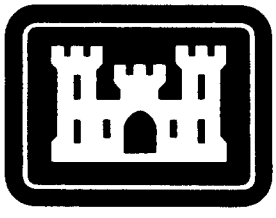
BLACK BUTTE DAM AND LAKE STONY CREEK, CALIFORNIA

WATER CONTROL MANUAL

APPENDIX III TO MASTER WATER CONTROL MANUAL SACRAMENTO RIVER BASIN, CALIFORNIA



US Army Corps of Engineers
Sacramento District

MAY 1987

[R]

BLACK BUTTE DAM AND LAKE
STONY CREEK, CALIFORNIA

WATER CONTROL MANUAL

APPENDIX III

TO

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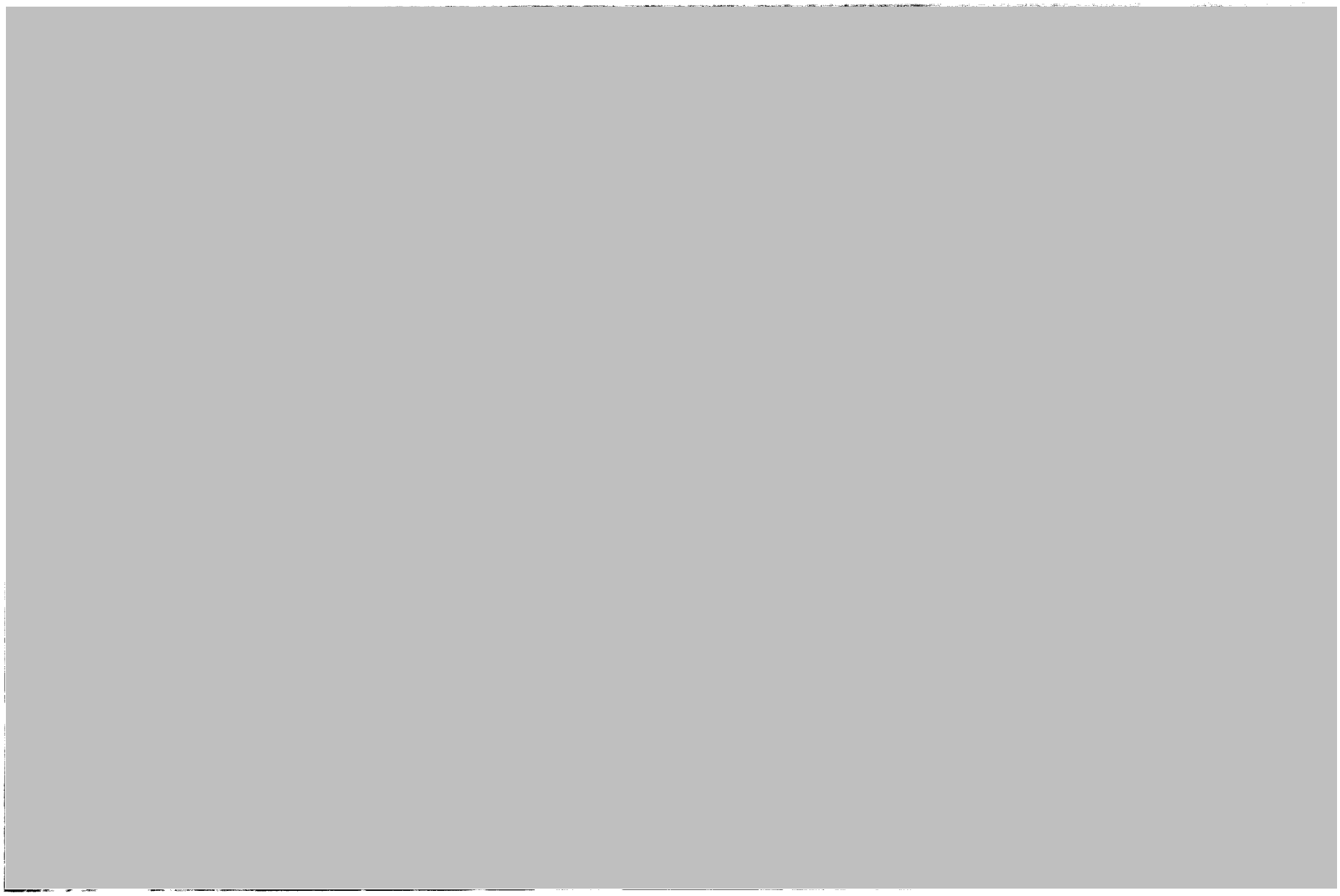


BLACK BUTTE DAM AND LAKE

USACE Sacramento District Datum Documentation Report

Project: Black Butte Dam and Lake

NGVD 29To NAVD 88 Datum Conversion Factor: add 2.77.

Datum Conversion Procedure: The USACE Mapping Unit and A-E Contractor performed field measurements with known historical elevations. All documentation and raw data is filed with the USACE Sacramento District Mapping Unit. All survey and gage control is in US feet and is tied to NGS monument KT0221. For questions or comments contact the Sacramento District Datum Coordinator. The results of this survey produced an averaged difference between NGVD 29 and NAVD 88 of 2.77 feet for the USACE Black Butte Dam and Lake civil works project.

Station ID	COE-NGVD29 record	NAVD 88	Difference
SC-82	515.66	518.43	2.78
SC-92	518.99	521.77	2.78
SC-90	509.90	512.65	2.75
KT0221	367.84	370.60	2.76
			2.767
Averaged Delta = 2.77ft conversion factor Black Butte Dam and Lake			

Accuracy Statement: The NAVD88 datum conversion accuracy is: =/- 0.25 feet to real work NAVD 88 elevations per EC- 1110-2-6065 Comprehensive Evaluation of Project Datums. The stated conversion factor is for planning, operations, water management and legacy conversion only. All future design work and survey work shall adhere to the NAVD 88 datum and follow EM 1110-1-1005 Control and Topographic Surveying. Contact the USACE Sacramento District's survey unit or the district's datum coordinator for current survey control.

BLACK BUTTE DAM AND LAKE
STONY CREEK, CALIFORNIA

PERTINENT DATA

General

Drainage areas
- Stony Creek at mouth ..... 780 sq miles
- Stony Creek near Hamilton City ..... 777 sq miles
- Black Butte Dam ..... 741 sq miles
- Stony Gorge Dam ..... 301 sq miles
- East Park Dam ..... 102 sq miles
- Rainbow Diversion Dam ..... 97 sq miles
- Grindstone Creek at mouth ..... 173 sq miles

Precipitation
- Basin normal annual ..... 32 inches

Flow at dam site
- Mean annual (unimpaired) ..... 716 cfs
  519,000 ac-ft
- Minimum daily mean (unimpaired) ..... 0 cfs
- Maximum instantaneous ..... 60,000 cfs
  (Dec 1937 unimpaired)
- Maximum instantaneous ..... 52,000 cfs
  (Feb 1986 impaired)
- Standard project peak inflow ..... 95,000 cfs
- Spillway design peak inflow ..... 154,000 cfs

Main Dam (rolled earthfill)

[redacted]

Freeboard above spillway design pool ..... 5.2 feet
Maximum height above stream bed ..... 140 feet
Side slope
- Upstream above elevation 450 ..... 1 on 2.5
- Upstream below elevation 450 ..... 1 on 3.0
- Downstream ..... 1 on 2.5

[redacted]

[redacted]

Reservoir

Elevation
- Inactive pool ..... 414.6 feet
- Gross pool ..... 473.5 feet
- Standard project flood pool ..... 483.1 feet
- Spillway design flood pool ..... 509.8 feet
- Guide-taking line (flowage easement) ..... 492.0 feet

Area
- Inactive pool ..... 577 acres
- Gross pool ..... 4,453 acres
- Standard project flood pool ..... 5,243 acres
- Spillway design flood pool ..... 7,090 acres

Storage capacity
- Inactive pool ..... 6,640 ac-ft
- Gross pool ..... 143,676 ac-ft
- Standard project flood pool ..... 223,000 ac-ft
- Spillway design flood pool ..... 354,000 ac-ft

Length of reservoir (at gross pool) ..... 6.8 miles

Spillway (uncontrolled weir)

[redacted]

Standard project flood head ..... 9.0 feet
Spillway flood head ..... 36.3 feet
Capacity ..... 76,600 cfs

Outlets (circular tunnel)

[redacted]

South Diversion Canal Outlet

[redacted]

Powerplant*

[redacted]

BLACK BUTTE DAM AND LAKE
STONY CREEK, CALIFORNIA

PERTINENT DATA (CONTINUED)

EAST PARK RESERVOIR

Reservoir

Stream	Little Stony Creek
Location	Near Lodoga, Calif.
Drainage area	102 sq miles
Capacity	50,900 ac-ft
Surface area	1,820 acres
Gross pool elevation	1,199.68 ft. msl

Dam

Spillway

Outlet Works

STONY GORGE RESERVOIR

Reservoir

Stream	Stony Creek
Location	Elk Creek, Calif.
Drainage area	301 sq miles
Capacity	50,000 ac-ft
Surface area	1,300 acres
Gross pool elevation	841.0 feet msl

Dam

Spillway

Outlet Works

NOTICE TO USERS OF THIS MANUAL

Regulations specify that this Water Control Manual be published in looseleaf form, and only those sections, or parts thereof, requiring changes will be revised and printed. Therefore this copy should be preserved in good condition so that inserts can be made to keep this manual current.

BLACK BUTTE DAM AND LAKE
STONY CREEK, CALIFORNIA

WATER CONTROL MANUAL

WATER CONTROL MANUAL (Continued)

IX. WATER CONTROL MANAGEMENT

LIST OF TABLES

PLATES

EXHIBITS

I - INTRODUCTION

1-01. AUTHORIZATION

The Black Butte Dam and Lake Water Control Manual, Stony Creek, California, is an appendix to the Sacramento River Basin Master Water Control Manual. It is prepared in accordance with instructions contained in ER 1110-2-240, EM 1110-2-3600, and ETL 1110-2-251, all pertaining to requirements for reports on reservoir regulation.

1-02. PURPOSE AND SCOPE

This manual provides the detailed plan for water control and management at the Black Butte Dam and Lake Project which is located on Stony Creek about 9 miles westerly from the town of Orland, California. A map of the Black Butte Lake area is shown on Plate 1. Location of the project is shown on Plate 2. A portion of the material used in preparation of this report was furnished by the Mid-Pacific Region of the U.S. Bureau Of Reclamation and the Orland Unit Water Users' Association. A description of the overall Sacramento River Basin plan of flood control is given in the Master Water Control Manual, Sacramento River Basin, California.

1-03. RELATED MANUALS AND REPORTS

Related manuals and reports are as follows:

Manuals

Title	Date
Master Manual of Reservoir Regulation Sacramento River Basin, California	March 1959
Reservoir Regulation Manual for Black Butte Project, Stony Creek, California	July 1963
Black Butte Lake Stony Creek, California Reservoir Regulation Manual	March 1971

Related Reports

Title	Date
Operation and Maintenance Manual	December 1983
Black Butte Lake Spillway Adequacy Studies	March 1980

Design Memoranda

Title	Date
No. 1 - Hydrology	01 May 1957
No. 2 - Real Estate	19 December 1958
No. 3 - Relocations	01 February 1958
Supplement No. 1	15 November 1960
No. 4 - Dam and Appurtenances	01 January 1959
Supplement No. 1	15 March 1959
Supplement No. 2	06 October 1959
No. 5 - Administration and Utility Bldgs	01 May 1958
No. 6 - Preliminary Recreation and Management Plan	30 January 1959
Supplement No. 1 (Rev 9 June 1961)	14 April 1961
No. 7 - Reservoir Regulation	April 1959
No. 8 - General Design	07 August 1959
Supplement No. 1	08 March 1960
No. 9 - Reservoir Clearing	15 January 1960
No. 10 - Master Plan with Appendix C	March 1962
No. 11 - Operators Quarters and Fallout Protection	15 November 1962
No. 13 - Master Plan	February 1977

1-04. PROJECT OWNER

Black Butte Dam and Lake is owned by the U.S. Army Corps of Engineers.

1-05. OPERATING AGENCY

Black Butte Dam and Lake, including recreation features, is operated and maintained by the U.S. Army Corps of Engineers, Sacramento District. Duties related to control of outflows are performed by the Park Manager or by a designated Damtender.

1-06. REGULATING AGENCIES

II - DESCRIPTION OF PROJECT

2-01. LOCATION

Black Butte Dam and Lake is on Stony Creek about 9 miles west of Orland, California. Black Butte Dam is located in Tehama County approximately 22 miles downstream from Stony Gorge Dam, and 23 miles upstream from its confluence with the Sacramento River. The location of the dam with respect to the Stony Creeek basin is shown on Plate 2. Primary access to the project is afforded by a good two-lane, paved, county road from the city of Orland. This county road connects at Orland with Interstate Route 5, a major north-south freeway route.

2-02. PURPOSE

The project, comprising Black Butte Dam and Lake was authorized for flood control and other purposes. Operation of the project affords flood protection, irrigation water supply, recreation opportunities and future hydropower. Black Butte Lake provides up to a maximum flood control space reservation of 137,000 acre-feet during the winter months, a portion of which can be satisfied by empty space in Orland Unit Water Users' Association East Park and Stony Gorge Reservoirs. The project provides for a minimum pool of 6,640 acre-feet for sediment and fishery values.

2-03. PHYSICAL COMPONENTS

The principal features of Black Butte Dam were completed in August 1963. [redacted]

At gross pool, the water-surface area of the reservoir is 4,450 acres and 6.8 miles long with a shoreline of about 40 miles. Area-capacity curves for the reservoir are shown on Chart A-1 in Exhibit A;, Chart A-2 is an area-capacity table. Water-surface elevations of Black Butte Lake at selected storage levels are:

Storage Level	Elevation (Feet, MSL)
Inactive pool-bottom flood control space (6,640 acre-feet)	414.6
Gross Pool (143,700 acre-feet)	473.5
Spillway design flood pool (354,000 acre-feet)	509.8

a. Outlet Works.

b. Spillway. The spillway is located adjacent to the left abutment of the dam.

Discharge capacity at elevation 509.8 feet MSL is 76,600 cfs. Exhibit A, Chart A-4 shows the spillway rating curve for Black Butte Dam.

c. Power Plant.

2-04. RELATED CONTROL FACILITIES

The flood control operation of Black Butte Lake is essentially independent of existing reservoir projects, except for coordination with Stony Gorge and East Park reservoirs upstream as indicated on the flood control diagram. When feasible, however, Black Butte Lake will be operated to provide the maximum practicable assistance in preventing damage from high flows on Sacramento River below the mouth of Stony Creek, at the head of the Sacramento River Flood Control Project. This project comprises a comprehensive system of levees, overflow weirs, drainage pumping plants, and flood bypass channels, extending along the Sacramento River from Collinsville near its mouth in Suisun Bay, upstream to Ord Bend.

2-05. REAL ESTATE ACQUISITION

The Federal Government has acquired project lands totaling 8,917.5 acres of which 8,074.0 acres are held in fee and 843.5 acres are in easements. The guide taking line for fee acquisition was contour elevation 473.5 MSL (gross pool) blocked out along section lines or quarter section lines to facilitate acquisition and to prevent leaving relatively unusable residuals. The flowage easement guide taking line was contour elevation 492.0 MSL. However, most of the land lying between elevation 473.5 MSL and elevation 492.0 MSL is steep and precipitous, and flowage easements were impractical except in the upper reaches of the reservoir. Land use allocation is shown on Plate 10.

2-06. PUBLIC FACILITIES

Improvements of the land and water areas for public purposes are authorized by Section 4 of the Flood Control Act of 1944 as amended. Most

recreational use of Black Butte Lake presently occurs in and originates from the developed northern and eastern shores of the lake with some uses occurring at the undeveloped Burris Creek, Squaw Point, Nomlaki Coves, and Grizzly Flat Recreation Areas on the western shore (see Plate 11). A full spectrum of water-oriented and other recreation is available at Black Butte Lake which includes fishing, picnicking, camping, pleasure boating, water skiing, swimming, off-road motorcycling, hunting, and sightseeing. These activities are expected to be continued and enhanced under the proposed development plan detailed in Design Memorandum No. 13, dated February 1977, "Black Butte Lake Master Plan." Opportunities for historic and environmental interpretation, hiking, biking, and natural trails is also provided. Recreation facilities currently available at Black Butte Lake include:

TABLE 1
MAJOR RECREATION FACILITIES

Area Facility	Camp Sites[1/]	Picnic Sites	Launch Lanes	Restroom Facilities: Flush	Restroom Facilities: Portable	Parking: Car	Parking: Car-Trailer
Overlook		4	2	1		110	
Eagle Pass		21	2	1	4	47	70
Orland Buttes	35		2	2		40	45
Burris Creek					2	30	
Buckhorn	85	14	2	4	17	150	60
Lower Stony Creek					2	75	

NOTE: [1/] Additional camping includes two group camp areas.

III - HISTORY OF PROJECT

3-01. AUTHORIZATION

The Black Butte Project was authorized as part of the comprehensive plan of development for the Sacramento River Basin, California, by the Flood Control Act of 1944 (Public Law 534, December 22, 1944, 78th Congress 2d Session), the pertinent portion which follows:

> ". . . The projects for the control of floods and other purposes on the Sacramento River, California, adopted by the Acts approved 1 March 1917, 15 May 1928, 26 August 1937 and 18 August 1941, are hereby modified substantially in accordance with the recommendations of the Chief of Engineers in House Document 649, Seventy-eight Congress, second session, at an estimated cost of $50,100,000; and in addition to previous authorizations there is hereby authorized to be appropriated the sum $15,000,000 for the prosecution of the modified projects . . ."

In that document a reservoir capacity of 160,000 acre-feet was recommended. However, authorizing legislation did not identify an agency responsible for maintaining the channel capacity of Stony Creek to 15,000 cfs below Black Butte Dam.

The basic legislation relating to the development of reservoir areas under the control of the Department of the Army for recreational purposes is contained in Section 4 of the Flood Control Act of 1944, as amended by Section 207 of the Flood Control Act of 1962, as further amended by Section 2 of the Land and Water Conservation Fund Act of 1965. The amended Section 207 provides authority for the Chief of Engineers, under supervision of the Secretary of the Army, to construct, maintain, and operate public park and recreation facilities for water resource projects under the control of the Department of the Army.

3-02. PLANNING AND DESIGN

Prior to authorization of the Black Butte Project, consideration was given to levees and channel improvement project and to using several small upstream reservoirs as alternatives to the Black Butte Project. These plans were rejected because the required flood protection could be provided more effectively and more economically by storage in Black Butte Reservoir.

Studies and investigations subsequent to project authorization resulted in changes in the project document plan. The principal changes, briefly summarized below, were based primarily on additional geologic data, extensive studies of alternative plans, cost comparisons for the various plans studied, and economic studies of height of dam versus width of spillway.

a. Main dam. [redacted] For purposes of greater stability, the axis of the main dam was arched upstream in lieu of the straight alignment in the project document.

b. Dikes. [redacted].

c. **Spillway.** The proposed spillway described in the [redacted]

d. **Outlets.** In the project document plan, flood-control and irrigation outlets were separate with the flood-control outlet (consisting of two 18-foot diameter concrete-lined tunnels) through the left abutment discharging into a common stilling basin with the spillway, and the irrigation outlet (consisting of a 5-foot diameter concrete-lined tunnel) through the right abutment. The adopted plan provides [redacted]

3-03. CONSTRUCTION

Construction of the main dam and appurtenances was initiated in June 1960. Closure of the dam was initiated 17 July 1962 and was completed 15 November 1962. The overall project was completed, except for minor recreation features, during August 1963. Storage was initiated in October 1963. The Orland Buttes Campground and Eagle Pass Day Use Area, were opened to the public on 1 June 1964. The Buckhorn Recreation area was completed in 1966. Construction of the powerplant was started in 1986.

3-04. RELATED PROJECTS

a. ORLAND PROJECT. The Orland Project, one of the oldest federal reclamation projects in the country and one of the first undertaken in California, was authorized by the Secretary of the Interior in October 1907 and constructed by the U.S. Bureau of Reclamation. Water was delivered to the first farm units in 1910. The Orland Project consists primarily of two reservoirs upstream from Black Butte Dam (East Park and Stony Gorge); three main diversion structures (Rainbow Diversion Structure, North Diversion Dam and South Canal Intake); and an irrigation distribution system located downstream of Black Butte Dam. The project facilities are owned by the Bureau of Reclamation and since October 1954 have been operated by the Orland Unit Water Users' Association under contract with the Federal Government. Irrigation releases from East Park are routed through Stony Gorge Dam and then to Black Butte Dam where project water is diverted either to the Orland Project South Canal or released down Stony Creek for diversion to Orland Project North Canal. Annual diversions for the project average 108,000 acre-feet with a current level of development of 17,000 irrigated acres. Ultimate level of development is estimated at 21,000 acres.

Stony Gorge Dam and Reservoir is located on Stony Creek approximately 22 miles upstream from Black Butte Dam. [redacted]

At elevation 841 feet MSL the reservoir has a capacity of 50,400 acre-feet.

Approximately 18 miles upstream from Stony Gorge Dam on Little Stony Creek, is East Park Dam and Reservoir. The dam, completed in 1910, is a concrete arch gravity structure at the crest (elevation 1,201.7 feet MSL). Maximum storage capacity of East Park Reservoir is 50,900 acre-feet at water surface elevation 1,199.7 feet MSL. The corresponding surface area is 1,820 acres.

The Rainbow Diversion Dam on Stony Creek is located about 3 miles west of the town of Stonyford. Its function is to divert part of the high flow of Stony Creek into the 7 mile long East Park Feed Canal and thence into East Park Reservoir to supplement the natural inflow to the reservoir.

Maximum storage capacity is 50 acre-feet at water surface elevation 1288.7 feet MSL. Maximum capacity of the East Park Feed Canal is 250 cfs.

The Northside Diversion Dam on Stony Creek is located approximately 4 miles below Black Butte Dam. Its function is to divert water into the headworks of the North Canal.

Maximum storage capacity is 50 acre-feet at water surface elevation 313.0 feet MSL. Maximum flow requirements for the North Canal are 150 cfs.

The construction of Black Butte Dam replaced the existing Southside Diversion Dam of the Orland Project. Presently, the Orland South Canal irrigation requirements are diverted into an irrigation wet well through slots in the right side-wall of the outlet structure of Black Butte Dam just upstream from the flip bucket.

.. Maximum capacity of the South canal is 530 cfs.

A distribution system constructed as part of the Orland Project consists of 39 miles of canal with a capacity of 50 to 300 cfs and 100 miles of laterals with a capacity of less than 50 cfs.

b. TEHAMA-COLUSA CANAL. The Tehama-Colusa Canal is part of the Sacramento Canals Unit of the U.S. Bureau of Reclamation's Central Valley Project (CVP). The Sacramento Canals Unit, authorized in 1950, was designed to provide irrigation water in the Sacramento Valley, principally in Tehama, Glenn and Colusa Counties. In addition to the Tehama-Colusa Canal, the Unit consists of the Red Bluff Diversion Dam, Corning Pumping Plant and Canal. The Red Bluff Diversion Dam on the Sacramento River about 2 miles southeast of Red Bluff diverts water from the Sacramento River to the Corning and the Tehama-Colusa Canals.

The Tehama-Colusa Canal extends a distance of 113.4 miles from the Red Bluff Diversion Dam through Glenn and Colusa Counties and terminates in Yolo County south of the town of Dunnigan. Initial capacity is 2,530 cfs diminishing to 1700 cfs at the terminus. The upper reaches of the canal also provide fish facilities by use of 1.6 million square feet of special gravel-bottomed portions of the canal for salmon spawning areas.

The canal crosses Stony Creek at approximately canal mile 30 with a siphon about 3 miles east of Interstate Route 5. The canal has the capability of releasing up to 350 cfs into Stony Creek through a wasteway for use in Glenn-Colusa Irrigation District's Main Canal. In addition, water can be released from the Tehama-Colusa Canal to the Main Canal at several locations further downstream to provide CVP water to the District.

c. GLENN-COLUSA IRRIGATION DISTRICT. The Glenn-Colusa Irrigation District is located in the Central portion of the Sacramento Valley on the west side of the Sacramento River. The District serves some 175,000 acres of farmland extending from northeastern Glenn County near Hamilton City at the north to below Williams in Colusa County at the south.

The District's 65 mile-long Main Canal diverts water into a complex system of some 420 miles of laterals, taking its principal supply from the Sacramento River and a limited supplemental diversion from Stony Creek via Black Butte releases and/or Tehama-Colusa Canal. The District has entitlement to a base supply of 720,000 acre-feet from the natural flows of the Sacramento River and a 105,000 acre feet of contract water from the Bureau of Reclamation's Central Valley Project (CVP).

The District does not have a permanent structure across Stony Creek for passage of canal waters; instead at the beginning of each irrigation season, usually the end of March, the District constructs a gravel dam across Stony Creek at the Main Canal crossing (canal mile 7.2). To complete the passage water the Stony Creek gates on downstream side of the canal crossing are opened at this time. At the conclusion of the irrigation season, usually November, the dam is breached and the Stony Creek gates closed.

CVP Contract water is provided to the District from the Sacramento River through the main pumping plant; from the Tehama Colusa Canal into Stony Creek or by two interties between the Tehama Colusa and the Main Canal , and from Black Butte releases to Stony Creek.

3-05. MODIFICATIONS TO REGULATION

a. The present flood control storage was modified to conform to the area - capacity tables developed in 1978 from 1977 aerial mapping. Due to sedimentation the capacity at Black Butte Lake at gross pool has been reduced from 160,000 acre feet to 143,700 acre feet, and the maximum flood control reservation reduced from 150,000 acre feet to 137,000 acre feet, or a reduction of 13,000 acre feet.

b. A variable release schedule based on peak inflow for the current flood event and the percentage of required flood control reservation that has been used was developed to help reduce downstream bank erosion.

c. Based on actual flood control and irrigation needs and operational experience over the last 20 years the Flood Control Diagram was modified so that:

(1) The flood control space increases uniformly from a zero requirement on 1 September up to a maximum reservation by 137,000 acre feet by 30 November, with a minimum reservation of 106,400 acre-feet being required from 10 November to 23 January. The previous diagram had a draw down period to the required space by 1 October with a minimum reservation of 75,000 acre-feet also required by that date.

(2) The conditional flood control reservation up to a maximum of 137,000 acre feet goes from 30 November to 20 March, decreasing again to zero on 15 June. On the previous diagram the maximum reservation ran from 1 October to 15 March.

d. The amount of creditable flood control space in Stony Gorge Reservoir was limited to storage below the crest elevation of the gated spillway.

3-06. PRINCIPAL REGULATION PROBLEMS

One problem experienced in operation of Black Butte Lake is downstream bank erosion and sloughing due to flood control releases. Through the years an alluvial fan has built up in the 24 mile reach of Stony Creek between Black Butte Dam and the Sacramento River. In this reach Stony Creek flows in a meandering pattern, eroding materials from the bank and channel bottom carrying most of these materials further downstream. Historically, erosion has always been a significant problem in Stony Creek; however, erosion characteristics of the stream were changed by construction of Black Butte Dam in 1963. Construction of the dam has resulted in reducing high flood flows to a maximum controlled release of 15,000 cfs and in trapping almost all sediment flows from the upstream drainage basin.

The effects that Black Butte Dam has had, and will continue to have on downstream erosion, cannot be specifically identified due to the limited time that the dam has been in operation. However, interpretation of aerial photographs reflecting pre- and post-Black Butte conditions indicate that the erosion problem was more widespread prior to construction of Black Butte Dam.

These photos show that prior to Black Butte Dam the channel was considerably wider in certain areas and that channel lands have been reclaimed in those areas and converted to primarily agricultural use. This reduction in magnitude of erosion appears to be a result of flood flows being controlled to a release of 15,000 cfs or less by Black Butte Lake. Since such flows have been contained within the main channel, erosion has occurred only along the primary channel banks and does not extend to the outer limits of the meander belt. The aerial photographs inspected also showed that although there has been an overall improvement, presently the most critical erosion area is located in the reach from Black Butte Dam to a point about 4 miles downstream.

Although flood control releases are allowed up to 15,000 cfs the erosion problem becomes apparent when flood control releases exceed 5,000 cfs. To help reduce the erosion rate a release schedule was developed for Black Butte Lake, shown on the Flood Control Diagram Chart A-10. Essentially, releases are limited up to 5,000 cfs until inflow has exceeded 10,000 cfs, then releasing one-half of inflow up to maximum release of 15,000 cfs. In addition, the releases from Black Butte are held constant for less than a day and then either increased or decreased, since it appears that a sustained release aggravates the erosion problem.

Since construction of Black Butte Dam, two spillway flows have occurred. The first spillway flow occurred from 2 March to 5 March 1983 with a peak flow of 1,600 cfs. The second spill occurred during the period 17-20 February 1986 with a maximum flow over the spillway of 3,900 cfs on the 18th.

A corrective action plan was developed in 1986 to limit spillway flows until the permanent spillway fix can be accomplished. The plan consists of a preventative concrete treatment (dental measures) to the spillway to slow erosion of the remaining spillway surface should additional flow occur and a modified reservoir operation plan to lessen the probability of additional spillway flows.

Discussion of the proposed dental measures and the modified operation plan is contained in Exhibit C. This modified operation contained in the Exhibit is designed to be used in conjunction with Exhibit A and charts A-9 and A-10 in the interim period until a complete spillway fix has been accomplished at which time it is to be discarded.

IV - WATERSHED CHARACTERISTICS

4-01. GENERAL CHARACTERISTICS

The Stony Creek Basin above Black Butte Dam is an L-shaped area of 741 square miles on the eastern slope of the Coast Range and is located about midway along the western edge of the Sacramento River Basin, as shown on Plate 2. Rising near the crest of the Coast Range at about 7,000 feet MSL elevation, the several forks of Stony Creek flow easterly about 16 miles down slope, joining as they reach a broad north and south upper valley. Stony Creek flows northerly through this valley for 16 miles and is joined by numerous other tributaries, the larger originating to the west. It then flows around the northern end of a low ridge which separates this upper valley from the main Sacramento Valley. The dam site is at the northern end of this ridge. Below Black Butte Dam, Stony Creek flows easterly across a sloping plain for 24 miles to join the Sacramento River near the head of the levees of the Sacramento River Flood Control Project. The overall slope of Stony Creek above Black Butte Dam is approximately 90 feet per mile, ranging from 10 feet per mile in the lower reaches to more than 400 feet per mile in the upper tributaries. Elevation ranges from 400 feet at the dam to 6,500 feet in the headwater regions. The profiles of the principal streams of the Stony Creek system are shown on Plate 13.

The mountain slopes have a moderate forest cover of pine and fir. Intermediate elevations support oak, manzanita, and chaparral. Low elevations, including the valley floor, have sparse brush with willows, cottonwoods, and tules. Grass covers many slopes, and most of the valley and foothill area is used for range land to graze cattle and sheep. An estimated 10 percent of the area is cultivated.

