capacity 30,000 ft³/s
(850 m³/s)
Outlet works capacity 320 ft³/s
at water surface elevation 1,902 (9 m³/s)
feet (580 m)

WHISKEYTOWN DAM AND LAKE

Whiskeytown Dam is located on Clear Creek, a tributary of the Sacramento River, approximately 10 miles (16 km) west of the city of Trinity River Division Background and Plan Trinity River flows discharged from the Judge Francis Carr Powerhouse and storage of water for the Clear Creek South Unit of the Central Valley Project.

Whiskeytown Dam

Crest length, saddle dams (2)	1,760 feet (53
Type	Zoned earthfill
Structural height	281.5 feet (85.8 m)
Lowest point in excavated foundation	El. 946.5 feet (288.5 m)
Height above streambed (at dam axis)	270 feet (82 m)
Crest elevation	1,228 feet (374 m)
Crest length, main dam	2,250 feet (686 m)
Crest length, saddle dams (2)	1,760 feet (537 m)
Crest width	30 feet (9 m)
Maximum base width	1,492 feet (455 m)
Volume of embankment (including saddle dams)	4,535,000 yd ³ (3 467 000 m ³)
Spillway, crest elevation	1,210 feet (369 m)
Type--morning glory, 92-foot (28-m) diameter with shaft leading to 21-foot (6.4-m) diameter tunnel	
Spillway capacity	28,780 ft ³ /s (815 m ³ /s)

Whiskeytown Lake

Normal water surface elevation	1,210 feet (369 m)
Maximum water surface elevation	1,220.5 feet (372 m)
Gross storage capacity at El. 1210 feet (369 m)	241,000 acre-feet (297 300 000 m ³)
Active storage capacity	213,600 acre-feet (263 500 000 m ³)
Inactive storage capacity at El. 1100 feet (335 m)	27,500 acre-feet (33 900 000 m ³)
Area at gross storage capacity	3,220 acres (1,300 ha)
Shoreline	36 miles (58 km)
Storage started	May 1963

GLOSSARY OF TERMS

Flood. An overflow of lands not normally covered by water and that are used or usable by man. Floods have two essential characteristics: The inundation of land is temporary; and the land is adjacent to and inundated by overflow from a river, stream, ocean, lake, or other body of standing water.

Normally, a flood is considered as any temporary rise in streamflow or stage, but not the ponding of surface water, that results in significant adverse effects in the vicinity. Adverse effects may include damages from overflow of land areas, temporary backwater effects in sewers and local drainage channels, creation of unsanitary conditions or other unfavorable situations by deposition of materials in stream channels during flood recessions, rise of ground water coincident with increased streamflow, and other problems.

Intermediate Regional Flood. A flood having an average frequency of occurrence in the order of once in 100 years although the flood may occur in any year. It is based on statistical analyses of streamflow records available for the watershed and analyses of rainfall and runoff characteristics in the general region of the watershed.

Standard Project Flood. The flood that may be expected from the most severe combination of meteorological and hydrological conditions that are considered reasonably characteristic of the geographical area in which the drainage basin is located, excluding extremely rare combinations. Peak discharges for these floods are generally about 40-60 percent of the Probable Maximum Floods for the same basins. As used by the Corps of Engineers, Standard Project Floods are intended as practicable expressions of the degree of protection that should be sought in the design of flood control works, the failure of which might be disastrous.

Probable Maximum Flood. The flood discharge that may be expected from the most severe combination of critical meteorological and hydrological conditions that are reasonably possible in the region. As used by the Corps of Engineers, Probable Maximum Floods are applicable to projects, such as dams, when consideration is to be given to virtually complete security from potential floods.