4-02. TOPOGRAPHY

The topography is mountainous with steep to precipitous slopes along the western edge of the basin and steeply rolling to gentle slopes in the valley. The watershed of Stony Creek ranges in elevation from about 200 feet MSL in the Sacramento Valley to over 7,000 feet MSL in the ridges and peaks of the interior Coast Range. Fifty percent of the area is above elevation 2,000 feet MSL but only seven percent is above 5,000 feet MSL. Topography and area elevation curves are shown on Plates 12 and 14, respectively. Elevations around the dam and reservoir area varies from elevation 385 feet MSL to about elevation 1100 feet MSL, with the hills sloping gradually towards the Sacramento Valley.

4-03. GEOLOGY AND SOILS

The Stony Creek Basin is underlain by a massive volcanic formation covered by layers of impervious shales, sandstones, and conglomerations. The volcanic formation and the overlying sedimentary strata dip steeply toward the Sacramento River. The valley plain is comprised of three different groups of sedimentary deposits. The lower group, which varies from zero thickness at the foothills to 2,000 feet in the Sacramento Valley is predominately impervious clay with occasional gravel, silt, sand, and thin volcanic deposits. The intermediate groups are composed of sub-rounded gravels and clayey sands with some hardpan and carbonate cement. The thickness varies from a few feet at foothills to 100 feet near the mouth of

Stony Creek. The top layer of deposits, which averages 25 feet thick is composed of sands, silts, and clayey silts, with small gravel. This layer, with lesser thickness, extends up the mountains sides of the Coast Range.

The structural geology of the foothill region has escaped the effects of intense folding and faulting typical of the Coast Ranges to south and west. The underlying formations have been uplifted somewhat resulting in a gentle east dip with little known warping. Minor faulting and jointing occur locally.

The dam, reservoir area, and surrounding areas feature low, rounded hills which have been formed by erosion of soft Tertiary and Quanterary continental deposits. The hills are generally smooth and have moderate to steep slopes with the exception of a prominent protruding butte extending from the dam site upstream (west) one mile and southward about 5 miles. The butte is formed by a resistant caprock of basalt which protects the softer underlying formations. The valley sides are strewn with basalt blocks in various stages of slumping, from those just beginning to move away from the basalt mass, to the ones which have moved downslope to the valley floor.

There is only a thin mantle of residual soil on the mountainous portion of the basin, with occasional rock outcrop. Soils in the foothills and valley areas are generally clay covered with shallow deposits of gravel and sand in the vicinity of the streams.

4-04. SEDIMENT

Sediment yield of the basin upstream from Black Butte Dam is derived from a mixture of relatively clear outflow from Stony Gorge Reservoir and unregulated discharge from the drainage area downstream from the reservoir. Unregulated tributaries of Stony Creek downstream from Stony Gorge Reservoir yield large amounts of sediments during periods of storm runoff. Most of the sediment yield from this area is from the Grindstone Creek basin; Elk Creek, and North Fork Stony Creek may transport significant quantities of sediment.

The estimate of sedimentation allowance in Black Butte Lake is based primarily on data furnished by the U.S. Soil Conservation Service in Special Report No. 10, dated July 1947, titled "Reservoir Sedimentation in the Sacramento-San Joaquin Drainage Basins, California". This estimate is based on the assumption that sediment in Black Butte Lake will originate largely from 440 square miles of its drainage area which lies below Stony Gorge Reservoir, since almost all sediment originating above that reservoir will be trapped therein. The average annual sediment inflow was found to be 0.22 acre-foot per square mile. The estimated trap efficiency of the reservoir was 94 percent. The same report gives average annual sediment accumulation values per square mile of drainage of 0.10 acre-foot for the 102 square mile area above East Park Reservoir and 0.20 acre-foot for the 199 square mile drainage area between East Park Dam and Stony Gorge Dam. The total deposition of sediment in a 50-year period was estimated at 4,550 acre feet with an average weight of 62 pounds per cubic foot and a composition of clayey silt, fine sands, and small amounts of heavier sands and gravels. The total estimated sediment deposition represented only 2.8 percent of the initial reservoir capacity and would not materially decrease the trap efficiency of the reservoir.

The U.S. Geological Survey Water-Supply Paper 1798 dated 1969 titled "Sedimentation in Upper Stony Creek Basin, Eastern Flank of Coast Range of Northern California" indicated that the average annual rate of accumulation in East Park Reservoir during the period 1910-62 was 0.37 acre-foot per square mile of drainage area and in Stony Gorge Reservoir during the period 1928-62 it was 0.27 acre-foot per square mile of drainage for the area between the two dams. Estimates of suspended-sediment discharge were made from periodic measurements at Black Butte damsite. Annual sediment yield average was 0.93 acre-foot per square mile during the 6 year period 1957-62 for the 440 square miles area between Black Butte and Stony Gorge dams.

A system of 24 sedimentation ranges have been established at Black Butte Lake to measure sediment deposition in the reservoir. Resurveys of the sediment ranges were made in 1963, 1966, 1973 and 1984. In addition, in October 1977 photogrammetric mapping of Black Butte Lake was accomplished during the historical low pool level.

The resurvey of the sediment ranges made in 1966 after the major flood of December 1964-January 1965 showed deposition of 2,730 acre-feet in 3 years or 900 acre-feet per year. That rate was about 10 times higher than had been predicted from data in the 1947 Soil Conservation report, but was not considered typical of the average annual rate because of the large amount of deposition believed to have occurred during the 1964-1965 flood and the shortness of records. However, the Geological Survey Water Supply Paper, 1798, seemed to bear out that the rate was higher than originally estimated. Area-capacity tables developed in 1978 from the 1977 aerial mapping indicated that the capacity at Black Butte Lake at gross pool had been reduced from 160,000 acre-feet to 143,700 acre-feet, and the flood control reservation reduced from 150,000 acre-feet to 137,000 acre-feet, or a reduction of 13,000 acre-feet over 15 years. Considering all factors, it would appear that the sediment rate is significantly higher than originally estimated, probably in the magnitude of 7 to 10 times.

4-05. CLIMATE

a. General. Climate in the Stony Creek Basin is characterized by cool, wet winters and hot dry summers. The major proportion of the seasonal rainfall occurs in 2 or 3 of the winter months. The seasons are so distinctly different that the period from May to October may be termed the dry season and November to April the wet season. The annual sunshine percentage is 73.

b. Temperature. Temperatures in the valley are high in the summer and moderate in the winter. During the summer, temperatures have been as high as 120°F and during the winter as low as 18°F at Orland. Temperatures in the mountains decrease generally with elevation, and the summers are cool at higher elevations while the winters are cold. The monthly distribution of mean temperatures in the Stony Creek Basin and an adjacent area is given in Table 2.

TABLE 2

MEAN MONTHLY TEMPERATURES
(Degrees Fahrenheit)

MONTH	Orland (El. 254')	Black Butte Dam (El. 410')	Covelo (El. 1390')
January	44.6	45.5	40.8
February	49.4	49.5	45.0
March	52.9	52.8	47.4
April	58.6	57.6	52.1
May	64.2	67.5	58.4
June	74.0	74.1	65.6
July	78.7	79.5	72.0
August	76.7	78.2	70.8
September	72.8	73.9	66.2
October	63.9	64.7	56.8
November	52.6	52.7	47.1
December	45.4	45.8	41.3
Average annual	61.3	61.8	55.3
Years record thru 1985	103	22	46

c. Precipitation. Normal annual precipitation varies from less than 18 inches in the valley section to over 60 inches in the mountains and averages about 32 inches over the basin above Black Butte Dam. Precipitation usually falls as rain up to the 5,000 foot elevation, and as snow at higher elevations, but some storms produce rain up to the highest elevation of the basin, and snowfall occurs as low as the valley floor at rare intervals.

The areal distribution of normal annual precipitation is shown on Plate 15. About 87 percent of the normal annual precipitation falls during the winter months from November through April. The normal distribution is given in Table 3, on page IV-5.

TABLE 3
MEAN MONTHLY PRECIPITATION

MONTH	East Park Res. (El. 1205') Inches:	%	Stony Gorge Res. (El. 800') Inches:	%	Black Butte Dam (El. 410') Inches:	%	Orland (El. 254') Inches:	%
July	0.03	.1	0.06	.3	0.08	.3	0.11	.5
August	0.17	.9	0.14	.7	0.30	1.4	0.25	1.3
September	0.26	1.4	0.25	1.3	0.41	2.0	0.35	1.8
October	1.05	5.5	1.05	5.3	1.22	5.8	1.05	5.3
November	2.30	12.1	2.61	13.2	3.24	15.5	2.85	14.3
December	3.50	18.4	3.49	17.7	3.33	15.9	3.42	17.2
January	4.55	23.9	4.45	22.6	4.01	19.2	4.24	21.3
February	3.39	17.8	3.41	17.3	3.30	15.8	3.20	16.1
March	1.94	10.2	2.20	11.2	2.90	13.9	2.11	10.6
April	1.14	6.0	1.27	6.4	1.42	6.8	1.35	6.8
May	0.40	2.1	0.47	2.4	0.39	1.9	0.61	3.1
June	0.31	1.6	0.32	1.6	0.31	1.5	0.35	1.7
TOTALS								
Nov-Apr	16.82	88.3	17.43	88.4	18.20	87.0	17.17	86.3
Annual	19.04	100.0	19.72	100.0	20.91	100.0	19.89	100.0
Years of Record thru 1986	76		60		22		104	

d. Snowfall. Winter snowfall above 5,000 feet elevation normally accumulates until the first of April, when increasing temperatures mark the beginning of the snowmelt season. Snow falling at lower elevations usually melts within a relatively short time. On 1 April of an average year, the snowpack at 6,000 feet elevation in the Stony Creek Basin has a water equivalent of 19 inches. When snowfall is abnormally heavy, the water equivalent may be as much as 150-200 percent of average. Representative data on average water equivalents during the late winter period is given in Table 4. Location of the snow course is shown on Plate 15.

TABLE 4

AVERAGE WATER EQUIVALENT

Station	Elevation (Feet MSL)	Average Water Equivalent (inches) 1 Feb.	1 Mar.	1 Apr.	1 May
Anthony Peak	6200	16.7	23.2	29.4	24.4

Source DWR Bulletin No. 129 1944-1985

e. Evaporation. The average historical monthly evaporation at Black Butte Dam is listed in Table 5. All data were obtained from a Class "A" pan.

TABLE 5
HISTORICAL MONTHLY EVAPORATION
BLACK BUTTE LAKE

Month	Lake Evaporation, Inches	
	Mean	Standard Deviation
January	1.52	.45
February	1.94	.65
March	3.01	.80
April	4.69	1.15
May	7.32	1.07
June	9.02	1.78
July	10.71	.76
August	10.05	.99
September	8.81	.97
October	6.13	.87
November	2.62	.83
December	1.58	.57
Total	67.37	

Period: 1964 - 1985

f. Wind. The prevailing wind direction in the lower Stony Creek Basin is from the south during the months of April through September, and from the north during the months of October through March. A continuous recording ground level anemometer is located at Black Butte Dam. Total wind movement is measured and daily movements are recorded. The nearest station with maximum wind records is Red Bluff, California. The Red Bluff records are considered representative of Black Butte Dam. The fastest wind recorded at Red Bluff was 68 miles per hour from the north and occurred in October 1968. Table 6 is a compilation of average monthly wind movement at the dam and peak monthly winds at Red Bluff.

TABLE 6
HISTORICAL AVERAGE MONTHLY WIND MOVEMENT BLACK BUTTE LAKE
AND
PEAK WIND AT RED BLUFF

Month	Wind Movement, Miles		Peak Winds
	Mean	Standard Deviation	Miles per hour
January	2289	556	59
February	2058	788	61
March	2512	587	63
April	2336	741	50
May	2158	477	46
June	2125	370	38
July	1884	322	38
August	1725	258	30
September	1776	428	50
October	1843	372	68
November	1928	414	56
December	2126	469	60
Total	24,760		

Period 1965 - 1984

4-06. STORMS AND FLOODS

The most important storms affecting this area are cyclonic wave disturbances along the polar front that usually originate in the vicinity of the Aleutian Islands. The normal trajectory of the waves along this polar front is south and east, crossing from the ocean to continent by way of Washington and Oregon. In the summertime, this front is located far to the north, and the accompanying precipitation seldom reaches as far south as California. During the summer, the air which reaches the region is generally stable, and the thunderstorm type of rainfall rarely occurs. During the wintertime, from September to April, the polar front moves southward and the cyclonic wave disturbances reach California. The Stony Creek Basin is partially shielded from these general storms by the continuous barrier of the Coast Range. Invading air masses cross the Coast Ranges, resulting in maximum precipitation along the crests and decreasing precipitation on the leeward slopes.

Rainstorms that produce precipitation simultaneously over the entire basin are responsible for all of the damaging floods on Stony Creek. Usually storm precipitation amounts are distributed areally in the same general pattern as normal annual precipitation amounts, although there are large departures from this rule. Large storms last 2 to 5 days, and practically all of the precipitation occurs, with few exceptions, within a 4 day period. Flooding results when the ground approaches saturation in the fall and the streams respond quickly to rain.

Rain floods can occur any time during the period from November through April. Rainfall intensities are generally moderate but prolonged over several days. Flood flows on Stony Creek may be affected somewhat by melting snow caused by rain at high elevations. The resulting floods are usually characterized by high peak flows of short duration; but when antecedent rainfall has resulted in saturated ground conditions or when the ground is frozen, the volume of runoff is much greater and flooding more severe. These floods often occur in rapid succession, with the succeeding peaks occurring before flows from the preceeding floods have completely subsided.

The February 1986 flood was a flood of this type. February 1986 began wet with rain every day between 31 January and 3 February. By 10 February the weather conditions looked very much like those that occurred during the December 1964 flood disaster in northern California. There was a strong possibility that a major storm was developing. On 11 February, mention was made in special weather announcements on the severity of the approaching storm. Light rain began to fall over northwest California the morning of 11 February and spread to the Stony Creek Basin by afternoon. Heavy rain was forecast to spread over Stony Creek Basin by 12 February.

Heavy rain did fall over all of northern California on 12 February. That evening very heavy rain fell in coastal mountains and Stony Creek Basin. Though precipitation was widespread and heavy this first day, flash flooding was not a problem. The rain ended briefly, early on February 13. However, another strong Pacific storm was already bearing down on the state. A watch was issued on the morning of February 13 for all of the central California coastal ranges for the evening of February 13 through the morning of February 14. By the evening of February 13, heavy rain began to fall over

all of northern and central California. It continued through the night and did not let up until the evening of February 14, with the heaviest occurring on the morning of February 14. By the morning of February 14, flash flooding was occurring in the North Bay counties. The watch area was extended to include much of coastal northern and central California by the afternoon of February 14. Warnings had to be issued for most of the counties in this watch area on the afternoon and evening of February 14.

By late February 14, the storm was tracking from the Bay Area northward and the watch was in effect for the coastal mountains north of San Francisco. By the morning of February 15, the rain had ended at most low elevation stations, but there was still a strong threat of heavy rain for the next few days as the jet stream continued to direct heavy rains toward California. The watch was cancelled during the afternoon of February 15 for all areas, as only showers persisted through the morning of February 16.

By the morning of February 16, another large storm system was moving onto the coast. Throughout the day, counties were added to the watch area. By 9:00 PM, most of northern California was under a storm watch. This watch was in effect through February 18. As the heavy rain moved through the area, warnings were issued for all counties in the watch area during the period from the afternoon of February 16 through the night of February 18.

By the afternoon of February 17, widespread flooding, flash flooding and earth movement was occurring throughout northern California. The very slow-moving, heavy subtropical rainfall progressed from the north and west gradually to the south and east. The heaviest precipitation occurred roughly 200 miles north to 100 miles south of a line from San Francisco to Sacramento to Lake Tahoe. At the height of the storm on February 17, the band of rain forecast to enter California stretched from California southwestward to the subtropics near Hawaii, thus creating the "pineapple connection" that usually causes warm intense rainfall in California.

The rain finally slackened in the west on the morning of February 18, but heavy rain and snow continued at the higher elevations in the Sierra Nevada with warnings in effect there and watches elsewhere. The next heavy band of precipitation moved onto the coast on the afternoon of February 18 with watches extended through February 19 and warnings again posted for the lower Sacramento Valley and Northern Sierra through the morning of February 19. By the afternoon of February 19, the major portion of the storm had moved east; though showers continued into the evening. Over much of the area, precipitation had ranged between 100-200 percent of normal February precipitation. The following tabulation lists the daily amount for the Hydrologic Automatic Data Acquisition (HADA) system precipitation stations for the Stony Creek Basin.

DAILY RAINFALL IN INCHES DURING THE FEBRUARY 1986 STORMS
STONY CREEK BASIN

	DATE										
STATION NAME	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**TOTAL**
Alder Springs	1.50	0.40	3.70	2.50	1.90	3.70	1.20	0.80	0 10	0.10	15.90
Black Butte Dam	1.52	0.58	2.14	0.46	0.63	0.12	0.06	0.38	0.16		6.05
Log Springs	1.50	0.50	3.90	2.40	2.30	4.40	1.60	0.80	0.20	0.10	17.70
Noel Springs	1.40	0.60	4.80	2.60	2.40	6.80	2.40	1.20	0.20	0.20	22.60
Trough Springs	2.10	0.80	5.60	3.20	3.50	5.40	2.60	1.20	0.30	0 20	24.90

Thunderstorms lasting up to three hours can occur over small areas at higher elevations from late spring through early fall. The resulting runoff is characterized by high peak flows of short duration with low volumes. For small tributaries, peak flows from thunderstorms can approach those which occur during major winter rain floods, but flows on Stony Creek are barely affected.

Very little is known concerning the magnitude of floods in Stony Creek Basin prior to 1901 when a gaging station was installed near Black Butte Dam site. Since construction of East Park and Stony Gorge Dams in 1910 and 1928 respectively, flood flows at this site have sometimes been reduced by conservation storage. In terms of natural flows, without such reduction, the flood of 11 December 1937 would have the largest peak flow, and the flood of December 1964 the largest 3-day volume. During the recent 1986 February flood Stony Creek below Black Butte Dam recorded a new peak flow of 23,300 cfs. High inflows caused encroachment into surcharge storage and spillway discharge. Inflow from the 1986 storm, actually a series of storms over ten days, resulted in a hydrograph with two major waves in a 4 day period with bihourly peak flows of 41,000 cfs and 44,400 cfs. The resultant 10 day inflow volume of 370,000 acre-feet was a historical record. The natural flows of major floods that have occurred in Stony Creek Basin are given in Table 7.

TABLE 7
ESTIMATED NATURAL FLOOD PEAKS AND
VOLUMES AT BLACK BUTTE DAM

Date of Peak		Peak Flow (cfs)	3-day Volume (ac-ft)
2 February	1909	50,000	122,000
2 February	1915	51,000	134,000
11 May	1915	30,000	94,000
11 December	1937	60,000	102,000
28 February	1940	47,000	145,000
1 March	1941	39,000	148,000
22 December	1955	25,000	87,000
24 February	1958	39,000	95,000
23 December	1964	57,000	175,000
24 January	1970	37,000	112,000
16 January	1974	43,000	117,000
14 January	1978	30,000	115,000
13 January	1980	29,000	117,000
1 March	1983	56,000	166,000
17 February	1986	52,000	173,000

The flood of May 1915 is of interest principally because of its occurrence after the flood season is usually considered to have ended. Like the other major floods, it resulted from rainfall associated with an extratropical cyclone. In addition to recorded floods, major floods are known to have occurred on Stony Creek in the years 1867, 1878, 1890, and 1891. Major floods have also occurred on the Sacramento River in the years 1805, 1850, and 1862, and Stony Creek probably experienced large floods during those years.

4-07. RUNOFF CHARACTERISTICS

The seasonal distribution of runoff in Stony Creek Basin is similar to that of the rainfall, in that low flows prevail from June through October, the season of low precipitation, and high flows may occur during the remainder of the year. The seasonal variation of natural flows and the same flows as improved by upstream storage in East Park and Stony Gorge Reservoirs are illustrated in Table 8.

After the ground approaches saturation in the fall, the streams respond rapidly to rain. The runoff is not greatly affected by snowmelt. Water year runoff has ranged from a minimum of 17,400 acre-feet in 1977 to a maximum of 1,425,000 acre-feet in 1983. The extremes represent 3 and 275 percent, respectively, of the 22 year average runoff of 519,100 acre-feet.

TABLE 8

MEAN MONTHLY RUNOFF AT BLACK BUTTE DAM

Month	Natural Conditions Flow (AF)	Natural Conditions Percent	Existing Conditions Flow (AF)	Existing Conditions Percent
October	1,900	0.4	4,400	0.9
November	27,500	5.3	14,600	2.9
December	74,400	14.3	54,000	10.5
January	138,200	22.6	115,700	22.6
February	97,800	18.8	89,100	17.4
March	92,000	17.7	85,200	16.6
April	50,900	9.8	53,500	10.5
May	26,200	5.1	34,700	6.8
June	8,500	1.6	16,700	3.3
July	1,100	0.2	15,700	3.1
August	300	0.1	17,200	3.4
September	300	0.1	10,500	2.0
Total	519,100	100.0	511,300	100.0

4-08. WATER QUALITY

The chemical, physical, and biological properties of surface water at any given point are the product of a multitude of factors including geography; geology; climatic conditions; discharge; floral and faunal communities; ground water supply; and of major significance - the effect of man, his activities, and his domestic animals. Generally the quality of surface waters in the Stony Creek Basin is good. As the waters of Stony Creek descend from the headwaters towards the Sacramento River, water quality is gradually degraded primarily by natural geochemical process and the influence of small localized areas of human habitation and utilization.

Water in Stony Creek is generally considered excellent in quality for both agricultural and municipal and industrial purposes. The maximum dissolved solids and hardness recorded for the stream are associated with periods of minimum flows during summer months. Maximum and minimum levels of water quality constituents measured in Stony Creek downstream of Black Butte Dam by the California Department of Water Resources for the period October 1973 to September 1979 are given in Table 9.

TABLE 9
WATER QUALITY CONSTITUENTS

Constituent[a]	Maximum	Minimum
Specific Conductance (micromhos at 25°C)	616.0	243.0
pH	8.4	7.5
Temperature, °C	31.5	3.5
Turbidity, NTU	330.0	6.0
Dissolved Oxygen	14.5	7.6
Total Hardness, as $CaCO_3$	278.0	97.0
Non-Carbonate Hardness, as $CaCO_3$	40.0	8.0
Calcium	49.0	25.0
Magnesium	24.0	8.4
Sodium	37.0	9.0
Percent Sodium	24.0	21.0
Sodium Absorption Ratio	1.0	0.4
Alkalinity, as $CaCO_3$	253.0	71.0
Sulfate	31.0	16.0
Chloride	50.0	8.0
Total Dissolved Solids, at 180°C	340.0	163.0
Nitrite + Nitrate, as N	.50	.00
Organic Nitrogen, as N	.55	.26
Total Kjeldahl Nitrogen, as N	.4	.1
Ammonia, as N	.05	.04
Total Phosphorus, as P	.09	.01
Ortho Phosphorus, as P	.06	.00
Potassium	1.6	1.0
Boron	.6	.1
Bicarbonate	309.0	118.0
Total Cadmium	.00	.00
Total Copper	.02	.01
Total Iron	.69	.64
Total Lead	.00	.00
Total Manganese	.02	.01
Total Zinc	.02	.00

[a] Concentrations expressed in mg/L unless noted otherwise.

4-09. CHANNEL AND FLOODWAY CHARACTERISTICS

The channel of Stony Creek is characterized by a variety of conditions. In the reach from Black Butte Dam to business Interstate 5, the stream flows over a wide gravelly flood plain area. Stream banks are low or nonexistent. The low water channel is a fairly well established section ranging from two to four hundred feet wide. During large flows, numerous high water channels are used, while during flood periods, the entire streambed area, two to three thousand feet wide, will be inundated. As a result of floods and shifting channel conditions, several spur dikes and retaining barriers have been built to prevent flooding and bank erosion, and to deflect the flow of the stream back into the main channel.

In the reach from business I-5 to State Highway 32 somewhat the same conditions exist as in the upper reach, except that the stream gradient has decreased somewhat, the streambed material is finer, channels are generally more stabilized, and stream banks and low levees are more frequent at intermittent locations. In the reach from State Highway 32 to Sacramento River, the stream gradient decreases further as it passes through an alluvial soil area. The channel is fairly well stabilized between low banks and levees, and ranges from two hundred to four hundred feet in width and from 5 to 12 feet in depth. The channel between Black Butte Dam and the Sacramento River will carry 15,000 cfs without appreciable damage to agricultural areas and 40,000 cfs without appreciable damage to urban areas. Flows of 40,000 cfs will damage banks and levees by erosion and would flood about 20,000 acres of agricultural land. Flows in excess of 40,000 cfs would enter the towns of Orland and Hamilton City and damage highways and railroads. Estimated travel times of a flood wave from Stony Gorge Dam to Black Butte Lake and from Black Butte Dam to the Sacramento River are 8 and 11 hours, respectively.

4-10. UPSTREAM STRUCTURES

Structures that affect flow in Stony Creek system above Black Butte Lake are listed in Table 10. Refer to 3-04 for a discussion of these projects.

TABLE 10
STRUCTURES UPSTREAM OF BLACK BUTTE DAM

Description	Rainbow Diversion Dam	East Park Reservoir	Stony Gorge Reservoir
Operating Agency (1)	OUWUA	OUWUA	OUWUA
Active Storage Capacity, ac-ft	50	51,000	50,000
Drainage Area, sq-mi	97	102	301
Crest Elevation, feet MSL	1288.7	1198.7	858.7
Crest Length, feet	271	266	868
Height, feet	29	90	139
Spillway Crest Elevation, feet MSL	1279.4	1198.2	833.1

(1) OUWUA - Orland Unit Water Users Association

4-11. DOWNSTREAM STRUCTURES

Permanent structures downstream of Black Butte Dam that affect its operation include the Northside Diversion whose function is to divert water into the headworks of the North Canal of the Orland Project. See Section 3-04 for further discussion.

Each year the Glenn-Colusa Irrigation District constructs a seasonal gravel and sand dike across Stony Creek, (just upstream of State Highway 45) in order to carry the canal water around the creek channel. The dike is built at the start of the irrigation season and removed at the end of the irrigation season.

4-12. ECONOMIC DATA

The Stony Creek watershed lies in Colusa, Lake, Glenn and Tehama Counties, with approximately three fourths of the basin within Glenn County. The Stony Creek watershed is sparsely populated. The 1980 population of Glenn County was 21,000, a 19.8 percent increase over the 1970 population. This figure contrasts sharply with the 1.6 percent increase from 1960-1970.

Stony Creek Basin proper includes the towns of Lodoga and Stonyford in Colusa County and Elk Creek, Orland, and Hamilton City in Glenn County. The majority of the lands along Stony Creek are used for agriculture or livestock grazing.

Transportation in the basin is provided by rail, highway, and limited air facilities. A main line of Southern Pacific Railroad runs north to south through the towns of Orland and Willows. Interstate Route 5 passes through the basin adjacent to the railroad. California State Highway 162 and 32 cross the basin from east to west, while State Highway 45 crosses the basin from north to south. Improved two-lane county roads connect the rural areas with the major population centers. Amtrack, bus and truck lines provide passenger transportation and freight service. The Willows Airport and auxiliary field near Orland accommodate small commercial aircraft and private planes.

a. Population. The major population center in the Stony Creek Basin is Orland. Elsewhere, population is sparse with only a few small towns and settlements. Willows, the county seat of Glenn, lies out of the basin approximately 10 miles due south of Orland. Orland, the city nearest Black Butte Dam has experienced an increased growth rate, as have other Sacramento and San Joaquin Valley towns. This increased growth rate is expected to continue. The Tri-county (Glenn, Tehama, and Colusa), Glenn County and the City of Orland population is given in Table 11. Table 12 shows the population characteristics in the local area.

TABLE 11
POPULATION

	1950	1960	1970	1980
Tri County (Glenn, Tehama, Colusa)	46,375	54,625	59,469	72,947
Glenn County	15,448	17,245	17,521	21,333
City of Orland	2,067	2,534	2,884	4,160
% of Glenn County	13.4	14.7	17.0	19.5

TABLE 12
AGE AND RACIAL CHARACTERISTICS

Age	%	Racial Characteristics	%
Under 5 years	6.8	White	87.3
5-17 years	23.4	Black	0.3
18-64 years	56.9	Spanish-American	10.7
65 + years	12.9	Other	1.7
Median Age	30 years		

b. Land Use. Historically, logging, ranching and mining were dominant land uses, while stream waters were used for agriculture, and livestock watering. Land uses have shifted somewhat in the last 20 years. Appreciable logging is confined to the southeast section of the basin, sheep grazing has been reduced and cattle grazing is reduced but still prevalent in nonforested areas. The major new impacts are associated with recreational land use and suburban development. It is projected that there will be a continued conversion of land use from agricultural to people oriented, such as residental, small acreage ranches and public use.

c. Employment. As shown in Table 13, Glenn County's economic base in predominantly agricultural. Government and trade are the other two largest employment sectors. Employment fluctuates widely in an agricultural economy. For example, the Glenn Chamber of Commerce figures show that unemployment for an area within 30-mile radius of Willows varied from 5.0 percent to 13.3 percent on a monthly basis. In 1969 only 54 percent of all workers employed for 50-52 weeks of the year, versus 69 percent for the state. The county employment peaks in September or October. Table 14 shows yearly family income for 1976 in Glenn County. In 1969, 10.5 percent of Glenn County families were below poverty level (10.3 percent in Orland, 6.7 percent in Willows). These families below poverty level received a mean income of $2,087. Of these families, 18.8 percent received public assistance, versus 28 percent for the state as a whole.

TABLE 13
EMPLOYMENT GLENN COUNTY
(1976 Annual Average)

Classification	Number	% Employed
Labor Force	9,375	
Employment	6,725	
Unemployment	600	
Unemployment rate	6.4%	
Non-agricultural Wage and Salary Worker		
Construction	300	4.2
Manufacturing	900	12.5
Transportation, Communication and Utilities	300	4.2
Trade	1,475	20.4
Finance, Insurance, and Real Estate	150	2.1
Services	500	6.9
Government	1,700	23.5
Agriculture	1,900	26.3
Total	7,225	

TABLE 14
YEARLY FAMILY INCOME
(Glenn County 1976)

Yearly Income ($)	%
2,999 or less	12
3,000 to 5,999	16
6,000 to 9,999	24
10,000 to 14,999	25
15,000 to 24,999	16
25,000 and above	8
Median Income: 9,600	

d. Industry and Agriculture. Industries in Glenn County are mostly those that process agricultural and forest products. These include: rice dyers; fruit and nut processing; feedlots; nurseries; chemical and fertilizer companies; companies that provide aircraft for seeding, crop fertilization, and weed and pest control; livestock auction yards and slaughterhouses. Forest products are important in the region and Louisiana Pacific operates a lumber mill at Elk Creek. Natural gas and sand and gravel production are the principal mineral resources in the area. Table 15 gives the gross value of agriculture production for 1983 in the two counties in which the major portion of the Stony Creek basin lies. Out of the state's 59 counties, Colusa and Glenn rank 30 and 28 respectively, in agricultural production.

TABLE 15
GROSS VALUE OF COMMODITY GROUP PRODUCTION
BY COUNTY 1983

Commodity Group	Gross Value of Agricultural Production ($1,000) Colusa	Glenn
Field Crops	56,746	61,686
Seed Crops	14,630	9,433
Vegetable Crops	16,003	-
Fruit and Nut Crops	14,781	22,231
Nursery and Cut Flowers	-	16
Apiary Products	900	1,934
Livestock	7,379	11,304
Livestock Products	899	23,935
Poultry	-	28
Poultry Products	-	-
Total	111,338	130,567

The major crop produced in Colusa and Glenn Counties is rice. Gross value for rice produced in the two counties in 1983 was approximately $70,000,000 and amounted to about 36 percent of the rice grown in the state. A breakdown of irrigated crops within the Glenn-Colusa Irrigation District for 1983 is given in the following tabulation:

Crop	Acres	%
Rice	62,590	80.3
Tomatoes	926	1.2
Sugar Beets	622	0.8
Clover	4,280	5.4
Alfalfa	1,697	2.2
Corn	1,621	2.1
Orchard	1,746	2.2
General	4,507	5.8
Total	77,989	100.0

e. Damages. Agricultural losses during floods would include erosion and deposition of debris and silt on crop and pasture lands; damage to orchards due to flooding of trees; damage to farm improvements such as irrigation systems, diversions facilities, and fences; possible loss of growing crops, livestock, and poultry; increased cost of livestock maintenance; the cost of having land out of production for extended periods and land treatment for weed infestation. Other flood losses would include damage to roadbeds and bridges; damage to railroad embankment and stream crossings; erosion of channel and damage to communications and utility distribution systems. Residential losses would include damage to foundations, floors, furnishings, and lawns and gardens. Commercial losses would comprise damage to structures and equipment, loss of business and inventories, and costs of cleanup and repair.

Table 16 shows estimated dollar valuations of damages prevented by the Black Butte Project during selected historical floods.

TABLE 16

DAMAGES PREVENTED BY
BLACK BUTTE DAM AND LAKE
IN HISTORICAL FLOODS

Flood Event	Value of Damages Prevented at Time of Flood ($)	
April 1958	550,000	(a)
Dec 1964 - Jan 1965	500,000	
Jan - Feb 1967	100,000	
Jan - Feb 1969	200,000	
Jan 1970	1,900,000	
Jan 1974, Mar - Apr 1974	2,500,000	
Feb 1986	5,500,000	

(a) Includes $153,000 along Sacramento River and in Butte Basin.

V - DATA COLLECTION AND COMMUNICATION NETWORKS

5-01. HYDROMETEOROLOGIC STATIONS

Operation of the Black Butte Dam and Lake Project requires the use of real-time data which reflects reservoir stages, and discharge at key upstream points on Stony Creek and downstream on the Sacramento River. The hydrometeorological information at Black Butte Lake and elsewhere within the Stony Creek Basin is monitored through the Hydrologic Automatic Data Acquisition (HADA) system.

The data is collected automatically every hour by micro-processors located at the located in the upper Stony Creek Basin and at two U.S.G.S. streamgaging stations, (Stony Creek below Black Butte Dam near Orland, CA and South Diversion Canal near Orland, CA).

Temperature, wind, evaporation and precipitation data at the project and storage at East Park and Stony Gorge reservoirs, outflow from Stony Gorge and downstream demand to Glenn Colusa Irrigation District must be entered into the subcentral station memory manually with thumb wheels. Data in the Black Butte Lake subcentral station memory can be interrogated by the central station (HADA Central) in the Sacramento District Reservoir Control Section office. Normally, the precipitation gages automatically report every hour to HADA Central.

The facilities at the project include the following:

a. in the dam capable of recording pool levels up to the spillway design pool level, supplemented by a permanent staff gage in the reservoir.

b. One of these gages is on Stony Creek and the other is on South Canal of the Orland Project. Both are supplemented with visual staff gages.

c. A weather station at the dam. The weather station consists of:

1. Recording and non-recording precipitation gages.

2. A wind station recording total wind travel in miles.

3. A Weather Bureau Class-A evaporation pan with anemometer.

4. A recording hygrothermograph with maximum and minimum thermometers.

In addition to the project gages, the California Department of Water Resources operates a recording, radio-reporting, on call gage on the Sacramento River [redacted]. The gage is monitored directly by the State Flood Operations Unit in Sacramento, and the information is available to the Corps of Engineers via telephone and computerized teletype.

Hydrologic and meteorologic data are recorded and published for many sites throughout the Stony Creek Basin and adjacent basins as shown on Plates 12 and 15.

5-02. WATER QUALITY STATIONS

The Corps of Engineers has a limited program of water quality sampling at Black Butte Lake. Water quality measurements on the lake and inflow and outflow are made at least semiannually. Table 17 lists data concerning "Water Quality Stations" as of the end of Water Year 1982. The U.S. Geological Survey (USGS) in conjunction with the California Department of Water Resources collects samples to determine sediment quantities, sizes, and to perform chemical analyses. The U.S.G.S. publishes all water quality data in their annual surface water and water quality reports for California. Provisional data are obtained from U.S.G.S. as needed, by telephone.

TABLE 17
WATER QUALITY STATIONS

Sampling Station	Drainage Area sq. mi.	Sample	Sample Frequency
[redacted]	623	Temperature	Daily
		Sediment Discharge	Daily
		Suspended Sediment and Particle Size	Monthly
[redacted]	738	Temperature,	Daily
		Suspended Sediment and Particle Size	Monthly*
		Specific Conductance	Monthly in
		Trace Elements	the summer**
		Chemical Analysis	

* discontinued in 1962
**discontinued in 1979

5-03. SEDIMENT STATIONS

Twenty three sedimentation ranges have been established within Black Butte Lake as shown on Plate 19. In addition, a range line has been established downstream of Black Butte Dam to monitor degredation of the stream channel below the dam. Each range is straight with permanent concrete monuments at each end above gross pool level and with secondary capped

galvanized iron pipe markers located above inactive flood level. Sedimentation ranges are generally run after each large flood event.

Sediment data has been collected in the past at U.S.G.S. gaging stations, Stony Creek above Black Butte Lake near Orland, CA for the period November 1980 to May 1983, and Stony Creek below Black Butte Dam near Orland, CA for Water Years 1958, 1959, 1961 and 1962.

5-04. RECORDING HYDROLOGIC DATA

[redacted] is responsible for operation and maintenance of the weather station and certain stream gages in cooperation with the U.S. Geological Survey (USGS). [redacted] A report of daily observations for Black Butte Lake in the Sacramento District Office central control station of the Hydrologic Automatic Data Acquisition System (HADA) interrogates the (HADA) subcentral station to obtain the data. The following information is manually entered into subcentral stations each day in addition to automatically sensed data:

a. Pan evaporation
b. Maximum temperature
c. Minimum temperature
d. Precipitation at dam
e. Wind anemometer reading
f. Diversion to Wackerman Ranch
g. Storage Stony Gorge Reservoir
h. Storage East Park Reservoir
i. Stony Gorge release
j. Glenn Colusa Irrigation District demand

Records of all required observations are entered in an electronic computer data base located in the Reservoir Control Section.

Outflows and storages for the project are published by the USGS from the Corps record. Continuous streamflow measurements at several locations throughout the Stony Creek watershed are recorded and published by the USGS. The California Department of Water Resources records streamflow measurements on the Sacramento River at Ord Ferry. This data was formerly published, but published streamflow data were discontinued in general by the State after Water Year 1975. Locations of important stations are shown on Plate 12.

Short-term data is obtained by the Reservoir Control Section through the central station of the HADA system in Sacramento by interrogation of the Black Butte subcentral station. A data update is automatically accomplished hourly and transmitted by the Black Butte subcentral to the Reservoir Control Section's central station.

5-05. COMMUNICATIONS NETWORK

Voice communication between the Sacramento Office and the project office is either by radio or telephone. The radios in both offices have backup power from batteries and standby generator.

The central station of the Hydrologic Automatic Data Acquisition system (HADA) located in the Reservoir Control Section, Sacramento Office can interrogate the subcentral station of the Black Butte Project by radio or telephone. The central and subcentral stations have backup power from batteries and generators.

The precipitation gages above the project report to the subcentral station by radio only and the reservoir stage and outflow gage are hard wired to the HADA system.

5-06. COMMUNICATIONS WITH PROJECT

Direct oral communication on a normal weekday basis between Reservoir Control Section and the Project Office will be made by radio with phone as a backup. In the event of a flood warning, project personnel can be placed on a standby basis at home where they can be reached by phone. In the event of flood operations, Reservoir Control and project personnel can be placed on 24 hour duty.

Radio-reporting project gages are linked to the project office. These gages automatically report at regular intervals, and may be interrogated at any time. Communication can also be accomplished from the District to the project through the District's computerized data system with teletype terminals. Routine, non-urgent communications may be transmitted by mail.

For flood control purposes, instructions for reservoir operation are the responsibility of the . Water supply releases for the Orland Unit Water Users Association (OUWUA), and the Glenn-Colusa Irrigation District are the responsibility of the , . Communication link is by commercial telephone lines.

The operators of the proposed Black Butte Power Plant will communicate with Black Butte Dam to coordinate and confirm water release changes. The (OUWUA) will, when necessary, operate the power plant for the City of Santa Clara (City). Normally the power plant will be monitored remotely from the City's operation center in Santa Clara. Operations will be initiated by instructions from the City's center. Control will be exercised by OUWUA when changes in flow rate or power settings are required. Once the settings have been made, the plant will be on automatic control. Communication will be maintained between OUWUA, the city and the Corps at Black Butte Dam on a day-to-day basis and emergency basis by commercial leased telephone lines. An emergency backup will consist of radio transmitters and receivers using the existing OUWUA radio system frequency.

5-07. PROJECT REPORTING INSTRUCTIONS

, is responsible for operation and maintenance of the weather station at the dam, for making daily observations of reservoirs gages and, for preparing the hydrologic data for the daily report. Daily reports of reservoir, streamflow, and other data are transmitted to the Reservoir Control Section at 0730 hours each day via HADA system. At that time, the Reservoir Control Section personnel issues the

necessary instructions for flood control regulation, weather, and streamflow forecasts, instructions for issuing flood warnings, and if necessary, the requirements for regulating procedures and collection of data to be performed outside the regular working hours.

During flood operations, reports are required at the discretion of the Reservoir Control Section. Radio reporting gages may be interrogated as necessary.

Project personnel shall contact the Reservoir Control Section immediately whenever any of the following conditions occur:

a. One-inch or more of rainfall at the project during any 6 hour period or 1.5 inches or more of rainfall during any 24-hour period.

b. An increase of 3,000 cfs or more during any 8 hour period in inflow.

Important phone numbers and key operating personnel are shown on page iii.

5-08. WARNINGS

The National Oceanic and Atmospheric Administration (NOAA), through its National Weather Service (NWS), maintains year-round surveillance of weather conditions. NOAA storm forecasts for the Stony Creek and Sacramento River Basins are issued by the NWS in Sacramento. These are distributed to agencies responsible for flood protection and by way of local news media, to the public.

Personnel from the NWS Office in Sacramento and the California Department of Water Resources are assigned to the Joint Federal-State River Forecast Center in Sacramento, which monitors weather conditions and river stages on a year-round basis. It operates on a 24-hour basis in conjunction with the River Forecast Center. In addition, among other flood emergency activities, the center advises interested parties of flood situations as they develop. The furnishes flood information and flood warnings for the Sacramento River Basin to the local news media, law enforcement agencies and other agencies for dissemination to the public.

The Park Manager notifies local agencies and property owners of scheduled changes in flood releases from Black Butte Dam by telephone and publishes these changes through the local news media.

There are no specific formalized plans for flood fighting or emergency evacuation of people and personal property from the Stony Creek flood plain below Black Butte Dam. However, Glenn County has a standing emergency plan that covers floods as one of several possible emergency situations. The California Department of Water Resources, through the Flood Operations Center, coordinates flood fighting activities throughout the State and is authorized to receive requests from local public agencies for assistance during floods. The Corps of Engineers responds to requests for flood fighting and rescue from the California Office of Emergency Services

(OES) when the emergency is beyond the capabilities of State and local governmental agencies.

Pursuant to the provisions of Section 8589.5, Government Code of California, emergency procedures must be established for the evacuation and control of areas of potential flooding in the event of sudden failure of dams. The Corps of Engineers has complied by preparing a map showing areas that would be inundated by failure of Black Butte Dam. On the basis of the map, the OES in cooperation with the California Department of Water Resources has designated evacuation areas. The local jurisdiction must then adopt emergency procedures that include, among other things, specific routes to be used for evacuation; traffic control measures, movement of people without their own transportation; shelter of evacuees; evacuation and care of people from institutions; and perimeter security, interior security, and reoccupation of evacuation areas.

VI - HYDROLOGIC FORECASTS

6-01. GENERAL

The purpose of the forecasting system for Black Butte Project is to estimate anticipated inflows to Black Butte Lake so that outflows rates may be adjusted to achieve the highest degree of control of non-damaging downstream flows, and damaging flows may be foreseen in order to give the earliest possible warnings. (Please see section 5-08 for a description of the flood warning system.)

6-02. FLOOD CONDITION FORECASTS

Forecasts of inflows are based on three variables: current inflows, measured precipitation, and forecasted precipitation.

Current inflows to Black Butte Lake are estimated from outflows plus the change in storage for the time period immediately preceeding the current one, taking into account an estimated rate of change of inflows.

Precipitation is measured by telemetry from the project hydrometeorological stations in the upper portions of the Stony Creek Basin. The gages report at hourly intervals.

Precipitation amounts are forecasted for the Stony Creek Basin by the National Weather Service (NWS) in Sacramento. During periods of significant anticipated precipitation, the data from the NWS is transmitted to the Sacramento District in a format known as the Quantitative Precipitation Forecast (QPF). The QPF is for the succeeding 24-hour period and is broken down in 6-hour increments. These short-term forecasts are updated twice daily at 4:00 a.m. and at 4:00 p.m.

The precipitation and streamflow data are translated into a prediction of inflows by means of a formalized procedure which accounts for precipitation losses due to evaportranspiration and infiltration, direct runoff due to excess precipitation, losses to infiltration in previous periods. Current and projected precipitation loss rates are estimated from previous measured precipitation and inflows. Base flow is estimated from previous inflow compared with previously projected inflows. Direct runoff is projected from excess precipitation by means of a unit hydrograph.

Predictions of warning and flood stages on the Sacramento River are computed by the joint Federal-State River Forecast Center using a hydrologic computer model of the basin and are relayed to the Sacramento District via computer terminal. Predicted stages and times of occurrence of flood peaks are prepared for Sacramento River, Ord Ferry and key upstream and downstream locations on the Sacramento River System.

The precision accuracy, and reliability of the inflow forecast procedure is under continual evaluation. A graphical forecasting scheme for rain flood runoff volumes that was developed from a correlation study using mean daily natural runoff at Black Butte dam site and 24-hour precipitation is shown on Chart A-8. All floods which were used in the development of this criteria were corrected for the effects of East Park and Stony Gorge Reservoirs.

6-03. CONSERVATION PURPOSE FORECASTS

The U.S. Bureau of Reclamation (USBR) is the operator of the conservation storage at Black Butte Lake, which was integrated in the operation of the Bureau Central Valley Project (CVP) in 1970. Each spring the USBR makes a forecast of the water supply available and project operation requirements of the CVP. An annual informational meeting with community interests in the Orland area is held in the spring of each year to discuss the projected operations of Black Butte Lake and Stony Gorge and East Park Reservoirs of the Orland Project for the current year. The projected operations are based on current storage conditions of the Stony Creek Reservoirs and the needs of Orland Unit Water Users Association, and the Glenn-Colusa Irrigation District. However, no reliable scheme of forecasting inflows for more than a few hours in the future has been developed. Expected inflows can only be estimated in terms of statistics of historic inflows. On the other hand, fairly reliable forecasts of water demand can be made, although demand also is fairly dependent on basically unpredictable meteorological variables.

6-04. LONG RANGE FORECASTS

Long range forecasting for flood control is not a consideration because of the short duration of storm events and because there is no significant snow in the basin. Long range forecasting for conservation purposes is the responsibility of the U.S Bureau of Reclamation. Basically, no reliable scheme of long-range forecasting has yet been developed. Consequently no long-range forecasts are made.

VII - WATER CONTROL PLAN

7-01. GENERAL OBJECTIVES

The Black Butte Project is a multi-purpose development with the objectives of providing areas below Black Butte Dam with a high degree of protection from floods; providing a conservation yield for irrigation; maintaining an inactive pool of 6,700 acre-feet when water is available; and generation of hydroelectric power. Recreation and lake fishing enhancement are also provided by the project.

7-02. MAJOR CONSTRAINTS

The maximum non-damaging flow on Stony Creek below Black Butte Dam to the Sacramento River is 15,000 cfs, although some erosion and bank sloughing occurs at flows well below the maximum non-damaging flow. Releases from Black Butte Lake will be at rates that will minimize erosion to the extent practicable. Sloughing is more likely to occur when channel flows decrease rapidly; therefore, rate of changes in release from Black Butte Lake are limited. (See chart A-10)

Maximum storage normally available for flood control at Black Butte is 137,000 acre-feet.

7-03. OVERALL PLAN FOR WATER CONTROL

The specific objectives of the operation of the Black Butte project are:

a. To protect the City of Orland against all reasonably probable rain floods.

b. To protect the agricultural areas along Stony Creek between Black Butte Dam and the mouth of Stony Creek against damaging flows during all but very large floods, and to minimize and delay damaging flows during large floods.

c. To control flows in Stony Creek downstream from Black Butte Dam to existing channel capacities, by restricting flows downstream in Stony Creek to a controlling rate of 15,000 cfs at the stream gage below Black Butte Dam, insofar as possible.

d. To limit releases from Black Butte Dam, insofar as possible, to inflow quantities or to 15,000 cfs (whichever is the lesser) whenever Sacramento River flow at the latitude of Ord Ferry exceeds 130,000 cfs, in order that floods in the Sacramento River Flood Control Project channels will not be augmented by Black Butte Lake operation.

e. To provide the maximum practicable amount of storage for conservation of irrigation water without impairment of the flood control functions.

f. To maintain an inactive pool of 6,700 acre-feet.

g. To provide the maximum amount of power practicable consistent with required flood control operations and conservation functions of the reservoir.

h. To provide maximum enhancement to recreation potential and warmwater fisheries.

7-04. STANDING INSTRUCTIONS TO DAMTENDER

During normal flood periods, the reservoir will be regulated in accordance with normal regulations for flood control operation in paragraph 7-05a and Exhibit A of this manual. Exhibit A is designed to function as a separate, complete document for sole use as a guide for flood control operation. Charts required for normal and emergency flood control operation are provided therein.

Instructions for storage and release of floodwaters in the flood control space will be issued by personnel of the Reservoir Control Section, Sacramento District, Corps of Engineers. In the event communications with the Sacramento District Offices are disrupted, the reservoir shall be operated in accordance with the emergency regulation for flood control operations in paragraph 7-05b.

7-05. FLOOD CONTROL

a. Normal regulations for Flood Control. Flood Control regulation begins when storage in Black Butte Lake exceeds the flood control space required at any particular time as determined from the Flood Control Diagram. The Flood Control Diagram for Black Butte Lake (Exhibit A, Chart A-10) is the basic project document regarding operation for flood control. This diagram is the result of careful analysis of flood frequency, seasonal flood potential and downstream channel capacities consistent with project objectives and operating experience gained in the last 22 years. This diagram requires:

(1) Flood Control space increasing uniformly from a zero requirement on 1 September up to a maximum reservation of 137,000 acre-feet by 30 November (a minimum reservation of 106,400 acre-feet is required from 10 November to 23 January).

(2) Conditional flood control reservation up to a maximum of 137,000 acre-feet from 30 November to 20 March, decreasing to zero as early as 7 April or as late as 15 June. The required reservation is determined by use of a ground wetness index during this period.

The precipitation index is computed from daily mean basin precipitation weighted according to station normal precipitation at the five project hydrometeorological system gages. Unit weightings are indicated on the Flood Control Diagram, Chart A-10. The index is computed by summing previous daily mean basin precipitations values reduced by three percent per day to the current date.

Increases in releases during normal flood control operations shall not be changed more than 2,000 cfs in any 2-hour period. No level of release above 1,000 cfs shall be held for more than 18 hours.

For a decrease in release; outflow shall be reduced in 1,000 cfs increments when existing release is between 15,000 cfs and 5,000 cfs, and in 500 cfs increments when existing release is below 5,000 cfs, with no release sustained for less than 2-hours.

When the reservoir pool elevation is below 473.5 feet MSL, (gross pool), flood control releases will be made in accordance with the release schedule shown on the Flood Control Diagram (Chart A-10). During floods in which flow over the spillway occurs, the outlet will be operated by gradually closing the outlet gates as the pool rises above gross pool in order to control the total outflow from the spillway and outlet to 15,000 cfs as long as possible (see Chart A-9). When the pool reaches elevation 486.5 feet MSL, the gates will be closed. Reservoir regulation will follow surcharge operations (described in 7-05b) when the pool exceeds 498.0 feet MSL, and transfer to flood control operation when the pool recedes to gross pool, elevation 473.5 feet MSL. Water stored in the flood control space will be released as rapidly as downstream conditions permit, but not to exceed 15,000 cfs. When the required flood control space has been obtained in Black Butte Lake, flood control operation will cease and conservation operation will resume.

b. Emergency Regulation. If communications with the project are disrupted the following procedures will be followed for project operation:

(1) Continue release in accordance with the last instructions from Reservoir Control Section, Sacramento District, Corps of Engineers, and make every attempt to re-establish communications.

(2) If communication cannot be re-established, make releases in accordance with Release Schedule on the Flood Control Diagram (Chart A-10).

(3) Surcharge operation.

(a) When the reservoir pool is above elevation 486.5 feet MSL, the outlet gates will be closed. Outlet gates will remain closed until the spillway flow exceeds 40,000 cfs, the flow at which appreciable damage begins to Orland. If the pool is expected to continue rising, the outlet gates will be opened one by one at the rate of 20 percent of the total capacity per foot of pool stage rise, beginning at pool stage elevation 498.0 feet MSL. When the pool reaches elevation 503.0 feet MSL the gates will be fully open.

(b) For receding pool, outlet openings will remain constant until a total release of 15,000 cfs (spillway plus outlets) is reached or the reservoir stage has receded to gross pool elevation 473.5 feet MSL, below which a release rate not to exceed 15,000 cfs will be maintained until the pool has receded to required amount of flood control space.

7-06. RECREATION

Although Black Butte Lake is operated primarily as a flood control facility and secondarily as irrigation storage, during the recreation season the highest pool level consistent with irrigation demands is maintained to enhance recreation opportunities. By August in an average water year, water surface elevation is near 440 feet MSL. As the lake drops below this elevation, the boat launching facilities at Orland Buttes Recreation Area are

unusable, extensive mud flats are exposed in the upper arms of the lake and most developable land is some distance from the water. This limits the area in which year around recreation facilities may be developed to Buckhorn, Eagle Pass and Squaw Point recreation areas. The summer drawdown is a definite constraint to be considered in any future recreation area development.

As part of the U.S. Bureau of Reclamation proposed operating objectives for the Stony Creek Reservoir (See Exhibit B), to the extent possible, a minimum reservoir storage of 40,000 acre-feet, 441 feet MSL, will be the objective at Black Butte Lake until Labor Day weekend. During the fall months after Labor Day, provided flood control parameters or carryover storage do not dictate lower levels, a minimum reservoir level of 20,000 acre-feet, 429 feet MSL, will be maintained at Black Butte Lake. The minimum level under any condition shall not be under 6,700 acre-feet.

7-07. WATER QUALITY

Black Butte Lake is not operated for water quality as it is not a project purpose. However, water quality standards for Black Butte Lake and Stony Creek are those established by the California Water Quality Control Board, Central Valley Region. The standards for individual basin flows in California were prepared by the State in response to requirements set forth in Section 303 of the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500) and in the Porter Cologne Water Quality Control Act (Division 7 of the California Water Code). The purpose of the plans are to develop a comprehensive water quality management plan for individual water basins in California, accounting for the complex interrelationships of water quality and water quantity. The Basin Plan has divided the Stony Creek Basin into three areas; (Stony Creek, Black Butte Lake, and East Park Reservoir) and has set beneficial uses as shown in the following tabulation:

Stony Creek
- Irrigation and stock watering
- Contact and non-contact recreation
- Warm freshwater habitat
- Potential cold freshwater habitat
- Coldwater fish migration
- Warmwater and coldwater fish spawning
- Wildlife habitat

Black Butte Lake
- Irrigation and stock watering
- Contact and non-contact recreation
- Warm freshwater habitat
- Warmwater fish spawning
- Wildlife habitat

East Park Reservoir
- Contact and non-contact recreation
- Warm and cold freshwater habitat
- Warmwater fish spawning
- Wildlife habitat

A monitoring program has been established for Black Butte Lake to determine the pollutional input into the lake from the inflows and that resulting from lake use, to determine if the quality is within the criteria needed to satisfy the beneficial uses, and to determine a data base against which to compare future qualities and conditions. The monitoring program consists of two sampling runs per year. On both runs field data is collected as well as samples being collected for laboratory analyses. The laboratory samples are collected in April and August, which allows to conditions of the lake prior to and during summer stratifications to be determined (in the August run samples are taken from both the epilimnion and hypolimnion, because of the isolating effects of stratification). Sampling is done on inflows to the lake, in the lake, and on lake outflows. The parameters tested for are as follows:

a. Field program. Vertical profiles of water temperature, dissolved oxygen, electrical conductivity, and pH are obtained with an electronic probe lowered by winch from a boat. Verifications of probe data is done by the use of simple field tests. These same simple field tests are used to obtain this data on the inflows to and outflows from the lake.

b. Laboratory program. The general classifications of data collected for and sampled in the laboratory consists of general chemical, nutrients, oxygen demand, heavy metals, pesticides, and the identification and enumeration of algae to serve as bioassay in determining any future trend toward blooms or eutrophication in the lake.

7-08. FISH AND WILDLIFE

Ongoing fish and wildlife management programs are accomplished with the advice of the U.S. Fish and Wildlife Service in cooperation with the California Department of Fish and Game. The Corps operates and maintains the project lands consistent with the annual hunting and fishing rules and regulations specified by California Fish and Game Commission. Two reservoirs on Stony Creek (Stony Gorge and Black Butte) support important self-sustaining warmwater fisheries and receive considerable recreational usage, particularly from March through June. A major problem for the maintenance of a fishery resource in all three reservoirs has been the lack of any provision for a firm minimum pool. As a result, these reservoirs were drawn down to critically low levels during the recent (1976-77) drought period.

Prior to construction of Black Butte Dam there was no significant year-round fishery within the project area. Although the area to be inundated was generally cleared of all trees during construction of the project, Butte Mountain Creek arm of the lake was left uncleared for fish habitat and the area is popularly known as "Fisherman's Cove". This area provides sufficient habitat to maintain a diverse aquatic community. Black Butte Lake provides an excellent warmwater fishery. The most important gamefish is white crappie, although white and channel catfish and largemouth bass are also taken in good numbers. Other common fish species in Black Butte Lake include smallmouth bass, bluegill, green sunfish, red-ear sunfish, and black crappie. Striped bass have been planted and spawning runs up Stony Creek have been recorded, but it is not known if the population is self-sustaining. Threadfin shad are very numerous in the reservoir, and are an important forage species for the gamefish. Large populations of non-game

fish are also frequent, including carp, Sacramento sucker and Sacramento squawfish.

A major concern for fishery management at Black Butte Lake is provision of stable water levels during a three-to-four week period in late spring for the production of crappie spawning habitat. With the cooperation of the U.S. Bureau of Reclamation (in distributing Stony Creek water among Black Butte, Stony Gorge and East Park reservoirs) the lake water level is regulated during the spawning season to provide optimum spawning conditions. General operating guidelines were set forth in a document entitled "General Operating Objectives Stony Creek Reservoirs", dated May 1971, a copy is enclosed as Exhibit B. The guidelines state that when the water surface temperature reaches 60 degrees Fahrenheit in the spring, the Black Butte storage level will be limited to a drawdown of 2 feet for a period of 3 weeks to facilitate the crappie spawning period. In order to accomplish this, a water exchange will be made with the Orland Unit Water Users' Association to replace water releases for Glenn-Colusa Irrigation District needs, or that required for a minimum release beyond the 2-foot allowable drawdown. At the request of California Department of Fish and Game this program has been expanded to include Stony Gorge Reservoir. Currently the drawdown is limited in Black Butte Lake in even numbered years and Stony Gorge Reservoir in odd numbered years in an attempt to establish a self-sustaining crappie fishery in both reservoirs.

Wildlife habitat around Black Butte Lake has been degraded by past grazing practices. Present Corps management of the forage resource has attempted to improve the habitat. The area surrounding the lake supports a large population of black-tailed deer. Other game species include California valley quail, mourning dove and black tailed jackrabbit. Black Butte Lake is heavily used as a nesting area by waterfowl and other waterbirds during winter and migratory periods. The area is also significant because of the regular presence of overwintering bald eagles. Other raptors include golden eagle, prarie falcon and red-tailed hawk, which may nest in the vicinity. The peregrine falcon has been observed occasionally. A blue heron rookery is located in riparian woodland downstream from Black Butte Dam. Other wildlife species include carnivores such as the coyote, gray fox, bobcat, racoon and numerous rodents. The stream habitat supports muskrats and beavers. The Squaw Point Wildlife area is presently being managed for deer habitat improvement. This program includes a discing and broadcast-seeding process utilizing lana vetch as a forage plant. The vetch is also expected to improve cover for upland game birds such as quail, dove, pheasant, wild turkey and others. To encourage game birds, "quail cribs" have been constructed to improve nesting habitat.

7-09. WATER SUPPLY

Irrigation development upstream from Black Butte Lake consists principally of relatively small areas supplied by direct diversion from the creek with no significant storage. The total of such areas is about 1,000 acres. Small amounts of water from Stony Creek are also used for domestic and stock purposes. Downstream from Black Butte Project, the principal Stony Creek service area is located within the area of the U.S. Bureau of Reclamation (USBR) Orland Project. About 18,000 acres in this project are irrigated by diversion from Stony Creek and by use of regulation at East Park and Stony Gorge Reservoirs.

All the space in Black Butte Lake not required for flood control, over and above minimum pool, will be made available for conservation of irrigation water. During the summer months this may be the entire active reservoir space, while during the winter months all available space may be required for flood control. Under Public Law 91-502, approved 23 October 1970, the conservation operation of Black Butte Lake was financially integrated with the USBR's Central Valley Project (CVP) and is coordinated operationally with the other storage units of the CVP. Irrigation water released from Black Butte storage is utilized by the Glenn-Colusa Irrigation District as part of that agency's contractual entitlement for purchase of up to 105,000 acre-feet of CVP water.

Black Butte Dam and Lake are operated in conjunction with Stony Gorge and East Park Reservoirs of the Bureau of Reclamation's Orland Project. However, no storage for Orland Project irrigation supplies is allocated in Black Butte Lake. Irrigation releases from East Park are routed through Stony Gorge Dam and then to Black Butte Lake, where the water is diverted to the Orland Project's South Canal or released to Stony Creek for diversion to Orland Project's North Canal. Stored water may be exchanged between East Park, Stony Gorge and Black Butte reservoirs in order to maximize the conservation utilization of the stored water.

7-10. HYDROELECTRIC POWER

The underlying concept for hydroelectric power generation at Black Butte Dam is that it will ordinarily be operable when releases from the reservoir are between 200 cfs and 1,000 cfs. All flows less than 200 cfs are to be released by the Corps through service gates No. 3 or No. 4 of the outlet works. At flows above 1,000 cfs but below 1,200 cfs, releases through the powerplant and service gate will be adjusted to assure no flows below 200 cfs are passed through the Corps service gates (gate openings of less than 0.5 feet will not be permitted). If the required release is greater than 1,200 cfs, the first available 1,000 cfs will flow through the powerplant and the excess through Corps service gates in the outlet works. The powerplant is currently scheduled to come on line in early 1988.

7-11. NAVIGATION

Navigation is not a project purpose, and there have been no navigation projects on Stony Creek.

7-12. OTHER

Drought Contingency Plan. During droughts, flood control is not expected to be a principle factor in the operation of Black Butte Lake. Conservation water and conservation space is managed by the U.S. Bureau of Reclamation as part of the Central Valley Project (CVP). During droughts the watermaster for the Sacramento Canals Unit of the CVP and the various groups he represents can be expected to conserve water to the best of their ability. During the 1976-77 drought, the watermaster, in conjunction with the Orland Unit Water User's Association, developed a plan to conserve water loss due to evaporation on the three Stony Creek Basin reservoirs (East Park, Stony Gorge, and Black Butte). The plan called for all water stored in East Park and Stony Gorge above minimum pool, or not required for use in the immediate area, to be transferred to Black Butte Lake to reduce the total water surface area exposed to evaporation.

Any information that the Corps of Engineers may have that would be beneficial to drought operation will be passed on to the watermaster of Sacramento Canals Unit of the CVP. In extreme cases it may be desirable to pump water from the Black Butte Lake below the outlet invert. It should be noted the project toilets and shower and sink fixtures are low flows or microflow types.

7-13. DEVIATION FROM NORMAL OPERATION

Occasional deviations from normal operation are expected. Except as discussed below any deviations from normal flood control procedures must be approved in advance by the District Engineer, Sacramento District, Corps of Engineers. Emergency and some minor deviations can be made at the discretion of the Park Manager.

a. Emergencies. Some deviations that can arise from emergency conditions include: drownings or other accidents; equipment or livestock in downstream channels; and failure of important operating facilities. The District Engineer, Sacramento District, Corps of Engineers, will be informed as soon as practicable of any emergency deviations.

b. Unplanned Minor Deviations. Unplanned instances not considered emergencies can also create needs for temporary minor deviations from the normal regulation of the reservoir. Construction activities usually account for the greatest part of these minor deviations. Typical construction activities include: utility stream crossings, bridge work, bank protection work and major construction projects. Changes in releases are sometimes necessary for maintenance and inspection. Requests for changes of release rates are generally given for a few hours to a few days. Each request is analyzed on its own circumstances. Consideration is given to upstream watershed conditions, flood potential, reservoir conditions and possible alternative measures. In the interest of maintaining good public relations, the requests are complied with providing there are no adverse effects on the overall operation of the project for the authorized purposes. The District Engineer will be informed, in advance, if possible, of all minor deviations proposed or anticipated.

c. Planned Deviations. Long-term deviations shall be analyzed on their particular circumstances and merits. Sufficient data on flood potential, reservoir and watershed conditions, alternative measures, expected benefits and probable effects on other projects will be presented by letter or telephone to the District Engineer, Sacramento District, Corps of Engineers along with recommendations for review and approval.

7-14. RATE OF RELEASE CHANGE

In order to permit evacuation of people, property, livestock, etc., in advance of rising water downstream and to minimize the formation of dangerous flood waves, the rate of change for an increase in release shall not be more than 2,000 cfs in any 2 hour interval. To minimize bank caving due to periods of high sustained releases and/or decreasing releases after extended periods of bankful flows, no level of release above 1,000 cfs shall be held for more than 18 hours. The rate of change for a decrease in release shall be as follows:

a. When existing release is between 15,000 cfs and 5,000 cfs, outflow shall be reduced in 1,000 cfs increments with no release sustained for less than 2 hours.

b. When existing release is between 5,000 cfs and 50 cfs, outflow shall be reduced in 500 cfs increments, with no release sustained for less than 2 hours.

Except during spillway operation (pool elevation above 473.5 MSL) described below, releases from Black Butte Lake will be limited insofar as possible to 15,000 cubic feet per second. Releases shall be made in accordance to the Release Schedule shown on the Flood Control Diagram Chart A-10.

VIII - EFFECT OF WATER CONTROL PLAN

8-01. GENERAL

The Black Butte Project regulates floodflows in the lower Stony Creek basin by controlling its releases to obtain the maximum practical reduction in flood damages. The flood control storage in Black Butte Lake is sufficient to control all floods of record as well as all other floods with more than 2 percent annual chance of occurrence to existing channel capacities below the dam.

Joint use storage in Black Butte Lake provides about 57,000 acre-feet of water. Storage will also provide for hydroelectric power generation after construction of a power plant scheduled for completion in 1988. The joint use storage provides a pool for recreation opportunities for an estimated current annual average of about 210,000 visits. Black Butte Lake creates local environment attractive to many species of birds and terrestrial wildlife as well as a habitat for large, diverse fish populations.

8-02. SPILLWAY DESIGN FLOOD

Design of the spillway, development and establishment of the dam crest and real estate acquisition lines were based on hypothetical routings of the Spillway Design Flood. Spillway Design Flood studies were initially prepared in 1951 and presented in the Sacramento District's Report "Black Butte Project, Development of Spillway Design Flood", dated June 1951. Storm precipitation amounts were based on an analysis of maximum possible precipitation developed by the Hydrometeorological Section of the former U.S. Weather Bureau. Soon thereafter, the Hydrometeorological Section was requested to review its Probable Maximum Precipitation estimate. However, there was not substantial change from the previous estimate, and the original Spillway Design Flood was retained.

A flood similar to the Spillway Design Flood would result from the combination of the most severe meteorologic and hydrologic conditions considered possible in the basin above the dam. The Probable Maximum Precipitation quantities furnished by the Weather Bureau were given a time distribution patterned after the storm of 31 January to 2 February 1915 in the Stony Creek basin and an areal distribution patterned after the distribution of the normal annual precipitation. The probable maximum antecedent snow cover was completely melted during the spillway design storm. The adopted unit hydrograph and loss rates were based on the April 1941 flood recorded on Stony Creek near Hamilton City, with appropriate adjustment of the unit hydrograph for the difference in location and the reservoir effect. Pertinent hydrologic parameters for the probable maximum event were:

Storm rainfall	12.70 inches
Snowmelt	4.21 inches
Excess (runoff)	11.15 inches
Peak inflow	154,000 cfs
Inflow volume	488,000 acre-feet

A hypothetical routing of the Spillway Design Flood through Black Butte Lake resulted in a maximum pool elevation of 509.8 feet MSL, with total maximum storage of 370,000 acre-feet according to original area-capacity-elevation curves, including 210,00 acre feet of surcharge storage (storage above gross pool). The outlet works were assumed closed until elevation 498.0 feet MSL, resulting in a maximum outflow of 98,600 cfs. Plate 20 presents hydrographs pertinent to the routing.

A revised Probable Maximum Flood was developed in 1980 for a spillway adequacy study. The Probable Maximum Precipitation (PMP) was computed using the procedures outlined in Hydrometeorological Report No. 36, dated 1961 (revised October 1969). The PMP was assumed to have been part of a large storm series with the standard project storm preceding the PMP. This storm series removed antecedent snow cover and saturated the basin resulting in low loss rates and filling of upstream reservoirs. To test the sensitivity of the basin storms; October, December, and January-February PMP's of 72-hour duration were calculated and applied to four different storm centerings. Probable Maximum Floods were compiled for the various centerings; unit hydrographs previously developed, and baseflow and loss rates derived from those observed during the 1964, 1965, and 1970 floods. The initial loss rate was 0.10 inches and the constant rate was 0.10 inches/hr. The upstream reservoirs, East Park and Stony Gorge, were assumed filled and able to pass peak inflow without overtopping. The most critical condition, a January-February storm centered over each sub-basin using individual area convergence PMP indices resulted in an average of 22.95 inches over the total basin. The peak of the resulting inflow was 243,000 cfs and a volume of 597,000 acre-feet. Hypothetical routings through Black Butte Lake indicate that minimum freeboard would be - 0.80 feet with an outflow of 164,000 cfs.

8-03. FLOOD CONTROL

The principal objective of the flood control plan is prevention of flooding in the agricultural, urban and suburban areas adjacent to Stony Creek. Economic and other considerations indicate that Black Butte Lake should give protection to the downstream agricultural area against a flood that can be expected to be exceeded on the average about once in 50 years and to the downstream urban areas of Orland and Hamilton City against the standard project flood. There is practically no local runoff contributing to Stony Creek below Black Butte Dam, and consequently a reservoir release of 15,000 cfs can be made without appreciable damage to agricultural areas. Also, a release of 40,000 cfs can be made without appreciable damage to urban areas. The present flood control space in Black Butte Lake is sufficient to control all the floods of record and meet the above requirements.

a. Standard Project Flood. A general rain standard project flood was developed to test the operation of Black Butte Lake under extreme conditions. A standard project flood (SPF) is one that can be expected from the most severe combination of meteorologic and hydrologic conditions characteristic of the geographic region, excluding extremely rare combinations. The derivation of the standard project flood for Black Butte Lake was based on methods and criteria presented in the report of the Sacramento District Corps of Engineers dated April 1957, entitled "Standard Project Rain Flood Criteria, Sacramento-San Joaquin Valley, California". The standard project storm used in that report is approximately equivalent to a

transposition of the November 1950 storm from the Sierra Nevada Mountains to the Stony Creek Basin. The adopted SPF is described in detail in Design Memorandum No. 1, Black Butte Project Stony Creek, California - Hydrology, dated May 1957.

The standard project rain flood at Black Butte Dam has a peak of 95,000 cfs and a 3 day volume of 254,000 acre-feet. Values for the standard project rain flood, major historical rain floods and the Spillway Design Flood are tabulated below. All values reflect unimpaired flows.

FLOOD	PEAK INFLOW (cfs)	RATIO to SPF	3-DAY VOLUME (acre-feet)	RATIO TO SPF
Standard Project	95,000	1.00	254,000	1.00
February 1909	50,000	0.53	122,000	0.48
February 1915	51,000	0.54	134,000	0.53
December 1937	60,000	0.63	102,000	0.40
February 1940	47,000	0.49	145,000	0.57
March 1941	39,000	0.41	148,000	0.58
December 1955	25,000	0.26	87,000	0.34
February 1958	39,000	0.41	95,000	0.37
December 1964	57,000	0.60	175,000	0.69
January 1970	37,000	0.39	112,000	0.44
March 1983	56,000	0.59	166,000	0.66
February 1986	52,000	0.55	173,000	0.68
Spillway Design	154,000	1.62	470,000	1.85

A hypothetical routing of the SPF is shown on Plate 21, along with hypothetical routing of the Reservoir Design Flood.

b. Reservoir Design Flood. The Reservoir Design Flood is discussed in detail in "Design Memorandum No. 1 Black Butte Project Stony Creek, California - Hydrology", dated May 1957. It was determined that under perfect operation, the maximum amount of space (155,000 acre-feet) that would be available for flood control purposes during the rain flood season would control 90 percent of the standard project flood series to a maximum release of 15,000 cfs without using surcharge storage (exceeding gross pool elevation) in the reservoir. Frequency data of ten-day runoff existing at that time indicated this volume was approximately equal to the runoff volume exceeded on the average of once in 100 years. However, allowing for operational contingencies, such as mechanical difficulties, unexpected downstream conditions including those on Sacramento River, and such other irregularities as have been commonly experienced at flood control projects in general it was concluded that the 155,000 acre-feet of space and 15,000 cfs release capacity could be relied on to control only a flood exceeded on the average of once in 50 years or about 75 percent of the standard project flood.

Under present operating conditions for Black Butte the maximum amount of space available for flood control is 137,000 acre-feet. Routing the Reservoir Design Flood (90% of Standard Project Flood) through Black Butte Lake results in the use of the 137,000 acre-feet plus an additional 46,000 acre-feet of surcharge storage. Maximum storage obtained was 190,000 acre-feet, elevation 483.1 feet MSL, with a combined outflow of 15,000 cfs

through the outlet works and spillway. A balanced 50 year 12-day series rain flood was developed based on the frequency curve for unregulated rain floods at Black Butte Dam and routed through Black Butte Lake under existing operating conditions. The routing showed that a 50-year event could be controlled to 15,000 cfs release with a minimal use of surcharge storage (5,000 acre-feet).

Thus with the use of the maximum 137,000 acre-feet flood control space at Black Butte Lake it will fill to the spillway crest or above an average of once every 12.5 years, spill 15,000 cfs or more once every 60 years and exceed the channel capacity (40,000 cfs) thru Orland about once every 400 years on the average.

c. Historical Floods. Hypothetical operations of the historical December 1964-January 1965, January 1970, and January-April 1974 rain floods are shown on Plate 21. Historical operation of the March 1983 and February 1986 rain floods are also shown on the same plate.

8-04. RECREATION

Annual visitation records were started for Black Butte Lake in 1964 when 107,000 recreation days were recorded. Since 1964, visitation has fluctuated considerably with the highest annual visitation, 348,400 recreation days, recorded in 1983. Annual visitation from 1964 through 1984 is shown in Table 18.

TABLE 18
ANNUAL VISITATION

YEAR	ATTENDANCE IN RECREATION DAYS
1964	107,600
1965	155,800
1966	213,400
1967	179,700
1968	148,800
1969	136,900
1970	156,400
1971	232,300
1972	222,300
1973	170,500
1974	161,600
1975	248,000
1976	243,200
1977	183,800
1978	243,300
1979	133,600
1980	180,200
1981	290,300
1982	333,500
1983	348,400
1984	324,500
Total 1964 - 1984	4,418,100
Average 1964 - 1984	210,400

Combined data from Corps of Engineers recreation use surveys conducted between 1983 and 1985 indicate the pattern of use at Black Butte Lake as shown in the following tabulation:

Parameter	Value
Average number of people per vehicle	2.5
Percentage of visitors camping	13.5
Percentage of visitors picnicking	20.5
Percentage of visitors boatring	6.4
Percentage of visitors waterskiing	12.1
Percentage of visitors fishing from boat	10.5
Percentage of visitors fishing from shore	16.5
Percentage of visitors swimming	25.2
Percentage of visitors ORV riding	0.2
Percentage of visitors hiking	1.9
Percentage of visitors other	7.2
Percentage of visitors sightseeing[1/]	24.0
Length of camping stay per party	2.7 days
Length of day use stay per party	2.6 days
Percentage of visitors residing within:	
0-25 Miles	49%
26-50 miles	25%
51-75 miles	4%
70-100 miles	.7%
Further than 101 miles	21.3%

1/ Persons sightseeing are not participating in any other activity.

Over 80 percent of annual visitation occurs during a five-month recreation season (March 15 - August 15). The peak weekend is traditionally Memorial Day while other holidays such as Fourth of July and Labor Day also have a high attendance.

8-05. WATER QUALITY

The water control plan for Black Butte Lake has had minimal adverse impact on Stony Creek and Black Butte Lake water supply. Black Butte Lake normally stays relatively shallow during the summer months. Vertical temperature profiles indicate that the lake remains thermally unstable or weakly stratified and is easily mixed vertically by winds and diurnal heating and cooling. The waters are warm throughout the depths during the summer, providing for a warm fishery. The water temperatures of the inflow to and the outflow from the lake show that because of summer mixing in the lake the outflow water temperatures do not remain cool during the summer, but follow the rise and fall of the season air temperatures. This would seem to preclude setting the stream reach below Black Butte Lake as a potential coldwater habitat, because of natural conditions not related to the operation of the lake. Although dissolved oxygen concentration at the lake's bottom often gets as low as 2-3 mg/l in the summer, anaerobic conditions do not occur because of the oxygenation provided by the mixing.

Turbidity is an occasional problem in the lake, with spring turbidities at 1-2 foot Secchi depths and summer turbidities at 4-5 feet Secchi depths. A Secchi depth of four feet is the recreational criteria set by the Environmental Protection Agency (EPA). The low-level release of turbid waters from upstream reservoirs, plus the vertical mixing at Black Butte reservoir, produces this turbidity. Turbid waters reduce photosynthetic activity and thereby reduces the amount of food available to a fishery, and additionally makes the water less appealing and less safe for body contact sports.

Salt, pesticides and heavy metal concentration are below the EPA criteria; the exception being mercury. Normally mercury in both April and August sampling exceed the 1980 EPA standards for human health, as well as the EPA standards (24 hour and maximum concentrations for freshwater aquatic life). However, the standard for human health protection applies to drinking water only in areas where populations consume mercury-contaminated fish. Should contaminated fish not be eaten, then the drinking water mercury standard reverts to 2.0 umg/l, which also equals the State of California drinking water standard, and Black Butte water meets this criteria. The electrical conductivity values show that the salt content of the water is satisfactory for irrigation of all types of crops. Salt concentrates in the lake are highly reflected by summer evaporation because of the shallow water depths involved. For example, it is not uncommon for the salt concentration in the water to double from April to August samplings. Evaporation can account for about 10 percent of this increase in salt concentration, while high salt concentration in Spring-Summer inflows account for the rest. Table 19 gives the results of the Black Butte Project Chemical Analysis of Water Samples for 1983.

8-06. FISH AND WILDLIFE

Wildlife habitat around Black Butte Lake had been degraded by past grazing practices. The intensive grazing pressure for well over 100 years caused considerable cropping and elimination of shrubs and oak seedlings. This intensive grazing has been eliminated with purchase of the land by the Corps of Engineers. Twenty years of sound range management practices has increased the quality of forage and improved the wildlife habitat. Annual range surveys will be conducted until grazing is eventually phased out. These surveys provide the basis of determining the numbers of animal unit months that will be permitted to graze project lands and not result in detrimental impact to wildlife habitat and native vegetation regeneration.

Creel census are undertaken at irregular intervals at Black Butte, Stony Gorge and East Park reservoirs to provide information on the effectiveness of the fishery management program. Creel census indicate that current management program of providing optimum spawning conditions between Black Butte and Stony Gorge reservoirs on an alternate year basis by holding the selected lake level constant during the crappie spawning season has proved to be effective.

BLACK BUTTE PROJECT

CHEMICAL ANALYSIS OF WATER SAMPLES
1983

Location		Lake Surface	Lake Bottom		Stony Creek Outflow		N. Stony Creek Nr. Newville	Stony Creek Nr. Fruto	
		August *	April	August	April	August	April**	April	August
Total Dissolved Solids (TDS)	Milgms/1	–	160	183	182	188	306	150	218
Total Suspended Solids (TSS)	"	–	13	37	<1	37	11	<1	55
Volatile Suspended Solids (VSS)	"	–	<1	<1	<1	<1	<1	<1	2
Bicarbonate (HCO_3)	"	–	70	156	72	163	158	58	143
Total Iron (Fe)	"	–	<0.10	1.09	0.08	0.99	<0.01	<0.01	1.72
Dissolved Iron (Fe)	"	–	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Manganese (Mn)	"	–	<0.01	0.07	<0.01	0.06	<0.01	<0.01	0.09
Dissolved Manganese (Mn)	"	–	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Boron (B)	"	–	<0.01	0.09	<0.01	0.11	<0.01	<0.01	0.30
Dissolved Silica (SiO_2)	"	–	<1	<1	<1	<1	<1	<1	<1
Sodium (Na)	"	–	8	16	7	7	19	4	21
Calcium (Ca)	"	–	38	33	32	33	46	41	43
Magnesium (Mg)	"	–	14	18	14	15	54	8	20
Potassium (K)	"	–	<0.1	1	<0.1	<1	<0.1	<0.1	1
Heavy Metals									
Copper (Cu)	"	–	0.005	0.018	–	–	0.006	0.007	0.018
Zinc (Zn)	"	–	0.026	0.030	–	–	0.036	0.038	0.030
Lead (Pb)	"	–	0.028	0.044	–	–	0.018	0.025	0.039
Cadmium (Cd)	"	–	0.0009	0.0021	–	–	0.0021	0.0016	0.0018
Mercury (Hg)	"	–	0.0008	0.0007	–	–	0.0002	0.0008	0.0006
Chromium (Cr)	"	–	0.010	0.023	–	–	0.010	0.011	0.020
Organic Nitrogen	"	1.77	0.88	0.58	0.91	1.20	3.08	1.19	0.80
Nitrate (N)	"	0.04	0.07	0.14	0.03	0.07	0.24	0.03	0.40
Ammonia (N)	"	0.01	0.03	0.02	0.03	0.01	0.03	0.02	0.03
Chemical Oxygen Demand (COD)	"	–	–	–	–	–	6	5	<1
Chlorinated Hydrocarbons	Microgms/1	–	–	–	–	–	–	N.F.	N.F.

NOTES:
* Sample not taken in April
** Sample not taken in August, stream is dry
N.F. - None Found

8-07. WATER SUPPLY

Under natural conditions, a large portion of annual runoff of Stony Creek can occur during one or more relatively short flood events. In addition, the need for water exists during late spring and the summer, while nearly all annual natural runoff occurs from late fall through early spring. Moreover, annual natural runoff is highly variable, and relatively dry periods, when annual runoff is less than annual demand, can occur over periods of several years. Black Butte Lake has no storage dedicated to conservation but must rely on joint use space in conjunction with flood control. Thus the reservoir has limited ability to carry over storage from year to year. Studies performed during the planning stages of the Black Butte Project, and since concurred on by the Bureau of Reclamation in real time operation, indicate that Black Butte Lake makes available, on the average, 57,000 acre-feet of new water annually for irrigation and related purposes.

8-08. HYDROELECTRIC POWER

The project proposed under the Federal Energy Regulatory Commission License makes no change in the storage capacities of Black Butte Lake and does not alter the timing or quantity of releases from Black Butte Lake. Its principle purpose is to use the current releases mandated for downsteam appropriation, flood control, and other uses to generate power. All water diverted by the proposed power plant will be returned to the river immediately downstream of the power plant. The current capabilities to operate for flood control will not be changed by the proposed power development. The estimated average annual generation is 15.4 X 10^6 KWH. The actual output will be in accordance with the best efficiency to suit available water conditions.

8-09. NAVIGATION

None.

8-10. FREQUENCIES

a. Unregulated Flow Frequencies. Unregulated flows and statistical parameters for Stony Creek at Black Butte Dam for rain floods are tabulated on Plate 22. Flow frequency curves for peak, 1 day, 3 day, 10 day and 30 day flows for rain floods are shown on Plate 23. The statistics were computed using the HEC Regional Frequency program. The unregulated frequency curves were based on both actual records and the conversion of difference of storage in East Park, Stony Gorge and Black Butte reservoirs. Data prior to 1944 was taken from "Design Memorandum No.1 Black Butte Project Hydrology" dated May 1957. Water year 1977 qualified as a low outlier and thus removed from the statistics.

b. Peak Flow Frequencies Project Condition. Peak flow frequency curves for Stony Creek below Black Butte Dam for project conditions for rain floods are shown on Plate 24. The curves reflects operation of Black Butte Dam for the period 1963-1986 which includes both dry and wet periods and is representative of a longer period of record. In order to extend the flow frequency curves to include very rare events, such as one percent and rarer floods, hypothetical floods were routed through Black Butte Lake.

c. Stage - Frequency Curves. A stage - frequency curve is shown on Plate 25, and a stage-duration curves are shown on Plate 26. The seasonal variation of reservoir storage frequency curve is shown on Plate 27. The level of storage is highest in the spring at the beginning of the recreation season (May - September) as a result of storing runoff for water supply and flood control. Subsequent releases made through the summer for water supply and downstream rights draw the reservoir system down for the beginning of the winter flood season.

d. Operation Record. The official record of Black Butte Lake is published in Water Supply papers of the U.S. Geological Survey.

Operation of Black Butte Dam began in October 1963 and is shown on Plate 28. A record of flood control requirements and storage and flows pertinent to flood control operation is contained in monthly reports submitted to Chief of Engineers by the District Engineer, Sacramento District, Corps of Engineers, Sacramento, California.

e. Key Control Points. Rating curves for key control points at South Diversion Canal, and Stony Creek Below Black Butte Dam are shown on Charts A-5 and A-6, respectively.

8-11. OTHER STUDIES

The Corps of Engineers does not have in progress or planned for immediate future, any studies in the Stony Creek basin.

IX - WATER CONTROL MANAGEMENT

9-01. RESPONSIBILITIES AND ORGANIZATION

The primary responsibilities for operating Black Butte Lake are delegated to units of the Engineering Division and Construction-Operations Division of the Sacramento District, Corps of Engineers, as outlined below. Names, addresses, and telephone numbers of those individuals whose responsibilities are outlined in the following paragraphs are given on the personnel sheet in front of this manual.

a. The Hydrology Section, Engineering Division, Corps of Engineers

(1) Obtain current hydrometeorogical data and weather forecasts for the region.

(2) Maintain hydrologic equipment and supervise its operations.

(3) Supervise a program of water quality and sediment measurement.

b. The Reservoir Control Section, Engineering Division, Corps of Engineers

(1) Analyze current reservoir and hydrologic data, determine schedule under which the reservoir shall be operated and issue appropriate operating instructions to the reservoir operators (except for day-to-day conservation operation).

(2) Prepare monthly operation and other special reports relative to the operation of the reservoir.

(3) Advise the District Engineer whenever there has been an unavoidable departure from the operating rules, or when there is a need for making temporary modification of these operating rules.

(4) Staying informed at all times of downstream channel conditions by making periodic field inspections.

(5) Make and distribute the necessary revisions to this Water Control Manual.

c. The Park Manager, Construction-Operations Division, Corps of Engineers

(1) Keep well informed of the operating rules contained in this Water Control Manual and bring to the attention of the Reservoir Control Section any feature of the manual that may require clarification or revision.

(2) Keep familiar with the operation of all recording and communication equipment.

(3) Accomplish the physical operation of the reservoir in accordance with instructions contained in this Water Control Manual or issued by the Reservoir Control Section. During storms, this may require 24-hour attendance at the dam.

(4) Calculate and maintain a record of inflows, outflows, storage, weather data, and other data specified by the Reservoir Control Section.

(5) Report data required in 9-05 and Exhibit A to the Reservoir Control Section daily or as required.

(6) Report to the Reservoir Control Section any unusual conditions which might interfere with the planned operation of the reservoir.

(7) Maintain a log of gate or valve operation to include the date, time, and water surface elevations when such changes were made, and initials of the individual making the change.

(8) Make and record weekly checks on reservoir and outflow gage readings to assure proper operation of all recording equipment.

(9) Obtain samples for water quality and sedimentation analysis as required.
(10) Immediately after end of each month, transmit to Reservoir Control Section data specified in paragraph 9-05.
(11) Make emergency gate changes when contact with the Reservoir Control Section is broken and a clearly defined change occurs that warrants immediate action.
(12) Maintain a record of instructions received from Reservoir Control Section; and requests received from the U.S. Bureau of Reclamation, Orland Unit Water Users' Association; Glenn-Colusa Irrigation District and the City of Santa Clara.

d. Operations Branch, Construction-Operations Division, Corps of Engineers
(1) Budgeting project operation and maintenance funds.
(2) Maintenance of project hydrometeorolgical stations. (This is partly accomplished by the Hydrology Section, Engineering Division).

e. Central Valley Project Operations (CVPO), U.S. Bureau of Reclamation
(1) Is responsible for overall coordination of scheduling of conservation releases from Black Butte Lake.
(2) Watermaster for Sacramento Canals Unit, CVPO located in Willows, will normally convey release schedule directly to Black Butte Project Office.

f. Orland Unit Water Users' Association
(1) Project Manager is responsible for scheduling required Orland Project releases through the South and North Diversion Canals.
(2) Is responsible for providing demand schedule from Black Butte Lake, to Sacramento Canals Unit CVPO Watermaster at Willows Office.
(3) Orland Project personnel will regulate outflow from Stony Gorge and East Park Reservoir and the North Diversion Dam outlet works.
(4) Orland Project personnel will, when necessary, operate the Black Butte power plant for the City of Santa Clara.

g. Glenn-Colusa Irrigation District.
(1) District personnel will provide flow requirements to Sacramento Canals Unit CVPO Watermaster at Willows Office.
(2) The District will construct the gravel diversion dam across Stony Creek in the spring (end of flood season) and remove at the start of the flood season in the fall.

h. City of Santa Clara
(1) City personnel will remotely operate the power facilities.
(2) Based upon flow requirements provided by the Corps and/or the water users, determine and set the respective flow rates through the turbines.

9-02. INTERAGENCY COORDINATION

To insure that the operation of Black Butte Project is effective as possible, it is essential that the Corps of Engineers be continually advised of all conditions with potential effects on operation. This is particularly important during flood control operations; when conditions often change rapidly, and anticipated conditions have important implications for current actions.

Flood control operations require close cooperation between the Corps of Engineers, the National Weather Service, California Department of Water Resources, and local downstream interests. Communications among these agencies is often needed hourly.

Operation involving water supply normally require close cooperation between the U.S. Bureau of Reclamation, Orland Unit Water Users' Association, Glenn-Colusa Irrigation District, and the Corps of Engineers.

9-03. INTERAGENCY AGREEMENTS

None.

9-04. COMMITTEES AND COMPACTS

None.

9-05. REPORTS

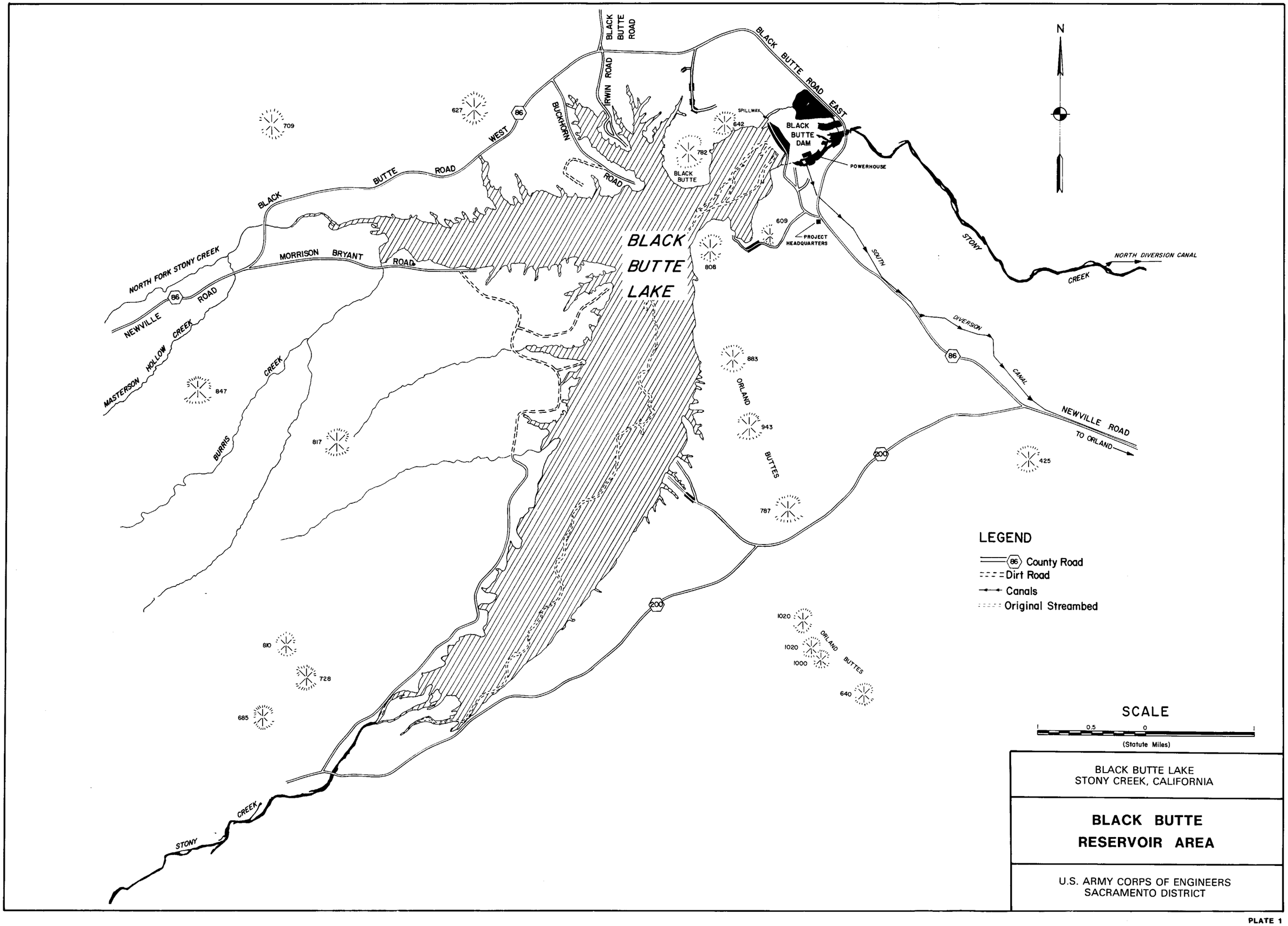
a. The reservoir operator shall report the following data via the Hydrologic Automatic Data Acquisition Network to the Reservoir Control Section each day prior to 0730 hours:

(1) Reservoir stage as of midnight.
(2) Reservoir stage as of 0700 hours.
(3) Pan evaporation as of 0700 hours.
(4) Daily precipitation at the dam as measured at 0700 hours.
(5) East Park Reservoir storage for current day.
(6) Stony Gorge Reservoir storage for current day.
(7) Stony Gorge Release for current day.
(8) Downstream Glenn Colusa Irrigation District demand to Stony Creek.
(9) Climate anemometer reading.
(10) Minimum temperature observation previous day at Black Butte Dam.
(11) Maximum temperature observation previous day at Black Butte Dam.
(12) Stage Stony Creek below Black Butte stream gage as of 0700 hours.
(13) Stage South Diversion below Dam stream gage as of 0700 hours.
(14) Flow diverted by Wackerman Ranch Diversion.

b. More frequent reports of the above information and reports of other data will be made in the same manner when requested by Reservoir Control Section.

c. Within 10 days after the end of each month, the Park Manager will send to the Reservoir Control Section all original forms used for observations and computations.

d. The Reservoir Control Section shall prepare monthly operations and other special reports relative to operation as required by the Chief of Engineers, and other reports as required for operational purposes.



LEGEND

- 86 County Road
- Dirt Road
- Canals
- Original Streambed

SCALE

1 0.5 0 1

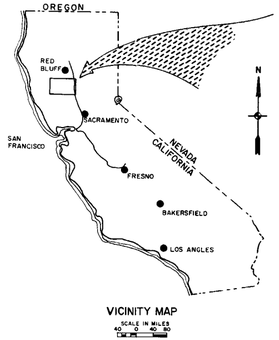
(Statute Miles)

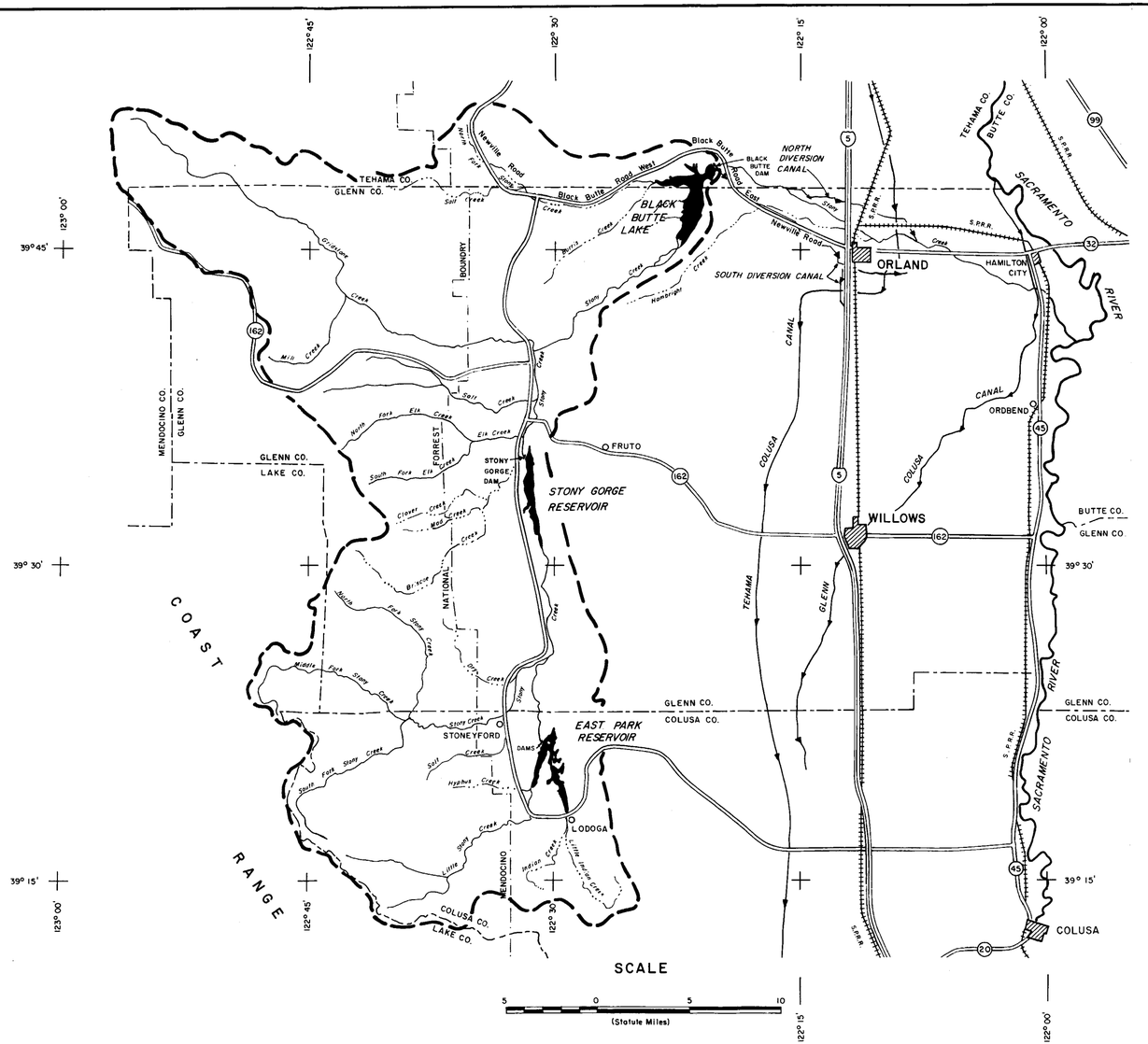
BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

BLACK BUTTE RESERVOIR AREA

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 1





LEGEND:

- Basin boundary
- County boundary
- (5) Interstate highway
- (32) State highway
- Railroad
- Intermittent stream
- Perennial stream
- Canal
- Reservoir

BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

GENERAL MAP

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 2

PLATE 3

PLATE 4

PLATE 5

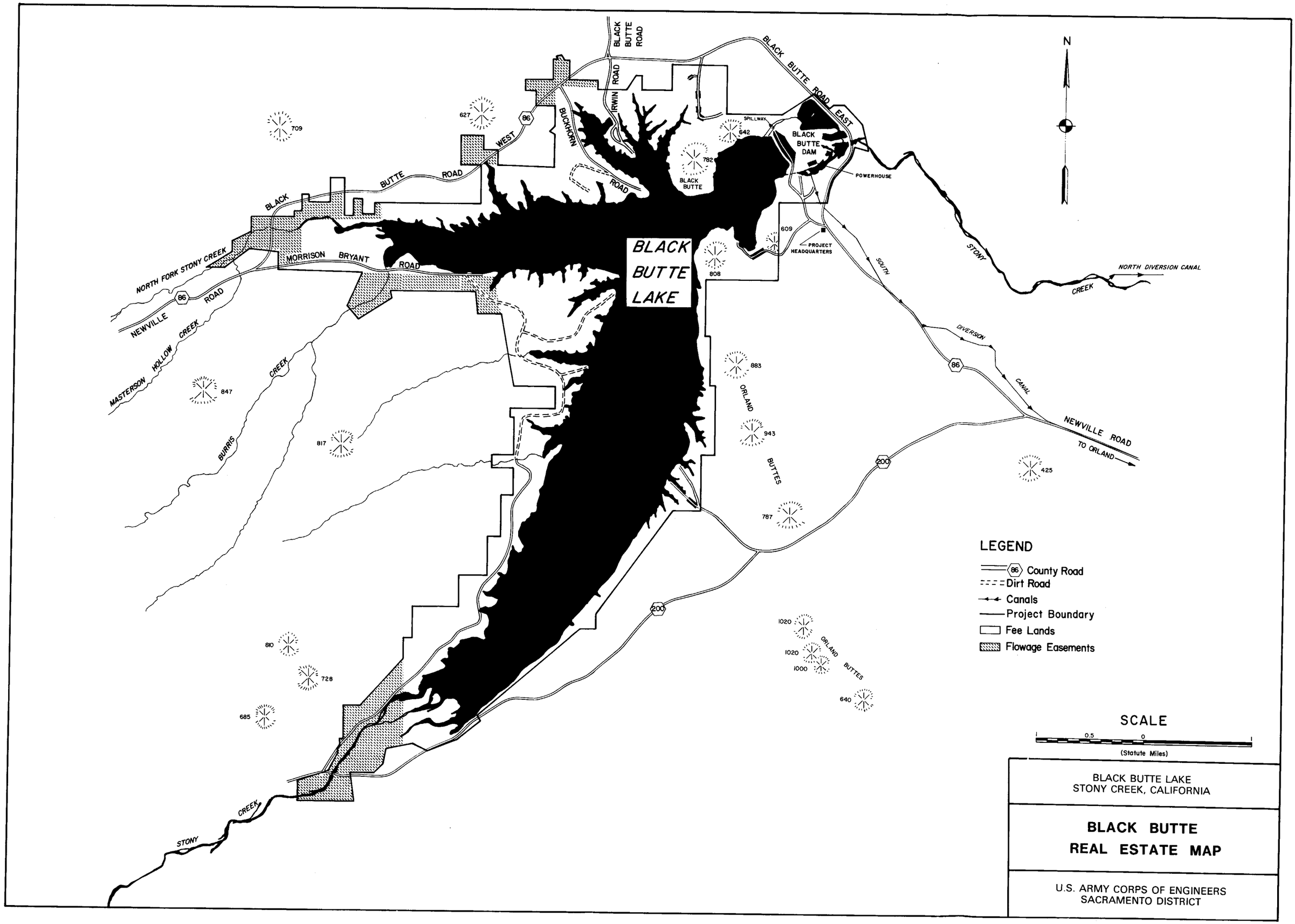
PLATE 8

PLATE 9-1

PLATE 9-2

PLATE 9-3

PLATE 9–4



LEGEND

- 86 County Road
- Dirt Road
- Canals
- Project Boundary
- Fee Lands
- Flowage Easements

SCALE

1 0.5 0 1

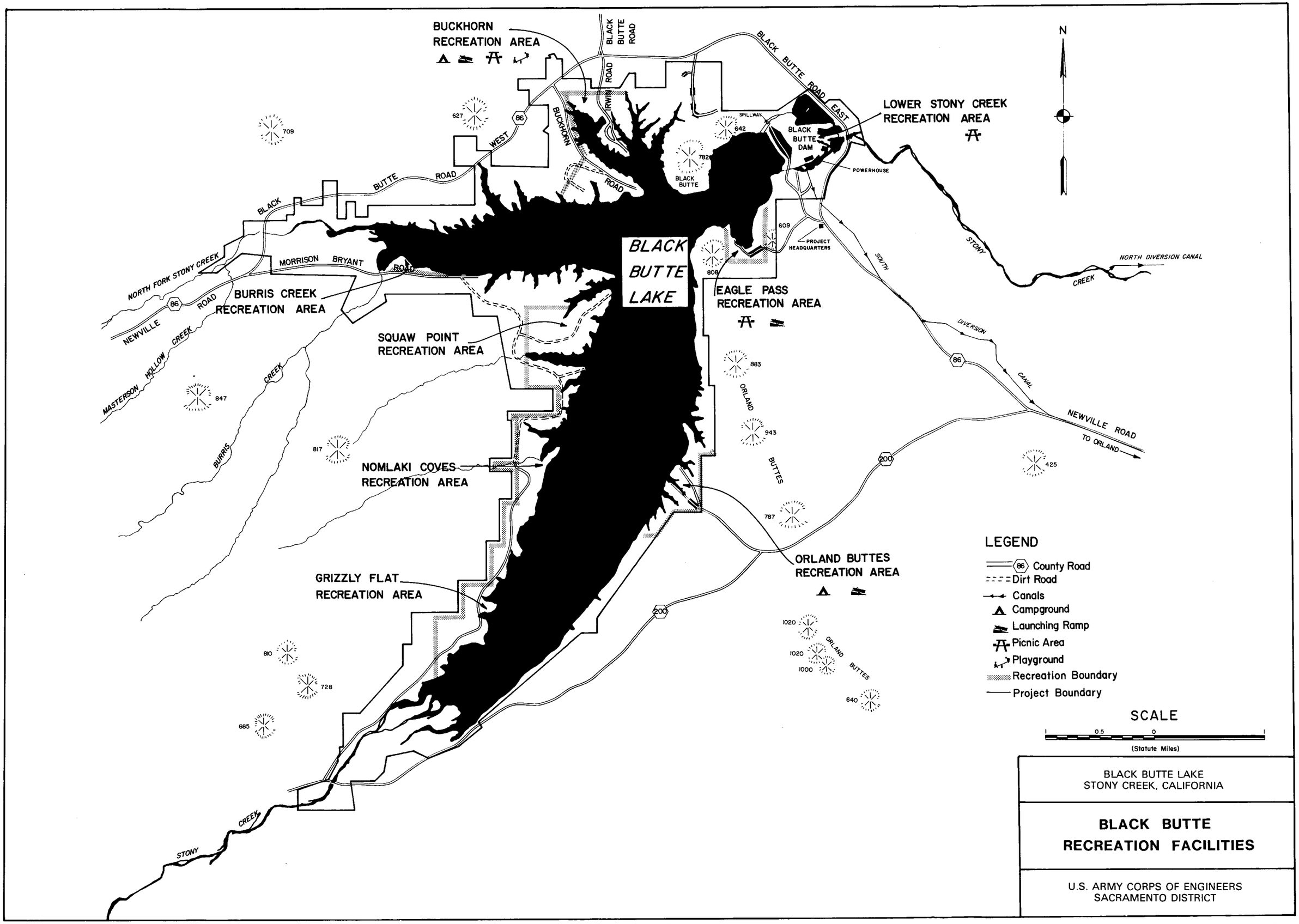
(Statute Miles)

BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

BLACK BUTTE REAL ESTATE MAP

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 10

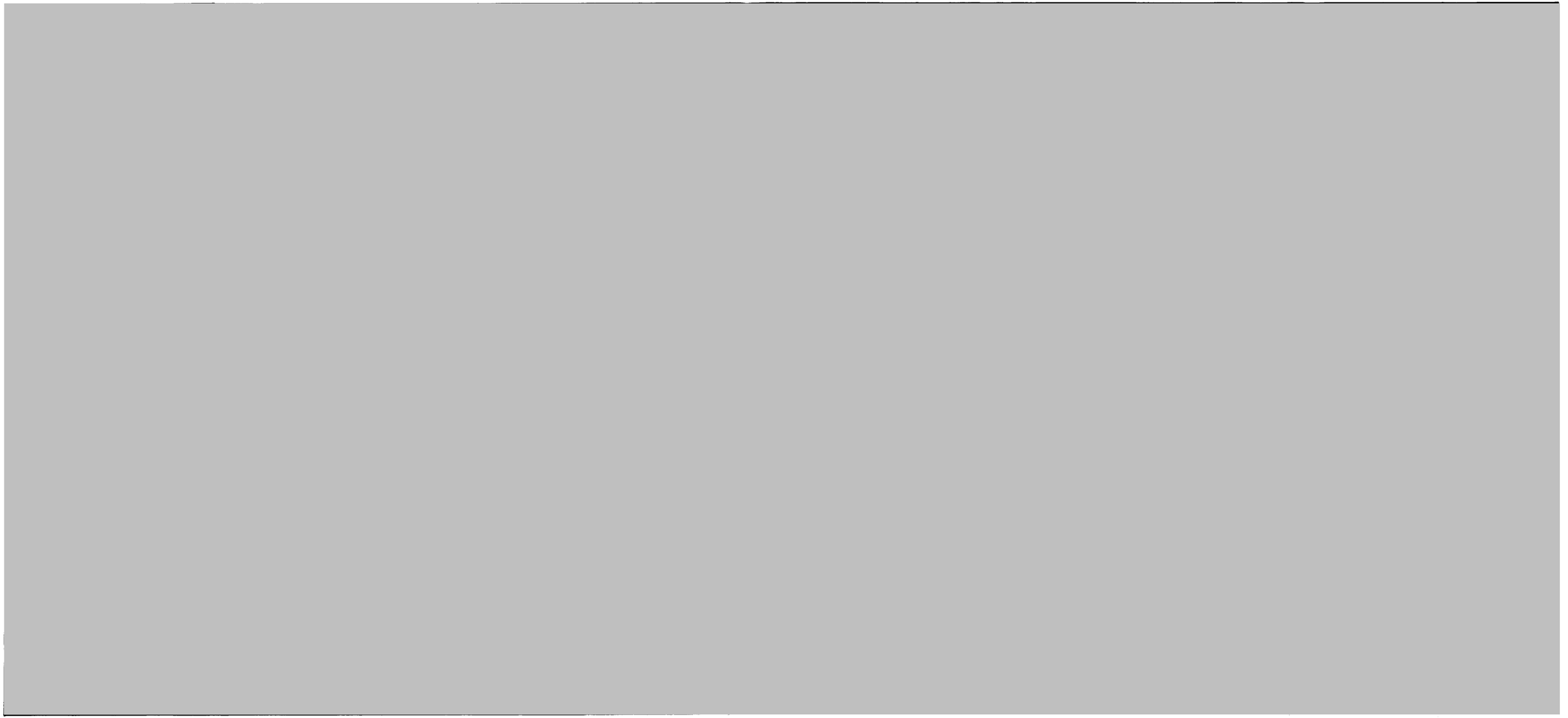


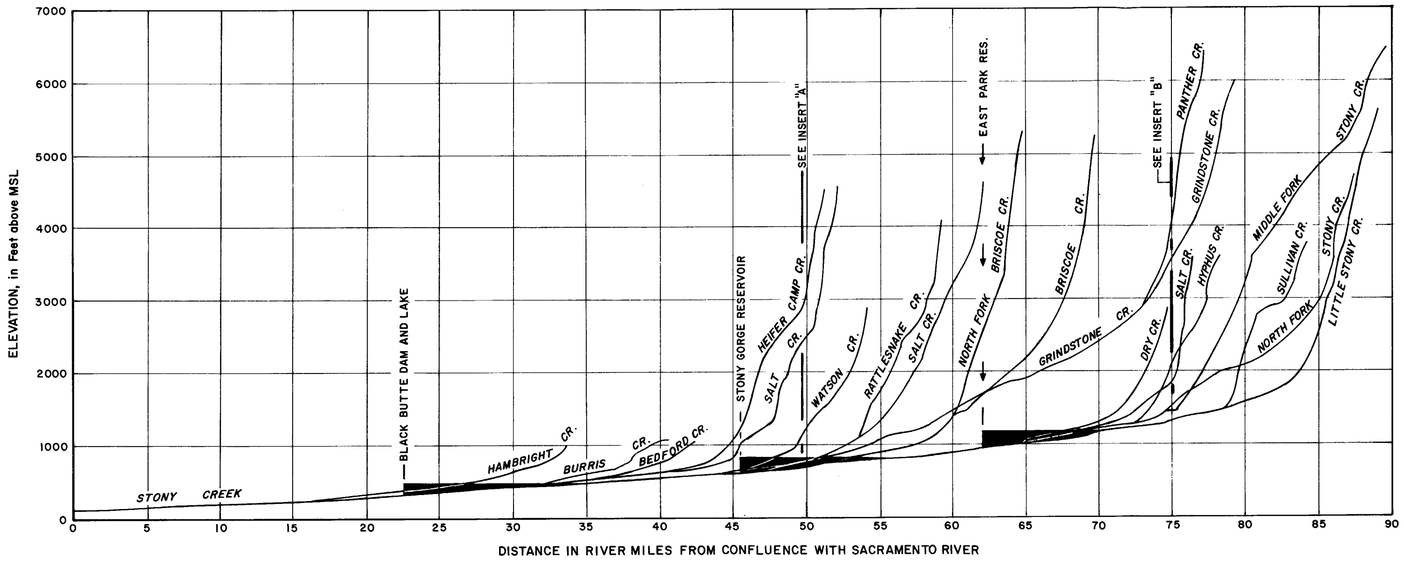
BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

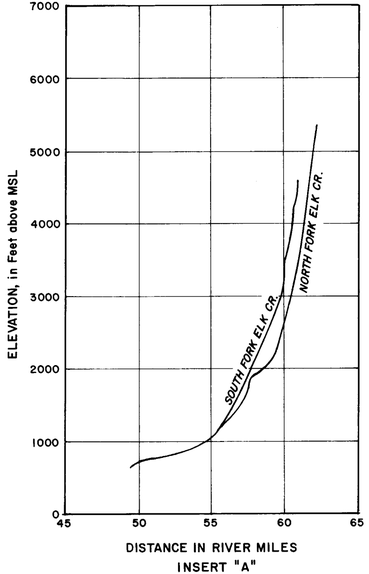
BLACK BUTTE RECREATION FACILITIES

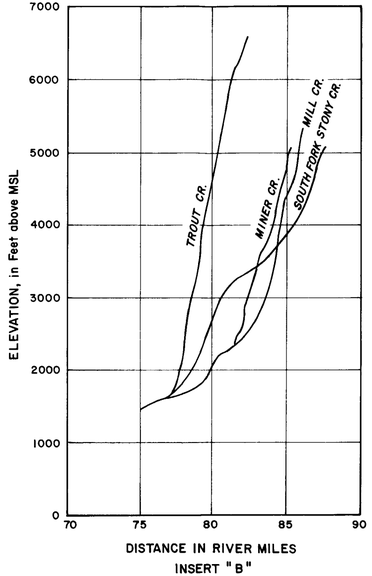
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 11





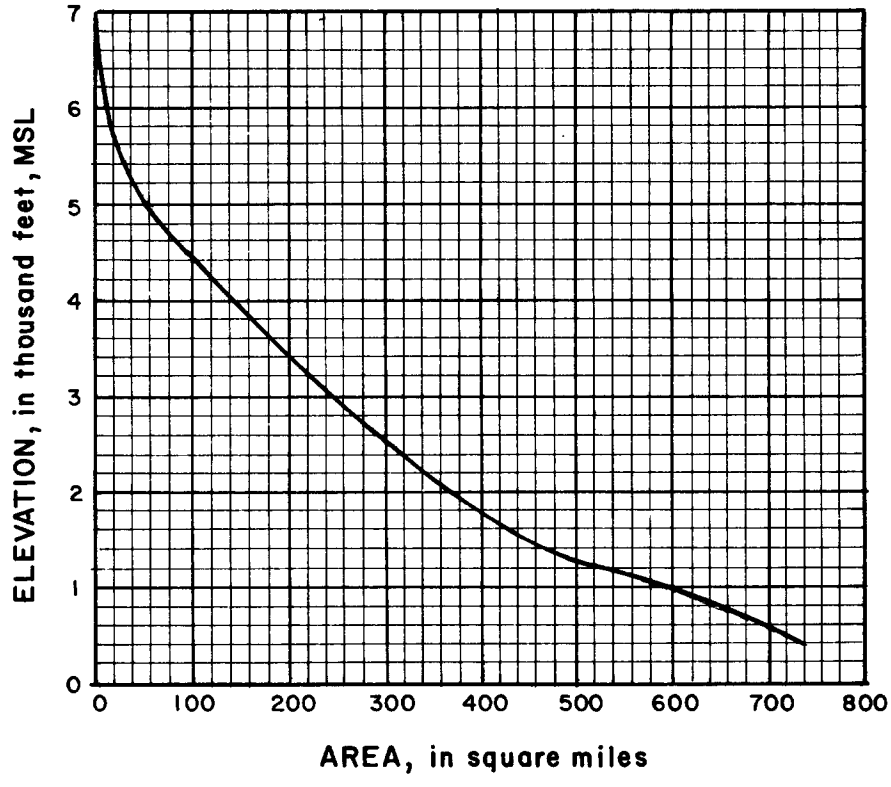




BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

STREAM PROFILES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

AREA - ELEVATION CURVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

CLIMATOLOGICAL STATIONS

Index No.	Stations	Elev in Feet	Type of Gage	Location				Records	
				Latitude		Longitude		Began in	Agency in Charge
				Deg.	Min.	Deg.	Min.		
8587	Stony Gorge Resv.	770	◐	39	35	122	32	1926	NWS
A30084011	Black Butte Dam	425	◆	39	45	122	20	1960	USCE
8580	Stonyford Resv	1168	○	39	23	122	32	1918	NWS
2640	East Park Resv	1205	◇	39	22	122	31	1910	NWS
8578	Stonyford Cooley Rch.	3020	○	39	15	122	39	1935	NWS

LEGEND FOR CLIMATOLOGICAL STATIONS

NWS — National Weather Service
USCE — US Army Corps of Engineers
◐ Recording Precipitation and Temperature
◆ Recording Precipitation Temperature and Evaporation
◇ Non-recording Precipitation and Temperature
○ Non-recording Precipitation

SNOW COURSE

Index No.	Station Name	Elevation (Feet, MSL)	Type of Gage	Location				Record Began	Measurement Dates*	Measured By	Average 1 Apr Water Content (Inches)
				Latitude		Longitude					
				Deg.	Min.	Deg.	Min.				
62	Anthony Peak	6200	●	39	51	122	57	1944	2, 3, 4	Covelo Dist. Ranger	29.3

LEGEND FOR SNOW COURSE:

● Snow Course

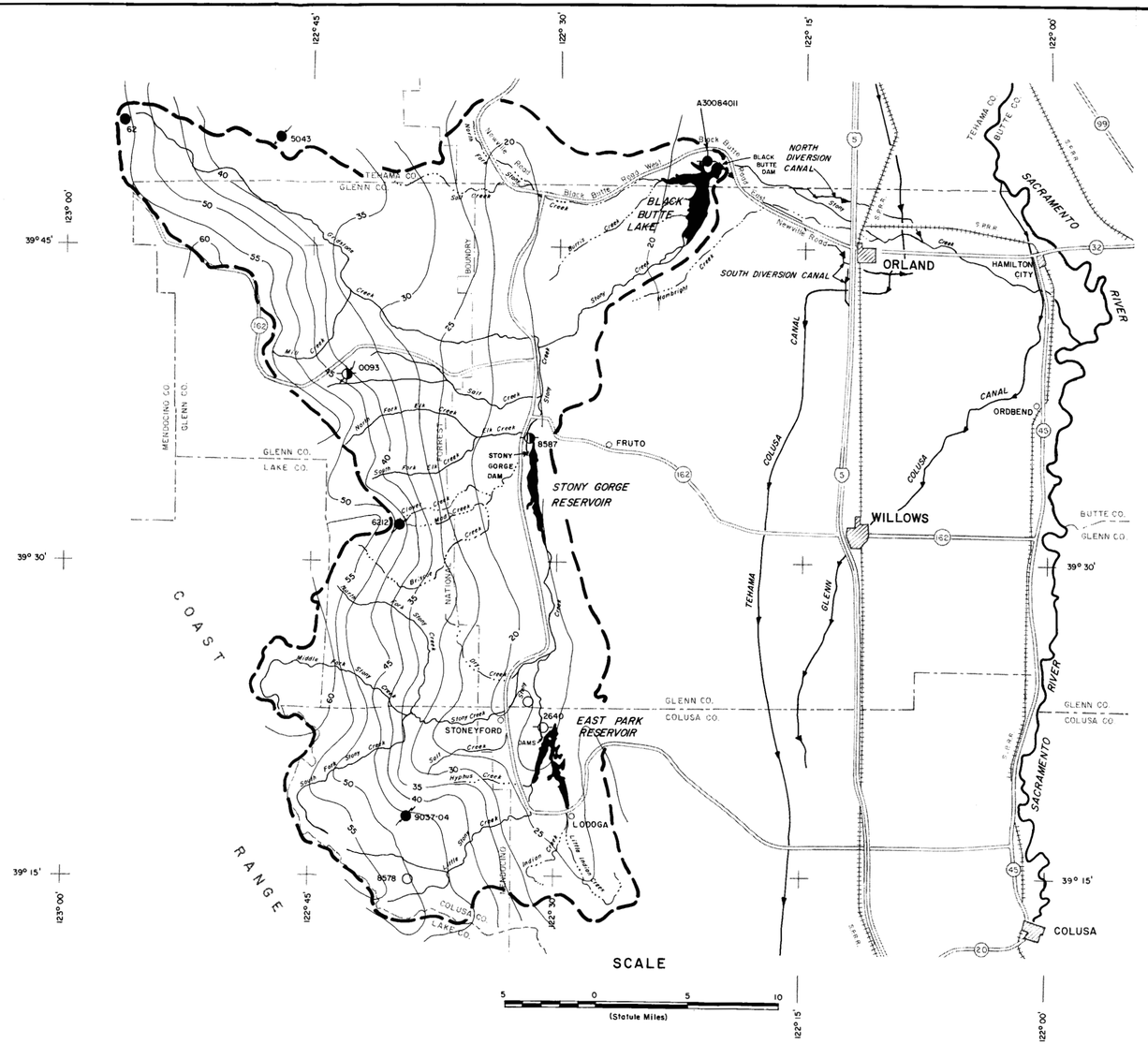
* Numbers indicate dates of scheduled observation: 1 — On or about 1 January. 2 — On or about 1 February. 3 — On or about 1 March. 4 — On or about 1 April, etc.

PROJECT HYDROMET STATIONS

Index No.	Stations	Elevation (Feet, MSL)	Type of Gage	Location			
				Latitude		Longitude	
				Deg.	Min.	Deg.	Min.
0093	Alder Springs	4440	⚡	39	39	122	43
5043	Log Springs	5050	⚡	39	50	122	47
6212	Noel Springs	5000	⚡	39	32	122	40
9037-04	Trough Springs	4000	⚡	39	18	122	39

LEGEND FOR PROJECT HYDROMET STATIONS:

⚡ Radio-reporting precipitation.
⚡ Radio-reporting, precipitation and temperature



LEGEND:

- Basin boundary
- County boundary
- (5) Interstate highway
- (32) State highway
- Railroad
- Intermittent stream
- Perennial stream
- Canal
- Reservoir
- 20" Isohyets

BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

Normal Annual Precipitation, Climatological Stations and Snow Course

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

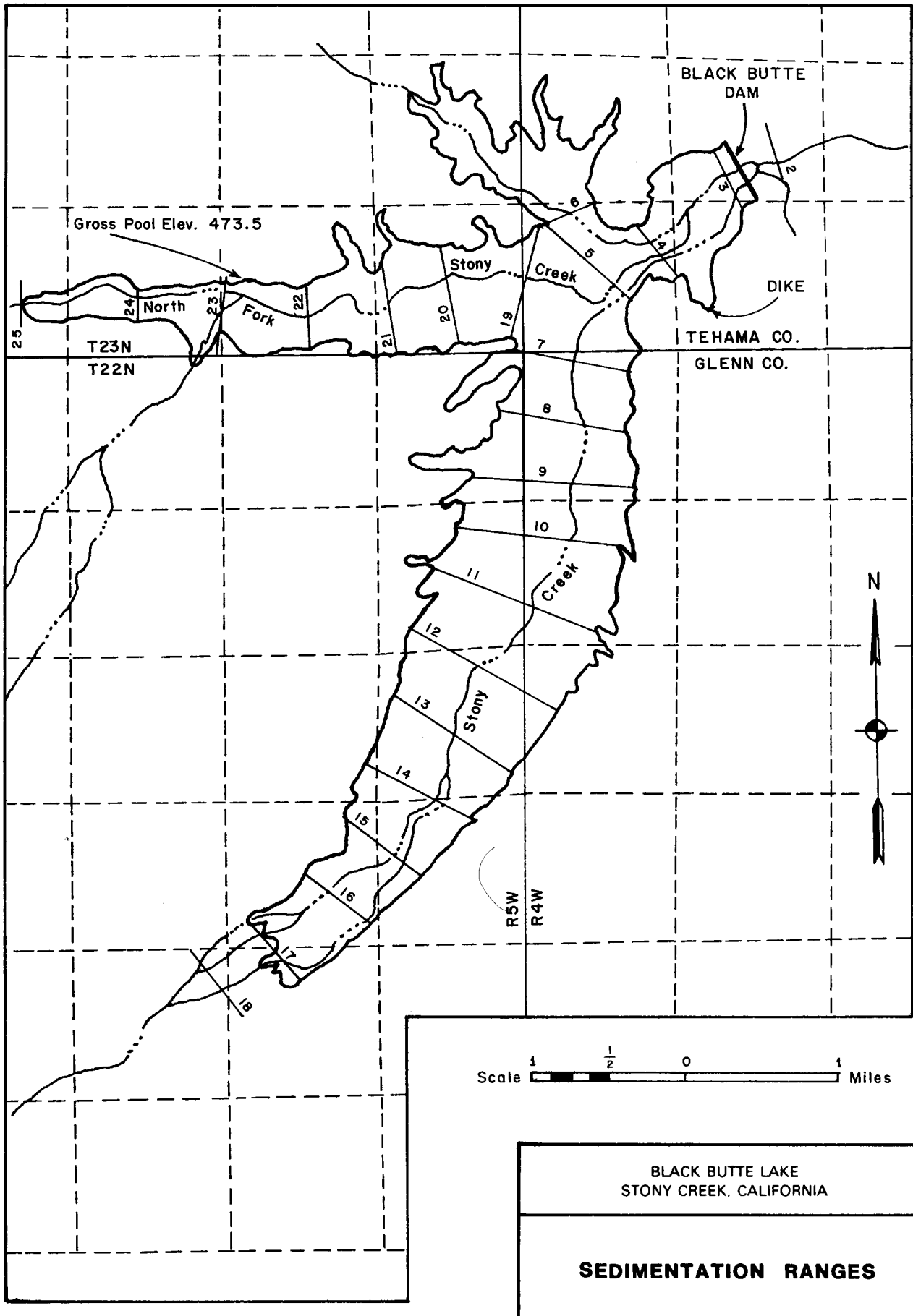
PLATE 16

UNIMPAIRED MONTHLY INFLOWS TO BLACK BUTTE LAKE
(1,000 ACRE-FEET)

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1964	3.1	23.3	7.8	30.2	16.9	11.0	7.5	4.5	0.5	0.0	0.0	0.0	104.8
1965	0.1	25.5	277.7	200.7	48.9	27.3	109.9	28.9	6.9	0.1	0.0	0.0	726.0
1966	0.6	36.6	21.0	115.6	63.1	45.1	38.8	15.7	3.1	0.3	0.2	0.1	340.2
1967	0.3	24.6	87.9	181.0	67.7	53.2	69.7	61.8	38.4	2.7	0.7	0.3	588.3
1968	1.0	5.7	15.5	82.5	123.0	47.3	17.2	8.2	1.3	0.6	0.2	0.1	302.6
1969	0.7	5.5	60.0	257.6	210.2	129.3	82.3	45.6	11.7	1.4	0.3	0.2	804.8
1970	2.2	2.9	79.9	406.7	88.9	64.9	17.9	9.3	1.7	0.7	0.2	0.1	675.4
1971	0.9	36.9	122.5	137.7	38.0	86.5	38.6	24.6	8.9	1.5	0.4	0.7	497.2
1972	0.5	4.6	16.1	38.2	36.8	51.5	19.9	11.3	1.7	0.4	0.2	0.3	181.5
1973	2.8	39.8	59.8	206.9	227.8	118.9	53.1	29.7	5.4	0.3	0.1	0.1	744.7
1974	3.1	82.8	122.4	249.9	53.1	164.8	98.2	27.8	8.8	0.8	0.3	0.2	812.2
1975	1.8	3.9	16.6	19.7	149.4	225.8	67.3	44.5	15.0	0.8	0.3	0.1	545.2
1976	3.6	6.3	6.3	4.3	12.3	18.0	11.5	4.3	1.5	0.1	1.4	0.4	70.0
1977	0.0	1.8	1.6	3.0	2.6	6.2	0.2	1.8	0.0	0.0	0.0	0.2	17.4
1978	0.4	4.3	49.3	368.9	190.0	145.4	57.2	28.9	14.0	1.9	0.2	0.2	860.7
1979	0.9	2.4	2.4	30.7	37.8	70.5	30.7	24.3	5.9	1.3	0.2	0.1	207.2
1980	4.7	23.0	45.0	191.8	257.2	95.3	35.8	17.6	7.7	0.5	0.1	0.6	679.3
1981	0.1	2.1	15.7	83.3	51.1	43.2	21.2	7.8	1.6	0.1	0.0	0.0	226.2
1982	4.5	76.9	149.3	108.9	114.9	92.7	161.9	56.2	14.6	3.5	0.2	0.1	783.7
1983	6.2	35.5	122.7	234.4	283.3	461.0	129.4	106.2	38.1	7.0	0.8	0.8	1,425.4
1984	2.5	102.8	313.4	73.8	48.8	41.6	23.5	13.1	2.0	0.4	0.2	0.2	622.3
1985	1.7	58.5	43.9	14.6	30.2	23.9	27.7	5.3	0.4	0.2	0.3	2.1	208.8
MEAN	1.9	27.5	74.4	138.2	97.8	92.0	50.9	26.2	8.5	1.1	0.3	0.3	519.1

HISTORICAL MONTHLY INFLOWS TO BLACK BUTTE LAKE
(1,000 ACRE-FEET)

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1964	9.6	9.1	3.0	11.1	8.1	4.6	13.2	11.2	12.4	11.3	10.0	3.7	107.3
1965	3.3	10.8	212.4	194.0	40.4	26.2	109.1	30.8	18.7	18.5	20.2	18.6	703.0
1966	11.7	18.5	7.3	64.6	59.1	40.9	39.5	27.7	18.8	16.2	24.7	13.0	342.0
1967	3.6	10.4	50.1	145.6	67.2	49.7	70.2	61.0	40.8	25.4	21.0	16.4	561.4
1968	11.3	4.8	5.2	36.7	120.3	41.7	24.1	20.2	12.5	22.3	13.5	16.3	328.9
1969	3.3	1.9	25.0	220.0	206.9	117.8	80.7	46.5	21.2	20.6	20.9	16.6	781.4
1970	7.3	1.6	45.9	376.3	82.4	56.0	23.8	20.3	15.6	21.0	20.2	10.0	680.4
1971	0	19.2	80.9	113.4	32.1	80.2	48.0	26.5	11.2	16.2	20.8	15.0	463.5
1972	8.4	5.8	6.4	17.6	17.0	33.7	23.8	27.6	21.1	8.3	7.0	11.2	187.9
1973	0.2	22.7	31.4	176.7	226.7	116.0	51.8	28.1	18.4	23.0	20.4	15.6	731.0
1974	5.1	41.7	104.9	239.6	43.9	160.6	97.4	47.5	4.0	15.3	21.2	17.8	799.0
1975	5.1	1.1	9.1	10.4	99.8	217.9	63.2	50.1	21.6	19.4	24.2	17.8	539.7
1976	4.0	2.3	2.7	1.7	7.0	9.5	31.5	21.9	0.9	0.5	0.4	0	82.4
1977	0	0.3	0.5	0.7	0.5	2.4	13.5	3.4	0	0	0.1	0.3	21.7
1978	0.5	0.7	21.5	260.8	189.8	138.6	55.6	56.9	11.9	3.5	21.8	5.4	767.0
1979	1.3	2.9	0.7	12.2	22.9	63.3	36.0	30.6	6.9	10.3	18.1	5.8	211.0
1980	3.7	9.3	20.1	193.3	254.7	84.7	35.8	21.4	15.7	17.8	23.2	5.0	684.7
1981	5.4	6.5	5.4	46.0	34.0	37.7	21.5	24.0	15.4	22.6	16.4	10.1	245.0
1982	2.0	32.0	119.3	111.0	111.5	83.8	166.8	55.9	30.0	16.1	20.3	9.5	758.2
1983	3.9	14.7	95.1	235.8	279.5	460.7	124.4	108.6	45.6	20.8	18.5	4.7	1,412.3
1984	5.6	71.7	305.5	72.0	41.5	36.8	21.2	14.1	13.1	22.4	16.9	12.9	633.7
1985	2.3	33.1	35.5	7.2	14.5	11.6	25.6	29.1	12.8	13.1	19.1	6.6	210.5
MEAN	4.4	14.6	54.0	115.7	89.1	85.2	53.5	34.7	16.7	15.7	17.2	10.5	511.3

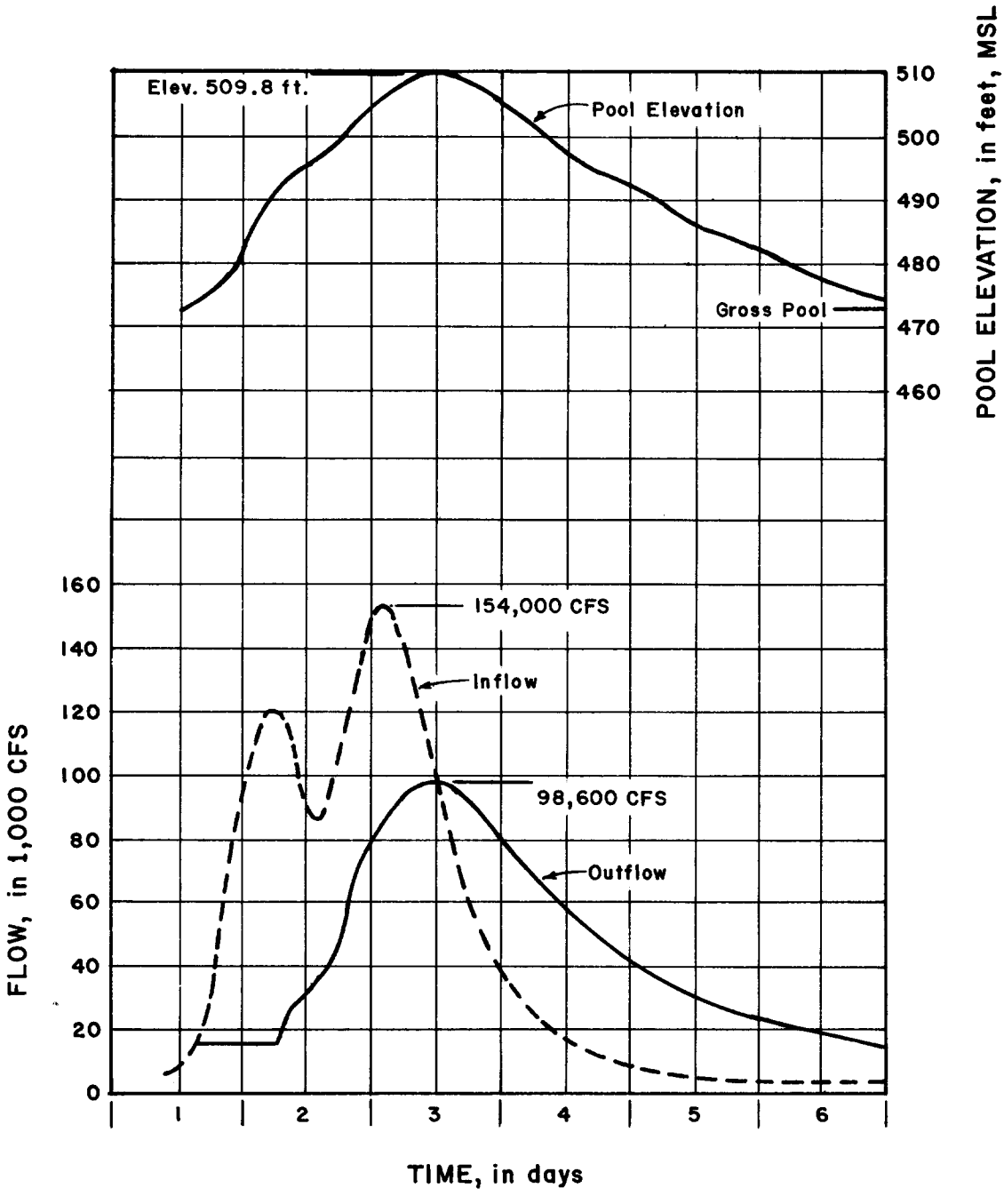


BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

SEDIMENTATION RANGES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 19

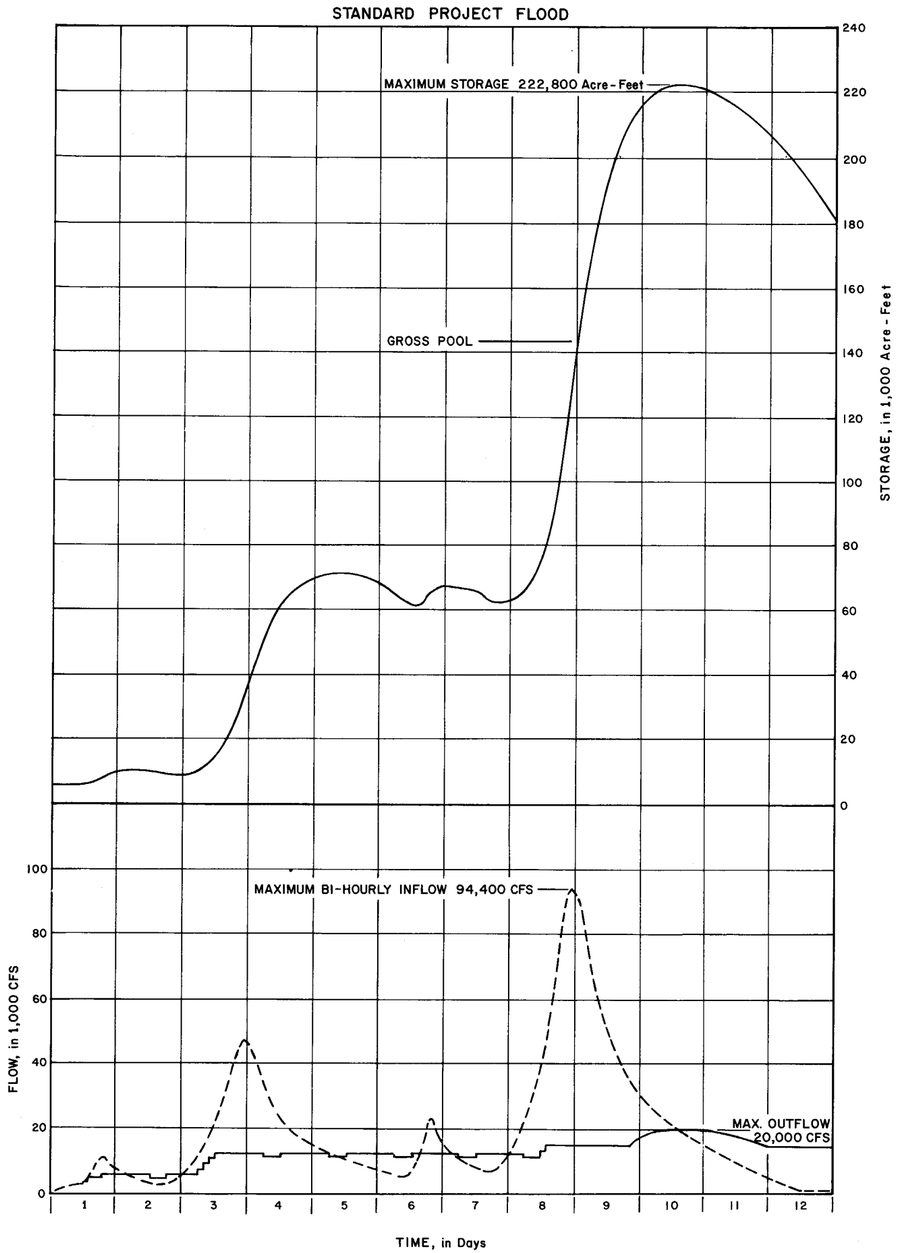


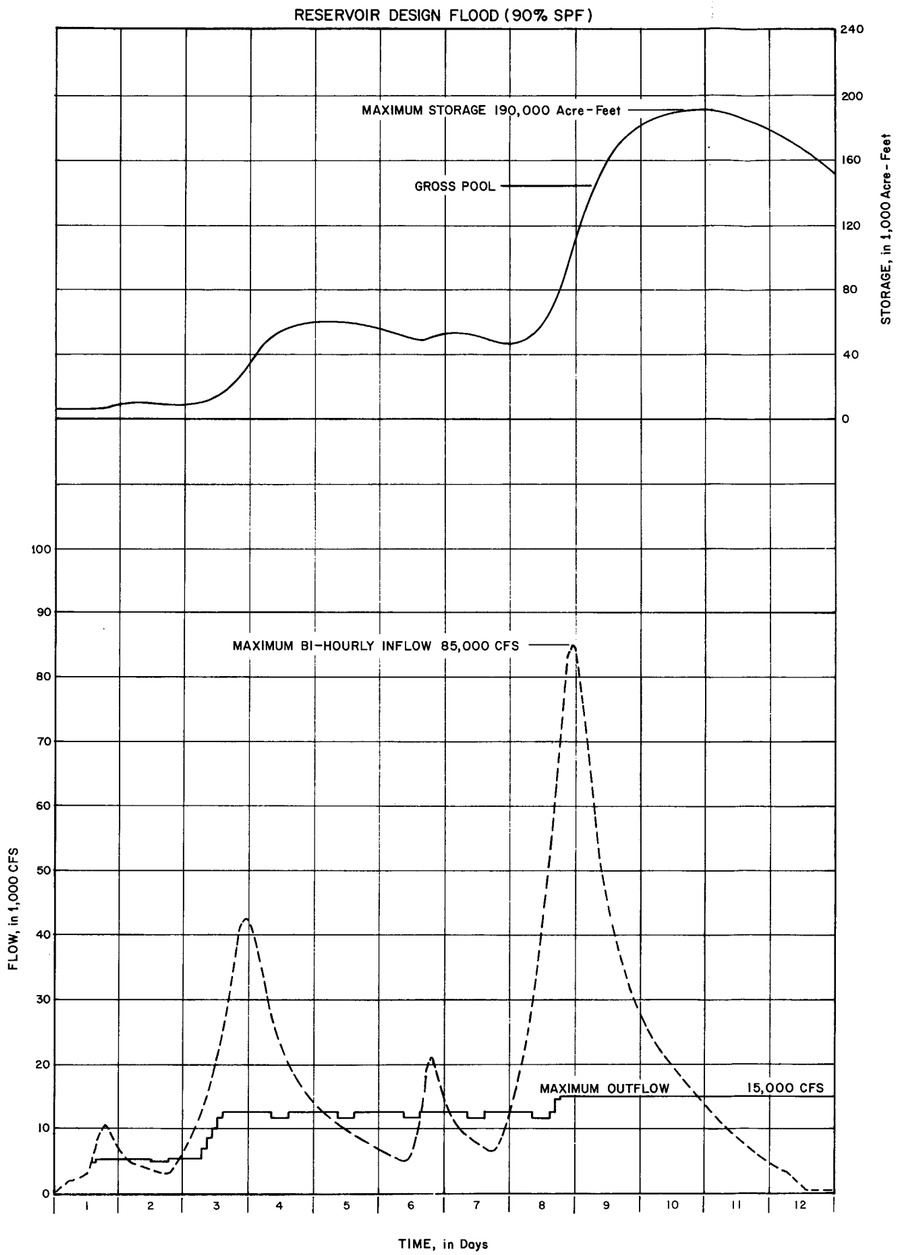
BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

SPILLWAY DESIGN
FLOOD ROUTING

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 20





NOTES:

1. Routings through Black Butte Lake are made in conformity with the Flood Control Diagram.

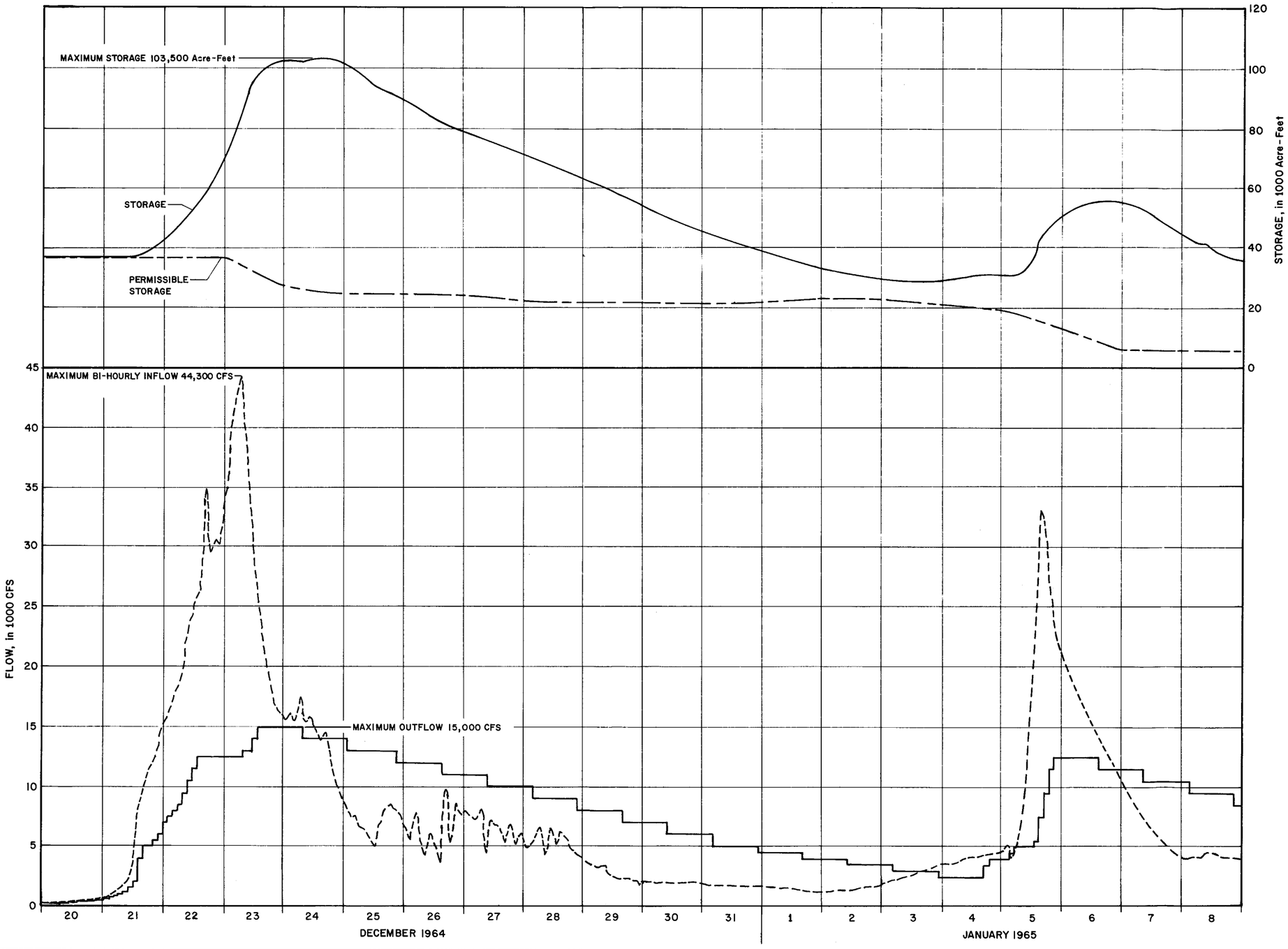
2. At the onset of each routing, it was assumed that all upstream reservoirs were full and that the required flood control space was available in Black Butte Lake.

BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

ROUTING OF SPF AND RESERVOIR DESIGN FLOOD

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 21-1



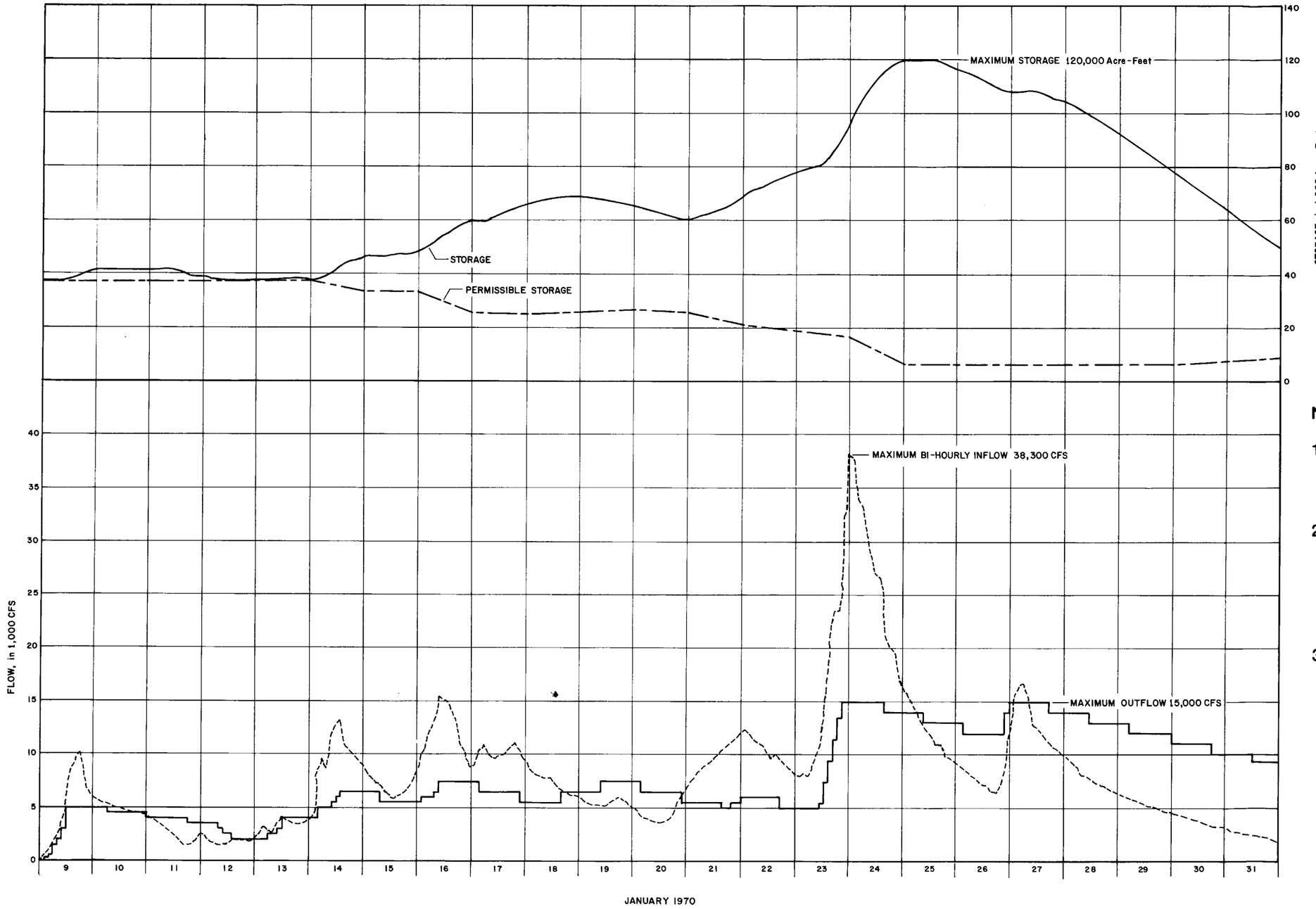
NOTES:

1. Routings through Black Butte Lake are made in conformity with the Flood Control Diagram.
2. At the onset of each routing, it was assumed that all upstream reservoirs were full and that the required flood control space was available in Black Butte Lake.
3. Inflow represents the historical inflow to Black Butte Lake.

BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

HYPOTHETICAL
FLOOD ROUTING OF HISTORICAL
DECEMBER 1964 RAIN FLOOD

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



NOTES:

1. Routings through Black Butte Lake are made in conformity with the Flood Control Diagram.
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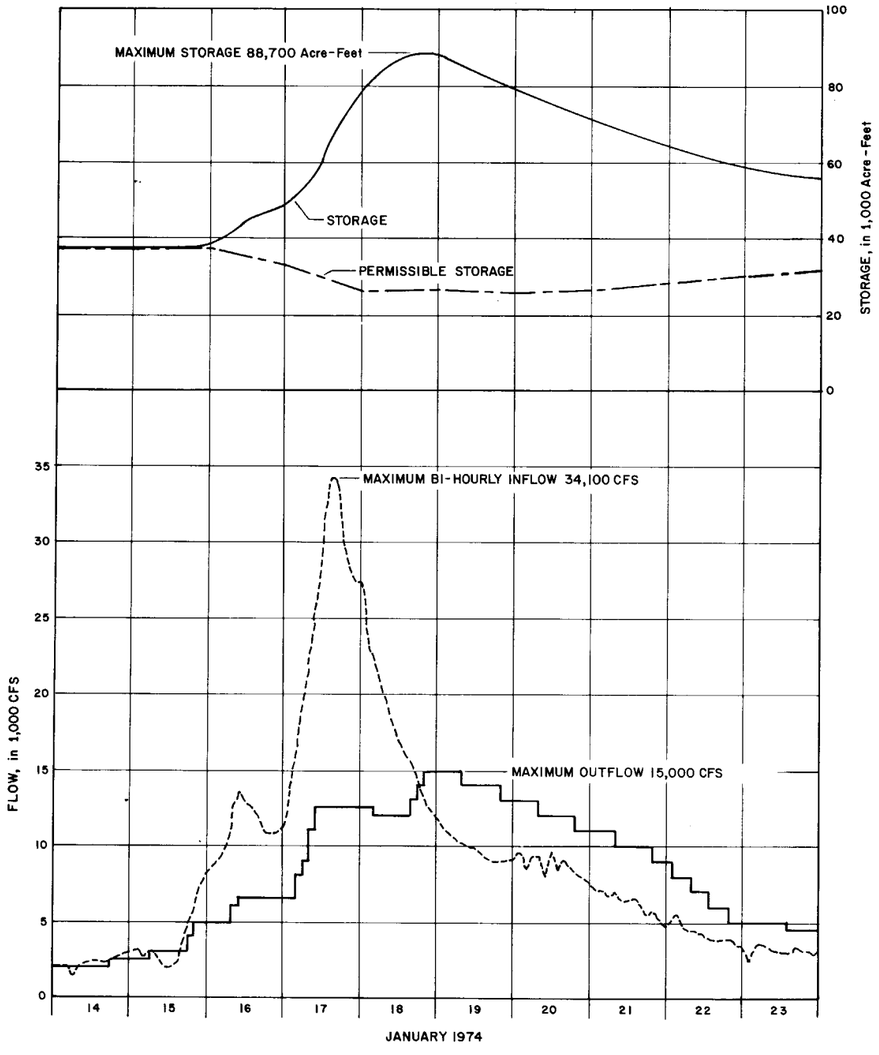
3. Inflow represents the historical inflow to Black Butte Lake.

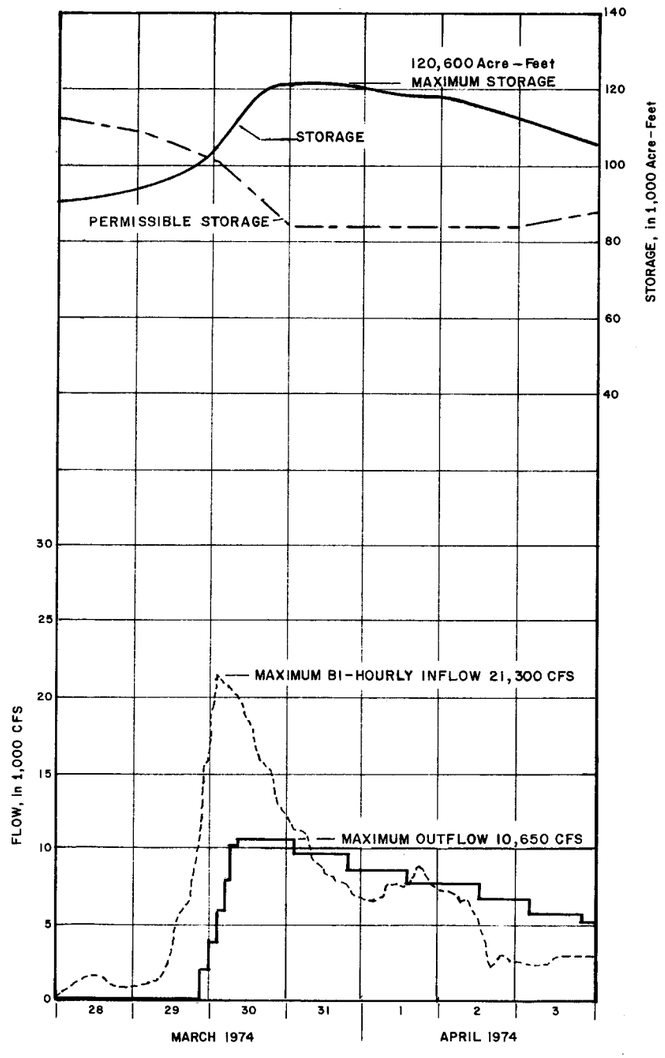
BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

HYPOTHETICAL
FLOOD ROUTING OF HISTORICAL
JANUARY 1970 RAIN FLOOD

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 21-3





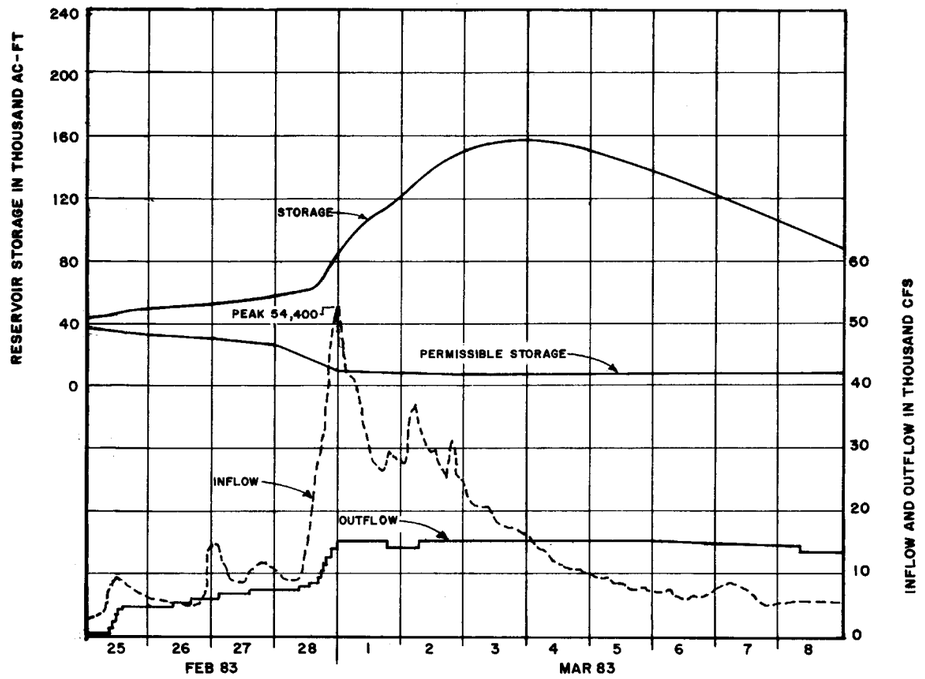
NOTES:

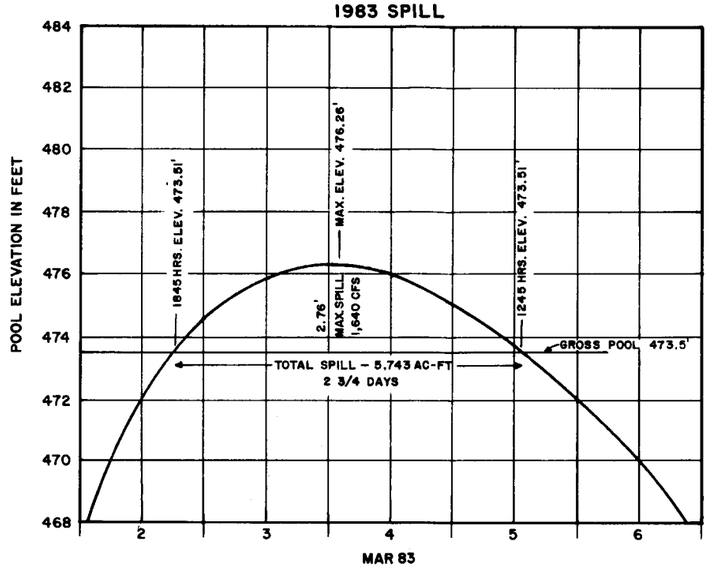
1. Routings through Black Butte Lake are made in conformity with the Flood Control Diagram.
2. At the onset of each routing, it was assumed that all upstream reservoirs were full and that the required flood control space was available in Black Butte Lake.
3. Inflow represents the historical inflow to Black Butte Lake.

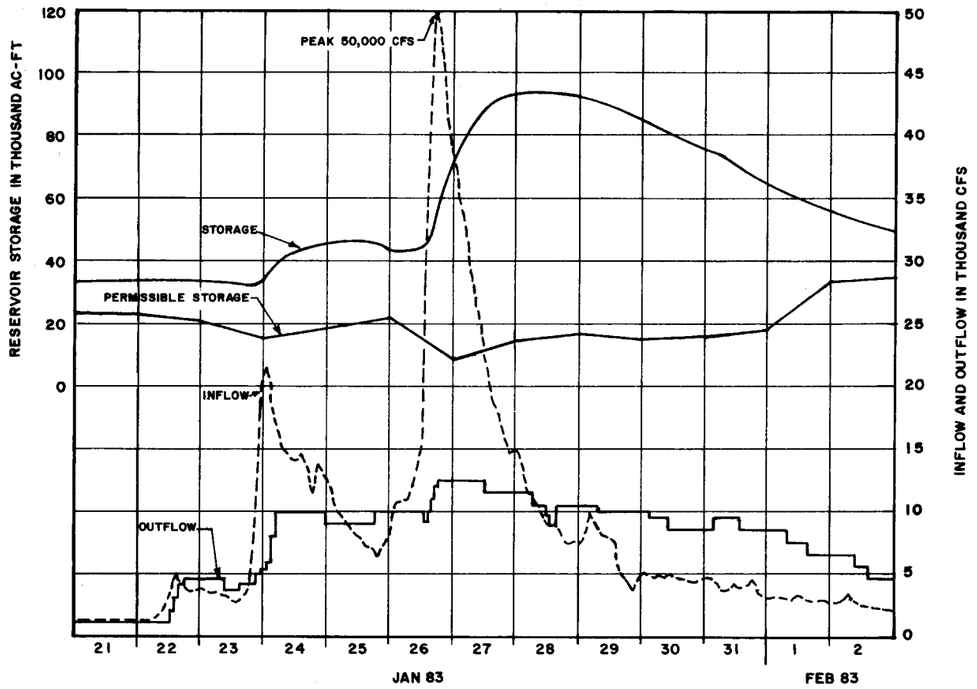
BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

HYPOTHETICAL
FLOOD ROUTING OF HISTORICAL
JANUARY-APRIL 1974 RAIN FLOOD

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT







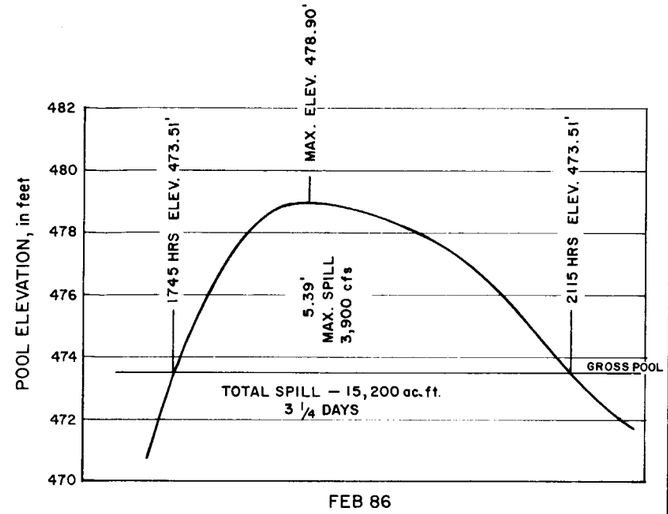
NOTES:

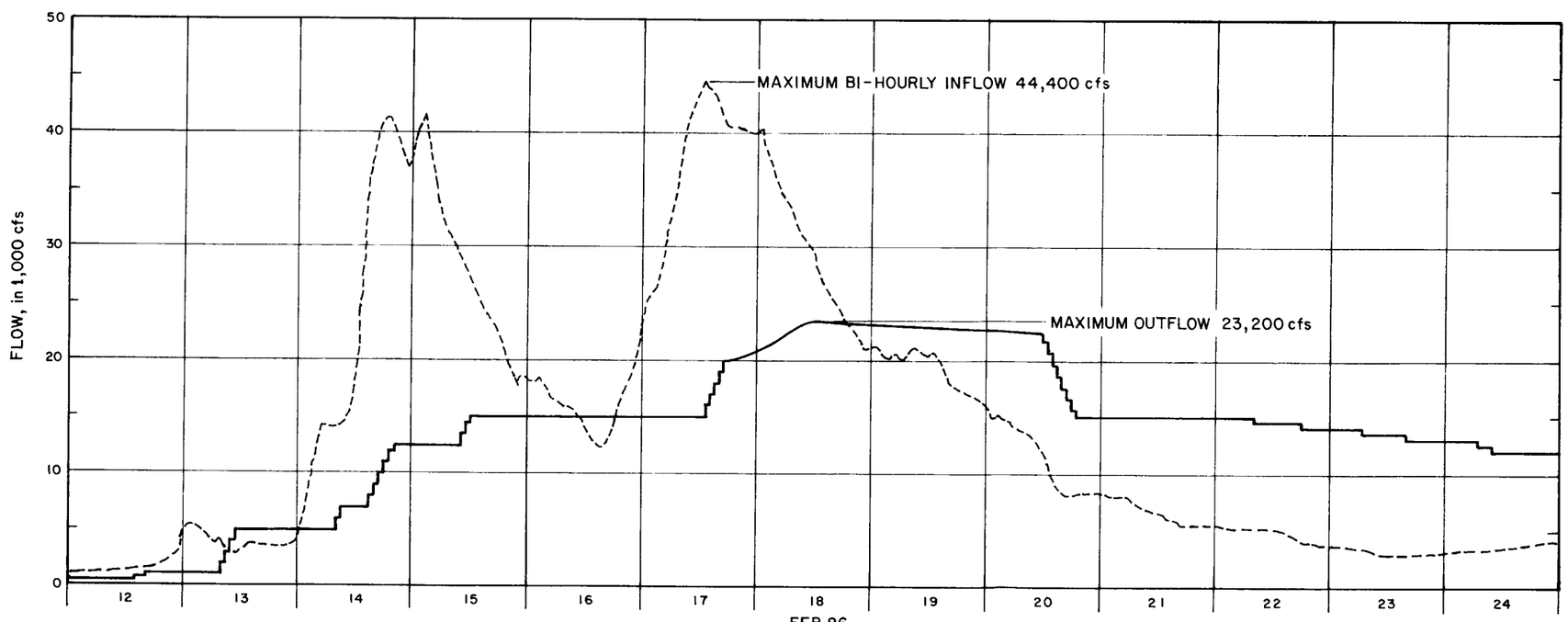
1. Routings through Black Butte Lake are made in conformity with the Flood Control Diagram.
2. Inflow represents the historical inflow to Black Butte Lake.

BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

HISTORICAL
FLOOD ROUTING OF
JAN-MAR 1983 RAIN FLOOD

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT





NOTES:

1. Routings through Black Butte Lake are made in conformity with the Flood Control Diagram.
2. Inflow represents the historical inflow to Black Butte Lake.

BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

HISTORICAL
FLOOD ROUTING OF
FEBRUARY 1986 RAIN FLOOD

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 21-6

ANNUAL MAXIMUM RAIN FLOOD FLOWS
STONY CREEK BELOW BLACK BUTTE DAM
(UNREGULATED CONDITIONS)

FLOWS IN CFS

WATER YEAR	PEAK		1-DAY		3-DAY		10-DAY		30-DAY	
	DATE	FLOW	DATE	FLOW	DATE	FLOW	DATE	FLOW	DATE	FLOW
1901	19 FEB	19,800	19 FEB	9,370	19 FEB	6,890	16 FEB	4,430	13 FEB	2,220
1902	24 FEB	33,000	24 FEB	23,400	24 FEB	19,000	19 FEB	11,600	10 FEB	6,300
1903	9 NOV	13,500	9 NOV	7,260	9 NOV	4,650	9 NOV	3,130	9 NOV	2,400
1904	24 FEB	38,500	24 FEB	24,400	22 FEB	14,900	16 FEB	8,670	16 FEB	6,230
1905	1 FEB	16,500	1 FEB	8,010	1 FEB	5,460	14 JAN	4,440	14 JAN	3,010
1906	18 JAN	41,800	18 JAN	24,400	16 JAN	19,800	12 JAN	8,110	2 MAR	3,440
1907	18 MAR	44,000	18 MAR	29,200	18 MAR	22,000	17 MAR	10,800	17 MAR	5,020
1908	9 FEB	17,600	9 FEB	8,570	9 FEB	4,600	2 FEB	3,510	20 JAN	1,850
1909	2 FEB	50,000	2 FEB	32,200	13 JAN	20,500	8 JAN	12,500	8 JAN	9,190
1910	21 MAR	20,400	21 MAR	9,880	21 MAR	6,400	21 MAR	3,820	1 MAR	2,390
1911	6 MAR	25,300	6 MAR	17,600	6 MAR	12,600	3 MAR	8,520	2 MAR	4,720
1912	26 JAN	3,300	26 JAN	1,660	26 JAN	920	1 MAY	530	1 MAY	360
1913	19 JAN	7,800		3,980		3,700		2,410		2,200
1914	2 JAN	39,600		31,000		21,200		11,000		9,090
1915	2 FEB	50,600		39,000		22,500		12,000		10,500
1916	23 JAN	47,800		28,700		21,500		10,700		7,390
1917	25 FEB	5,000		4,990		3,800		1,520		670
1918	7 FEB	2,200		1,510		880		800		770
1919	9 FEB	18,700		8,770		7,460		3,160		1,560
1920	16 APR	2,500		1,860		1,440		630		390
1921	30 JAN	22,300		15,300		9,190		6,200		3,460
1922	18 FEB	2,900		2,820		2,520		1,870		1,180
1923	31 DEC	6,600		4,430		2,540		1,500		830
1924	8 FEB	3,400		1,920		1,060		470		320
1925	11 FEB	31,900		17,200		13,000		6,880		3,610
1926	4 FEB	9,000		8,520		7,530		4,230		2,440
1927	18 FEB	25,300		16,900		10,700		9,370		4,450
1928	27 MAR	18,700		13,800		9,790		4,520		2,320
1929	3 FEB	3,700		2,820		2,050		890		490
1930	5 MAR	5,500		4,130		2,840		1,470		1,180
1931	23 JAN	2,600		1,920		1,360		680		370
1932	27 DEC	11,900		9,270		5,530		2,770		1,380
1933	4 APR	800		700		700		590		570
1934	1 JAN	7,800		5,540		3,800		2,070		920
1935	15 APR	3,300		2,470		2,200		1,880		1,370
1936	22 FEB	14,300		8,470		5,820		4,390		2,270
1937	12 MAR	10,200		6,600		3,430		1,940		1,220
1938	11 DEC	60,000		39,100		17,100		6,400		3,340
1939	3 DEC	2,800		1,920		800		360		320
1940	26 FEB	46,700		36,500		24,400		10,100		4,890
1941	1 MAR	38,900		31,300		24,900		12,200		8,130
1942	6 FEB	26,800		24,500		16,400		9,270		5,580
1943	21 JAN	29,000		15,700		14,400		6,960		3,210
1944	3 FEB	4,500	2 FEB	2,930	3 MAR	2,000	3 MAR	1,220	22 FEB	700
1945	3 FEB	4,500	1 FEB	3,870	1 FEB	3,750	31 JAN	2,570	30 JAN	1,290
1946	25 DEC	19,400	28 DEC	12,800	27 DEC	10,200	22 DEC	7,210	20 DEC	3,580
1947	12 FEB	5,400	12 FEB	3,550	11 FEB	2,550	3 MAR	1,290	11 FEB	950
1948	15 APR	4,100	15 APR	3,570	15 APR	2,840	14 APR	1,850	8 APR	1,160
1949	11 MAR	15,100	11 MAR	10,600	10 MAR	8,870	10 MAR	4,410	3 MAR	2,600
1950	6 FEB	3,800	5 FEB	3,260	4 FEB	3,060	3 FEB	1,800	17 JAN	1,120
1951	22 JAN	10,800	22 JAN	9,920	22 JAN	6,890	20 JAN	3,620	18 JAN	2,520
1952	2 FEB	11,400	2 FEB	10,400	1 FEB	7,590	31 JAN	4,540	12 JAN	3,510
1953	10 JAN	12,100	10 JAN	11,300	9 JAN	8,880	6 JAN	6,340	26 DEC	4,230
1954	17 JAN	13,500	17 JAN	9,450	16 JAN	6,040	16 JAN	3,160	16 JAN	2,250
1955	6 DEC	2,500	6 DEC	2,040	5 DEC	1,540	2 DEC	1,230	14 NOV	670
1956	22 DEC	25,300	22 DEC	21,000	21 DEC	14,700	18 DEC	8,640	18 DEC	4,990
1957	24 FEB	11,800	24 FEB	9,900	23 FEB	7,790	22 FEB	3,740	22 FEB	2,041
1958	24 FEB	38,700	19 FEB	23,800	24 FEB	15,900	18 FEB	12,000	1 FEB	8,340
1959	16 FEB	18,300	16 FEB	12,400	15 FEB	7,850	14 FEB	3,980	13 FEB	1,910
1960	8 FEB	20,200	8 FEB	15,800	8 FEB	12,400	2 FEB	5,480	24 JAN	2,400
1961	1 DEC	7,600	2 FEB	4,000	31 JAN	3,590	26 JAN	2,440	26 JAN	1,590
1962	6 MAR	8,800	15 FEB	8,560	13 FEB	6,750	9 FEB	3,870	9 FEB	2,310
1963	1 FEB	20,000	1 FEB	16,900	31 JAN	12,200	31 JAN	5,090	30 JAN	3,060
1964	20 JAN	5,700	21 JAN	2,890	20 JAN	2,310	20 JAN	1,170	19 JAN	660
1965	23 DEC	57,000	23 DEC	38,800	22 DEC	29,400	21 DEC	12,900	21 DEC	6,920
1966	4 JAN	20,000	5 JAN	13,100	4 JAN	10,000	4 JAN	4,520	4 JAN	1,980
1967	29 JAN	17,500	29 JAN	13,100	29 JAN	10,800	21 JAN	7,690	20 JAN	3,890
1968	19 FEB	16,000	20 FEB	9,300	19 FEB	7,300	16 FEB	4,650	29 JAN	2,670
1969	21 JAN	17,000	21 JAN	14,900	20 JAN	12,600	12 JAN	7,230	19 JAN	5,090
1970	24 JAN	37,100	24 JAN	27,200	23 JAN	18,800	16 JAN	11,900	9 JAN	7,020
1971	16 JAN	18,500	17 JAN	11,900	16 JAN	10,800	15 JAN	5,090	10 JAN	2,340
1972	23 JAN	5,500	23 JAN	3,660	22 JAN	2,540	27 FEB	1,700	21 FEB	1,020
1973	7 FEB	19,300	7 FEB	15,000	16 JAN	11,400	11 JAN	7,980	11 JAN	4,780
1974	16 JAN	43,000	16 JAN	27,900	15 JAN	19,600	13 JAN	9,580	27 DEC	4,440
1975	7 MAR	25,000	7 MAR	10,700	7 MAR	7,960	18 MAR	5,430	6 MAR	3,800
1976	27 FEB	1,500	27 FEB	1,330	27 FEB	1,280	26 FEB	880	25 FEB	430
1977	16 MAR	500	16 MAR	340	16 MAR	280	16 MAR	190	3 MAR	100
1978	14 JAN	30,400	16 JAN	22,900	14 JAN	19,300	9 JAN	11,100	13 JAN	5,760
1979	27 MAR	8,000	27 MAR	5,610	27 MAR	3,440	13 FEB	2,160	13 FEB	1,380
1980	13 JAN	29,000	13 JAN	21,600	17 FEB	19,600	16 FEB	10,900	16 FEB	5,210
1981	28 JAN	16,400	28 JAN	10,000	27 JAN	6,950	22 JAN	3,920	22 JAN	2,010
1982	20 DEC	19,300	20 DEC	13,400	19 DEC	10,900	18 DEC	5,020	18 DEC	3,210
1983	1 MAR	56,000	1 MAR	30,100	28 FEB	27,900	25 FEB	15,100	25 FEB	6,300
1984	25 DEC	38,500	25 DEC	26,300	24 DEC	16,300	24 DEC	8,100	3 DEC	5,230
1985	28 NOV	5,300	28 NOV	3,750	27 NOV	2,970	24 NOV	1,850	12 NOV	1,310
1986	17 FEB	52,000	17 FEB	39,300	17 FEB	29,000	13 FEB	18,700	14 FEB	8,280

COMPUTED STATISTICS

YEARS	85	85	85	85	85
LOG MEAN	4.124	3.964	3.825	3.582	3.353
STD. DEV.	0.431	0.418	0.419	0.405	0.388
SKEW	-0.542	-0.459	-0.512	-0.577	-0.439

ADOPTED STATISTICS

LOG MEAN	4.124	3.964	3.825	3.582	3.353
STD. DEV.	0.428	0.417	0.409	0.389	0.379
SKEW	-0.506	-0.504	-0.503	-0.501	-0.499

PLATE 22

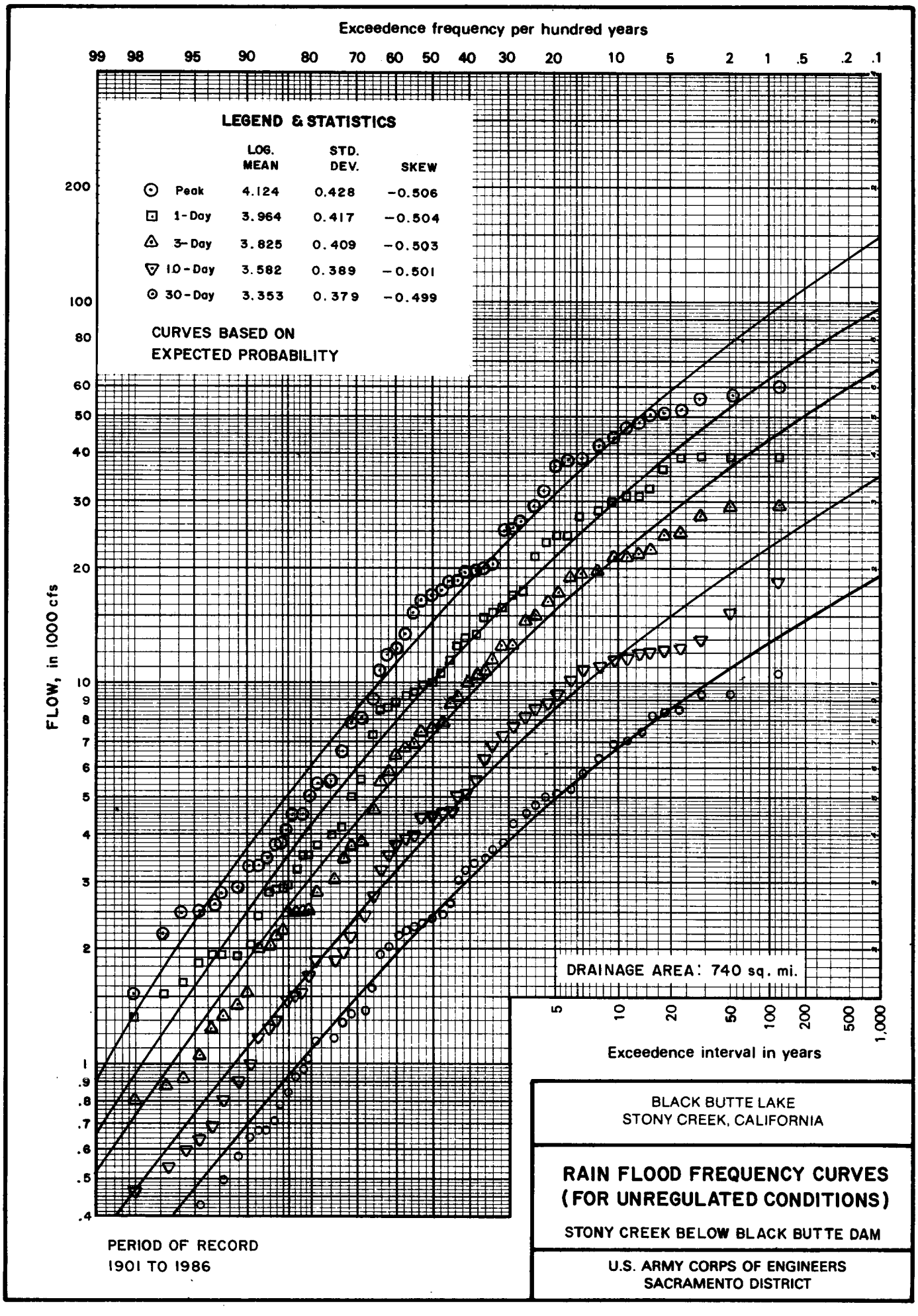
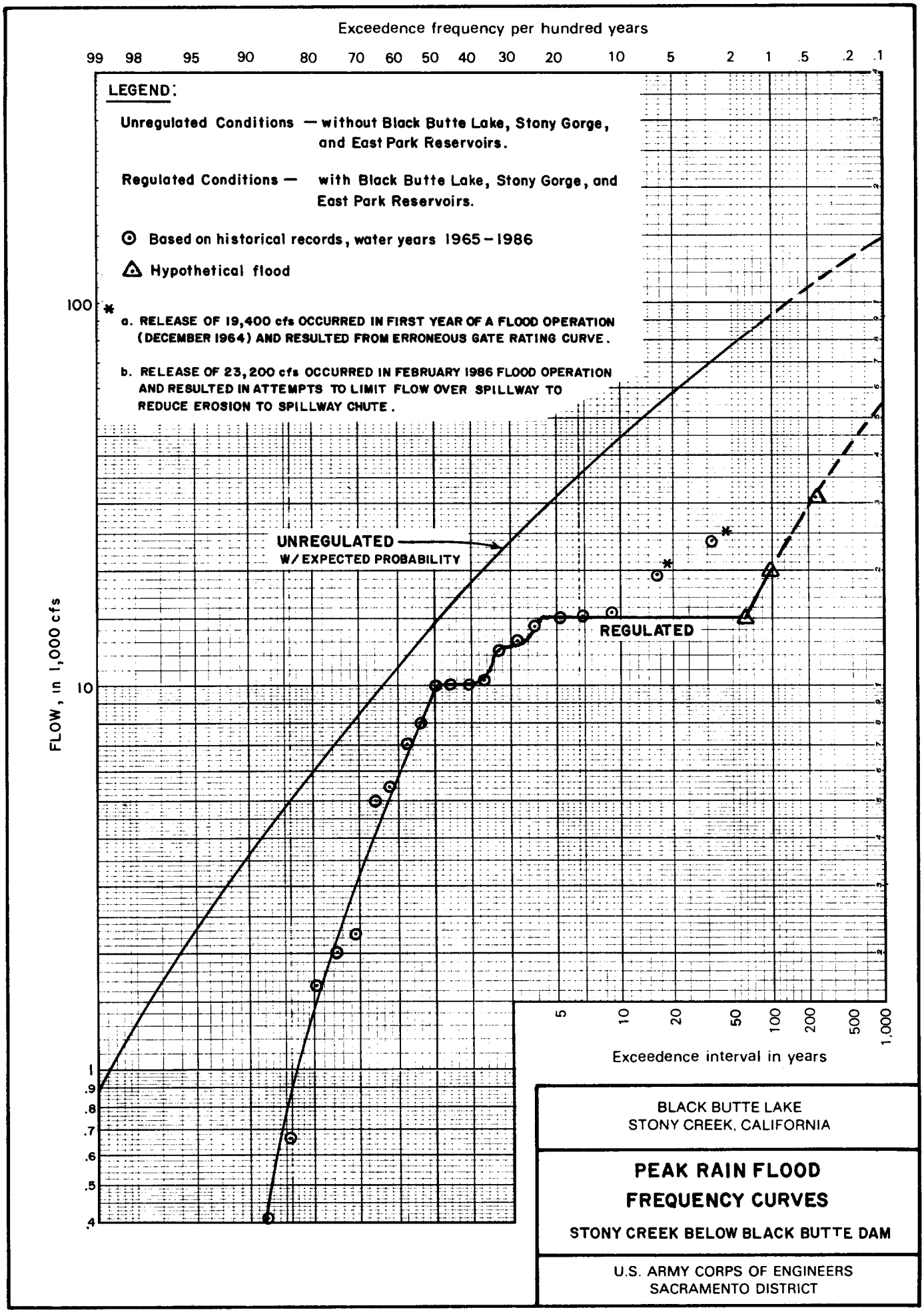

Exceedence frequency per hundred years
99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 .5 .2 .1
LEGEND & STATISTICS
LOG. MEAN
STD. DEV.
SKEW
Peak 4.124 0.428 -0.506
1-Day 3.964 0.417 -0.504
3-Day 3.825 0.409 -0.503
10-Day 3.582 0.389 -0.501
30-Day 3.353 0.379 -0.499
CURVES BASED ON EXPECTED PROBABILITY
FLOW, in 1000 cfs
200
100
80
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
.9
.8
.7
.6
.5
.4
DRAINAGE AREA: 740 sq. mi.
5 10 20 50 100 200 500 1,000
Exceedence interval in years
PERIOD OF RECORD
1901 TO 1986
BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA
RAIN FLOOD FREQUENCY CURVES
(FOR UNREGULATED CONDITIONS)
STONY CREEK BELOW BLACK BUTTE DAM
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 23



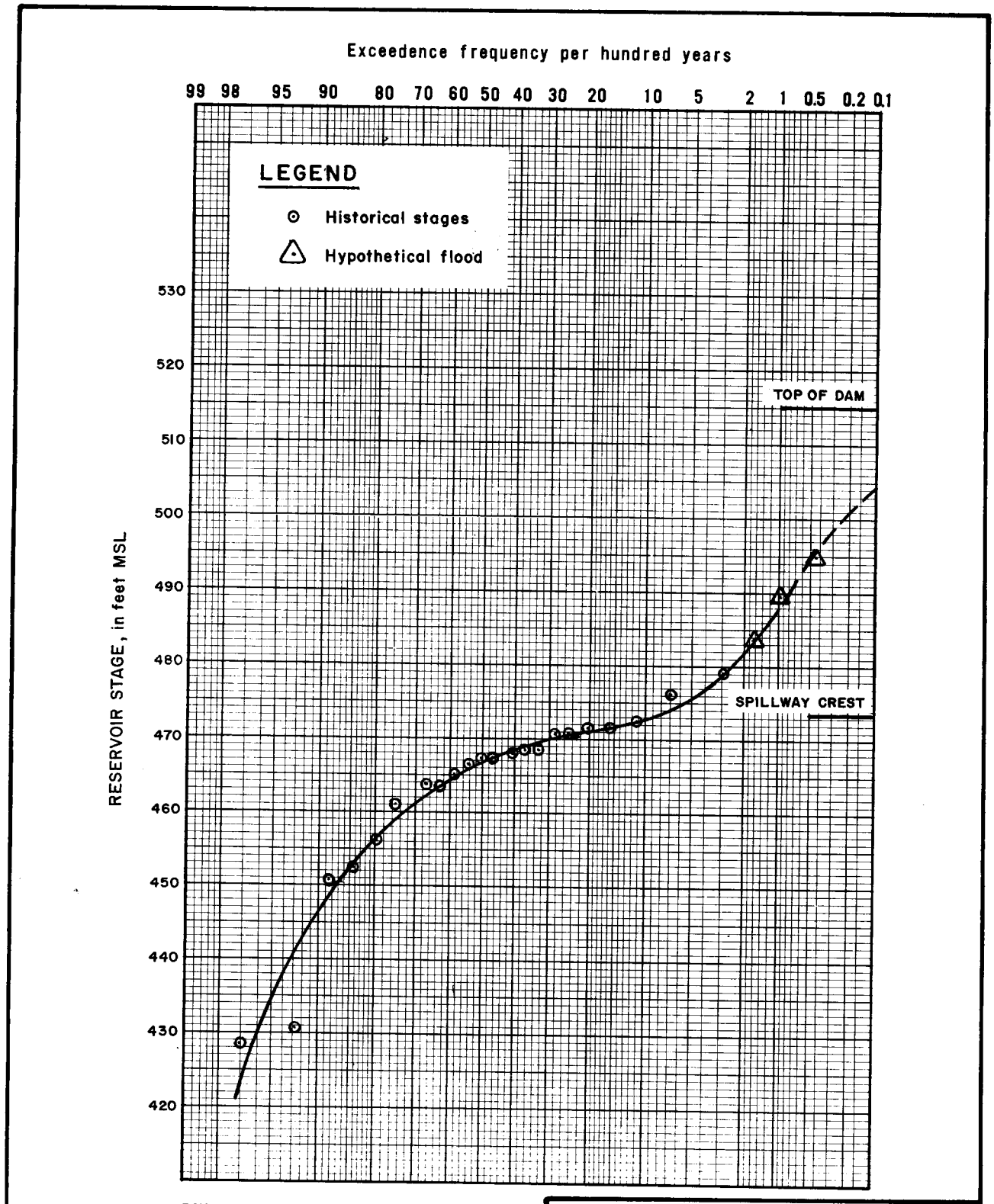
BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

PEAK RAIN FLOOD FREQUENCY CURVES

STONY CREEK BELOW BLACK BUTTE DAM

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 24



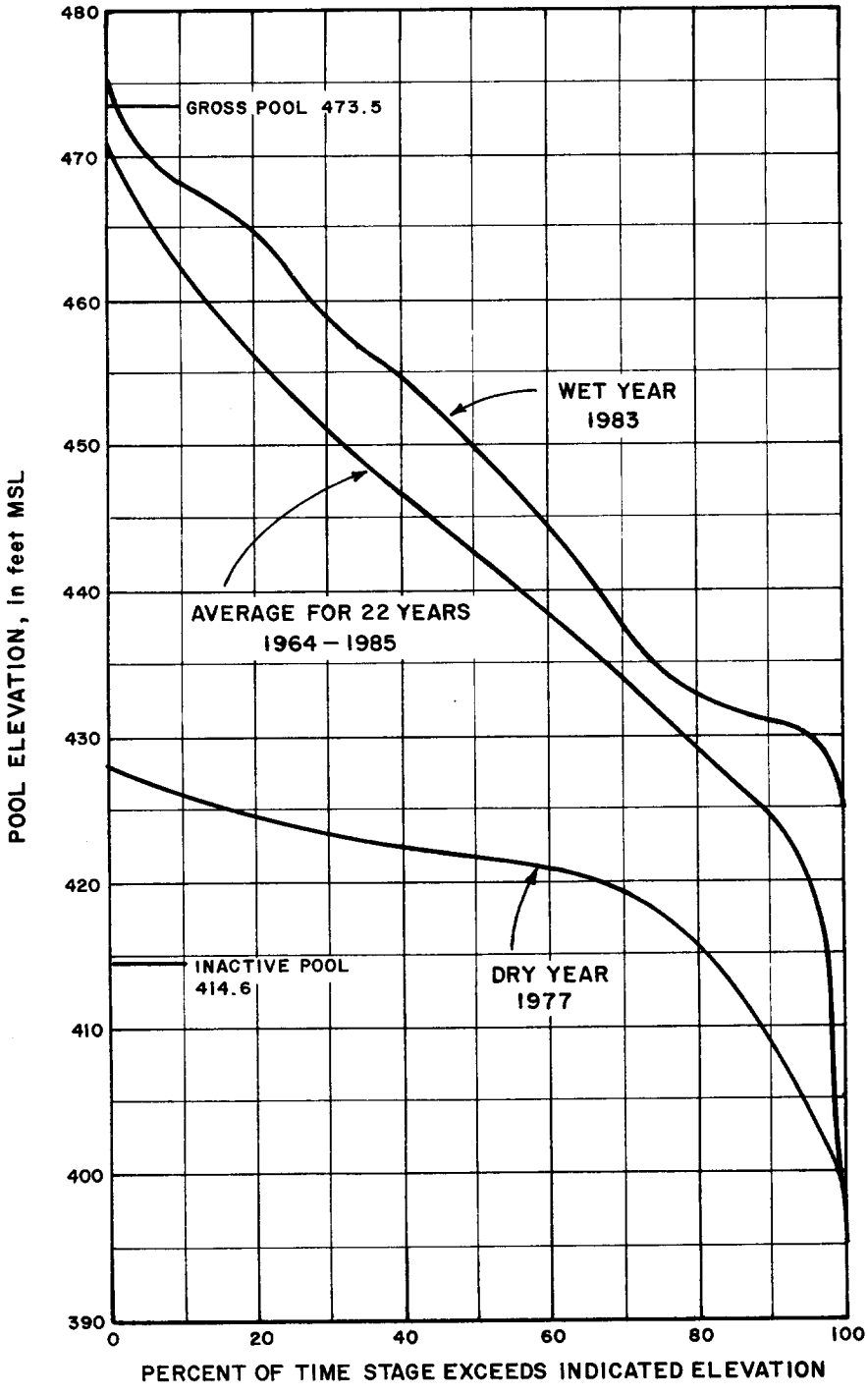
PERIOD OF RECORD: 1965 TO 1986

BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

RESERVOIR STAGE–FREQUENCY CURVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 25

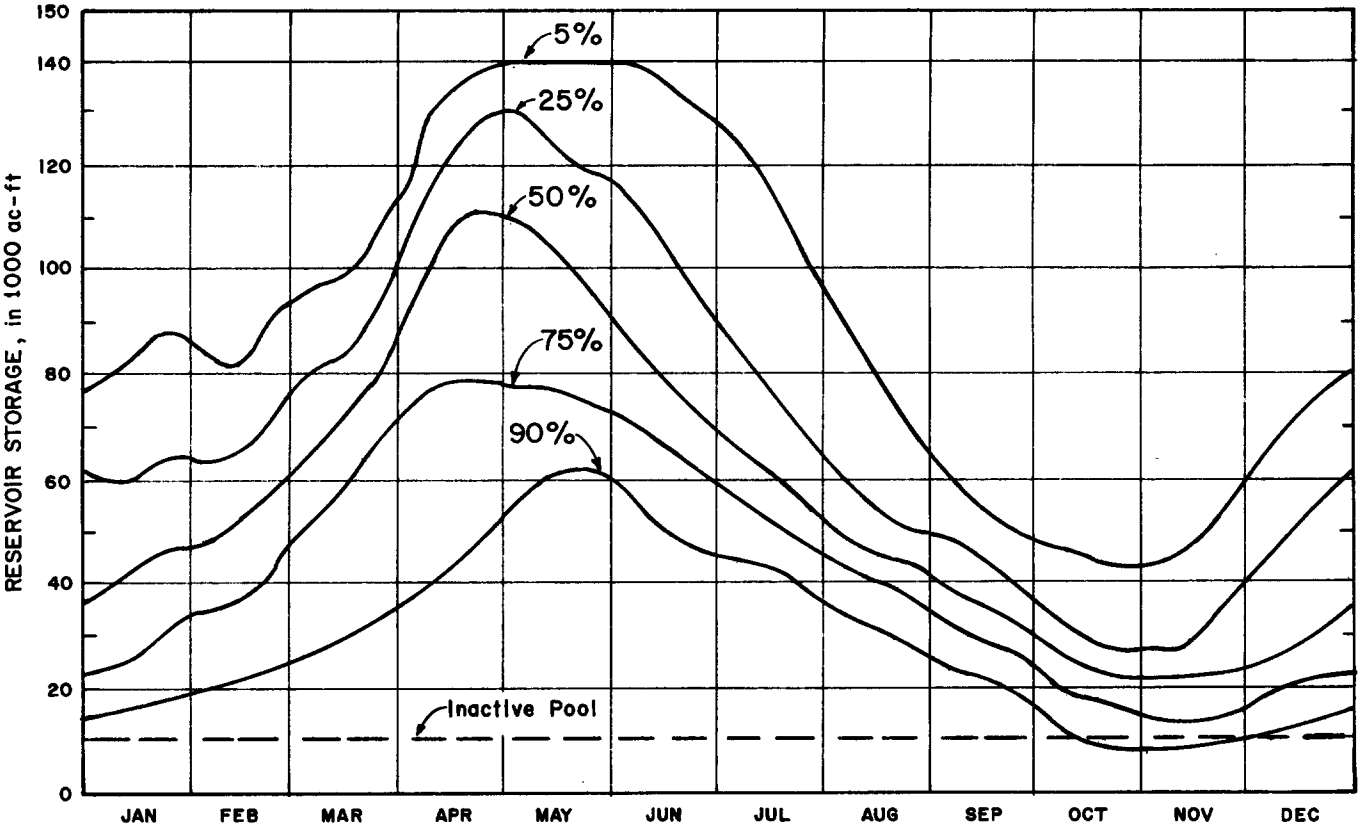


BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

STAGE-DURATION CURVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 26



NOTE:

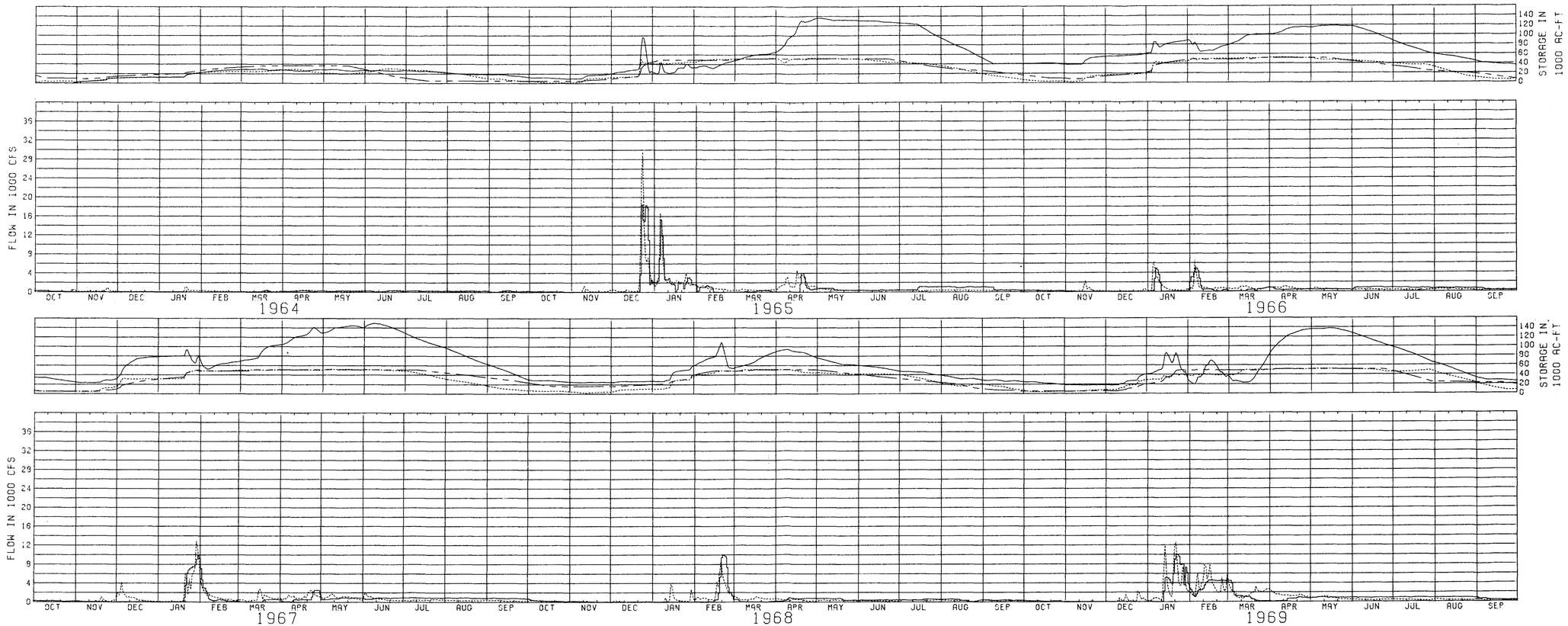
Parameters are percentage of years that maximum storage exceeds the indicated value.

BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

SEASONAL VARIATION OF STORAGE FREQUENCY

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

PLATE 27



LEGEND

OUTFLOW

INFLOW

STORAGE

BLACK BUTTE

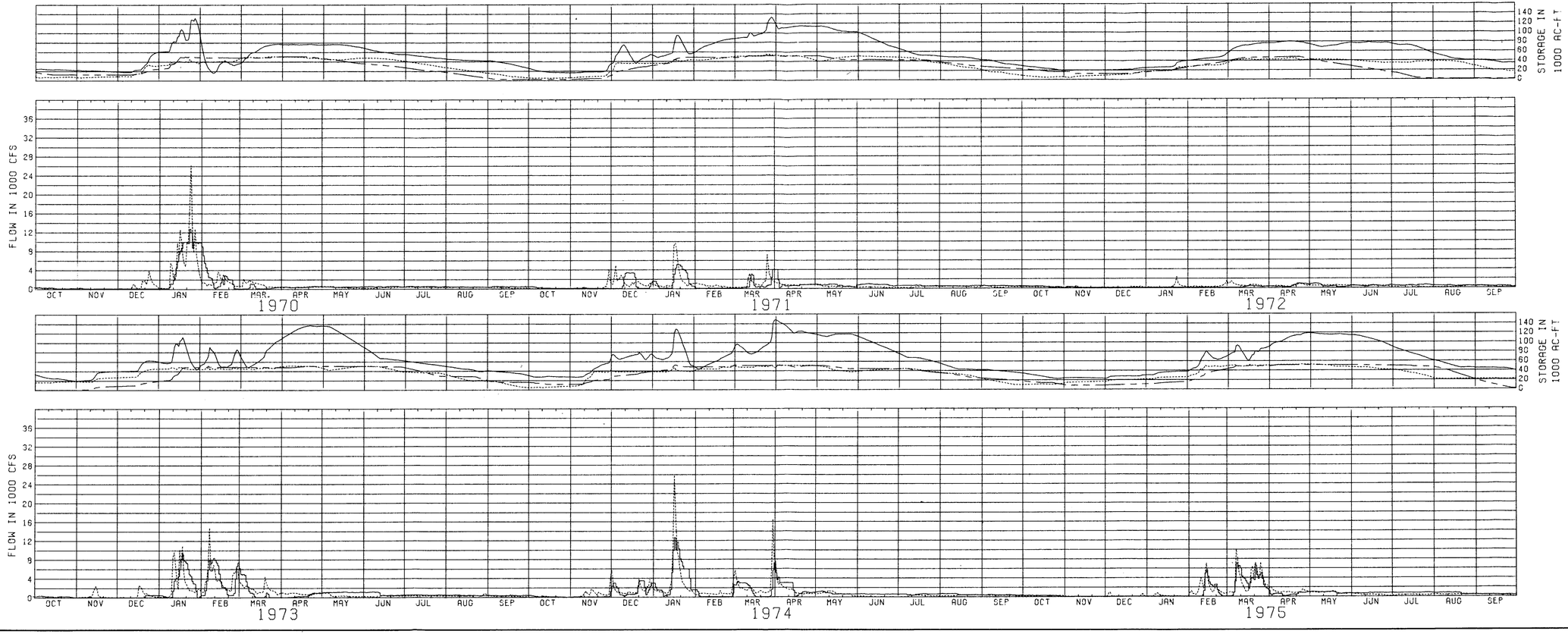
STONY GORGE

EAST PARK

BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

HISTORICAL OPERATION

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



LEGEND:

- OUTFLOW
- INFLOW

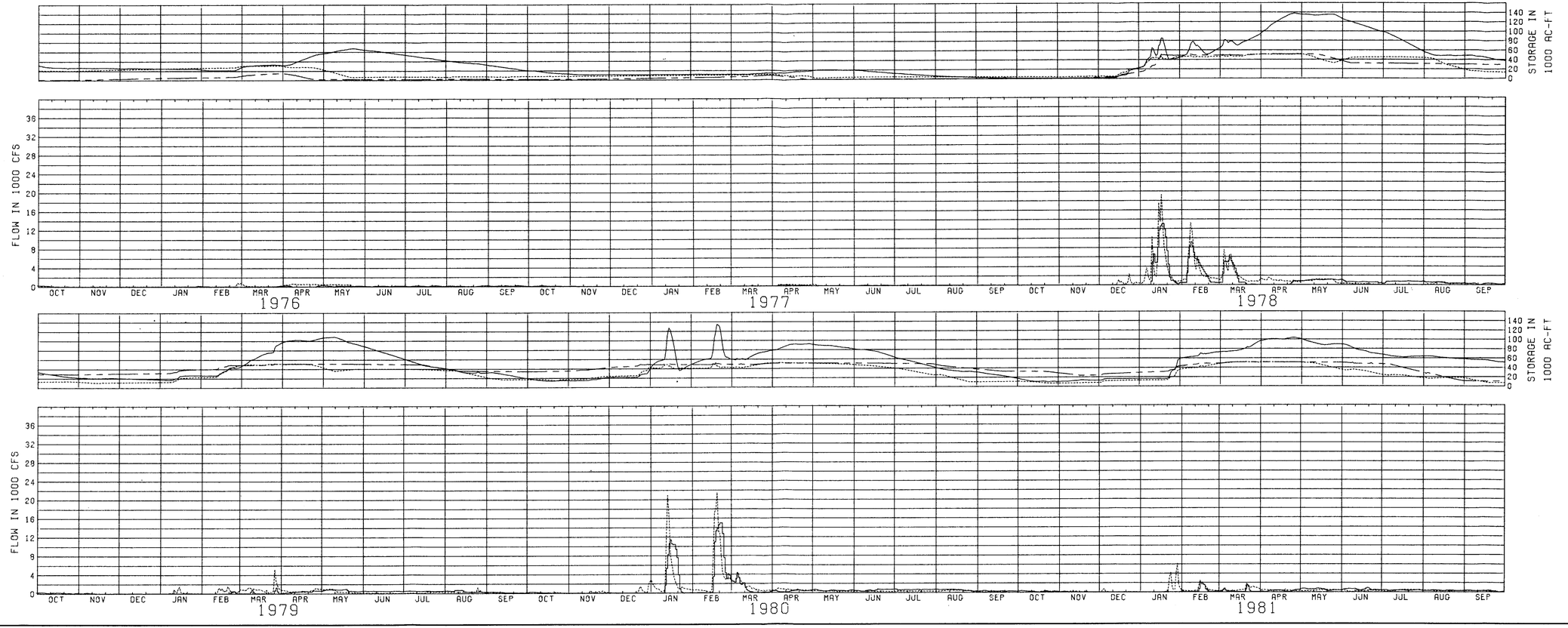
STORAGE:

- BLACK BUTTE
- STONY GORGE
- EAST PARK

BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

HISTORICAL OPERATION

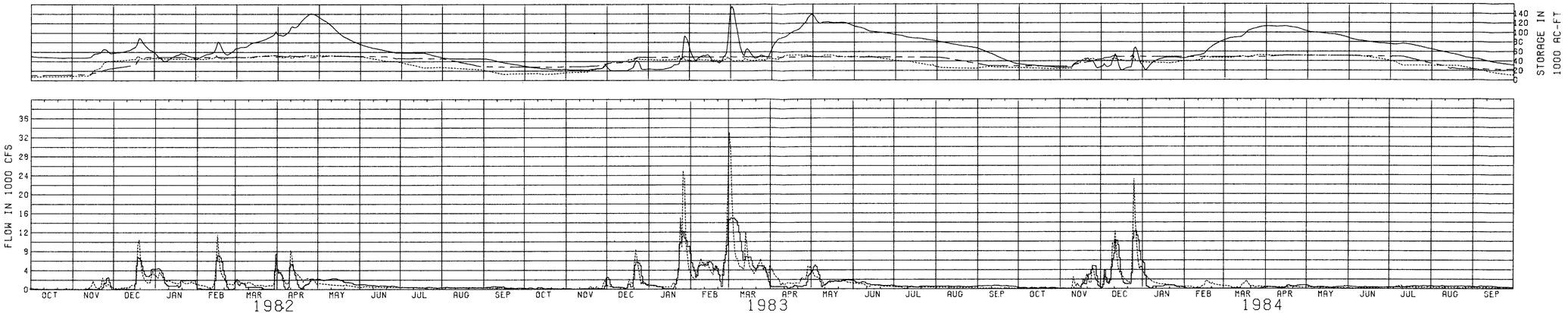
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

HISTORICAL OPERATION

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



LEGEND

OUTFLOW

INFLOW

STORAGE

BLACK BUTTE

STONY GORGE

EAST PARK

BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

HISTORICAL OPERATION

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

BLACK BUTTE DAM AND LAKE

STONY CREEK, CALIFORNIA

WATER CONTROL MANUAL

MAY 1987

EXHIBIT A

STANDING INSTRUCTIONS TO DAMTENDERS

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

EXHIBIT A

STANDING OPERATING INSTRUCTIONS TO DAMTENDERS FOR BLACK BUTTE DAM AND LAKE STONY CREEK, CALIFORNIA

CONTENTS

Personnel Concerned in Flood Control Operation of Black Butte Dam and Lake

CHARTS

BLACK BUTTE DAM
AND LAKE
STONY CREEK, CALIFORNIA
WATER CONTROL MANUAL
EXHIBIT A

STANDING INSTRUCTIONS TO DAMTENDERS

1. GENERAL

This exhibit is prepared in accordance with instructions contained in EM 1110-2-3600, paragraph 4-07, (Standing Instructions to Damtenders), and ETL 1110-2-251 and pertains to duties and responsibilities of the damtenders in connection with the operation of Black Butte Dam and the reporting of required hydrologic data.

Operational instructions to the damtenders are outlined with specific emphasis on flood emergencies when communication facilities between the damtender and the Reservoir Control Section have been disrupted. This exhibit is designed to be used independently as a flood control guide or in conjunction with the rest of the water control manual. Charts required for emergency flood control operation of Black Butte Dam are included in this exhibit.

2. FLOOD CONTROL OPERATION REQUIREMENTS

Black Butte Dam is operated for flood control according to the Flood Control Diagram (Chart A-10). The flood control objective for Black Butte Dam is to minimize flood damage downstream from the dam and insofar as practicable, to avoid causing damage that would not have occurred without the project.

Storage space up to a maximum of 137,000 acre-feet shall be reserved on the basis of the Flood Control Diagram, Chart A-10. Whenever encroachment into the flood control space occurs, water is released in accordance with the schedules shown on the Flood Control Diagram and outlined in paragraph 4.

Required flood control storage is determined from Chart A-10 which indicates the storage reservation required at any time from 1 September to 15 June. The diagram requires:

a. Flood control space increases uniformly from a zero requirement on 1 September up to a maximum reservation of 137,000 acre-feet by 30 November (a minimum reservation of 106,400 acre feet is required from 10 November to 23 January).

b. Conditional flood control reservation up to a maximum of 137,000 acre-feet from 30 November to 20 March, decreasing again to zero on 15 June. The required reservation is determined by use of a ground wetness index during this period.

c. Space not required for flood control may be filled for conservation purposes to allow more efficient operation of the project.

The flood control operation each day consists of determining the required flood control reservation, and scheduling releases to provide the required space by the end of the day, whenever possible.

3. LIMITATION ON STORAGE

Operation limitations of storage for flood control in Black Butte Lake are specified in paragraph 2 of this Exhibit and on the Flood Control Diagram Chart A-10. There are no legal limitations on storage, as the flowage easement guide taking line at elevation 492.0 feet MSL is 2.6 feet above standard project flood pool elevation. The fee acquisition guide taking line is at gross pool elevation (473.5 feet MSL).

Physical limitation on storage are as follows:

Storage 1/ Acre-feet	Water Surface 1/ Elevation (Feet, MSL)	Flow Over Spillway (cfs)	Remarks
6,600	414.6	0	Inactive pool
143,700	473.5	0	Gross pool
295,900	509.8	76,600	Spillway Design Flood pool

NOTES: 1/ Based on September 1978 storage-elevation, storage rounded.

4. LIMITATIONS ON RELEASES

During normal power generation operation, outflows between 200 and 1,000 cfs, releases will be regulated by the power facility. All flows less than 200 cfs will be released through the outlet works. During flood control operation, when required outflows are greater than 1,000 cfs, the flows in excess of 1,000 cfs will be regulated by the dam facility.

[redacted] To minimize bank caving due to periods of high sustained releases and/or decreasing releases after extended periods of bankful flows, no level of release above 1,000 cfs shall be held for more than 18 hours. The rate of change for a decrease in release shall be as follows:

a. When existing release is between 15,000 cfs and 5,000 cfs, outflow shall be reduced in 1,000 cfs increments with no release sustained for less than 2 hours.

b. When existing release is between 5,000 cfs and 50 cfs, outflow shall be reduced in 500 cfs increments, with no release sustained for less than 2 hours.

Except during spillway operation (pool elevation above 473.5 MSL) described below, releases from Black Butte Lake will be limited insofar as possible to 15,000 cubic feet per second. Releases shall be made in accordance to the Release Schedule shown on the Flood Control Diagram Chart A-10. A stage - discharge curve for Stony Creek below Black Butte Dam streamgage is shown on Chart A-6.

When Sacramento River flows at the latitude of Ord Ferry are forecasted to exceed 130,000 cfs release from Black Butte Dam should not be greater than inflow.

During floods in which flow over the spillway occurs, the outlet will be operated by gradually closing the outlet gates as the pool rises above gross pool elevation (473.5 feet MSL) in order to control the total outflow from the spillway and outlet to 15,000 cfs as long as possible (see Chart A-9). When the pool reaches elevation 486.5 feet MSL, the gates will be closed. [redacted]. If the pool is expected to continue rising, the outlet gates will be opened one by one at the rate of 20 percent of the total capacity per foot of pool stage rise, beginning at pool stage elevation 498.0 feet MSL. When the pool reaches elevation 503.0 feet MSL the gates should be fully open.

For receding pool, outlet openings will remain constant until a total release of 15,000 cfs (spillway plus outlets) is reached or the reservoir stage has receded to gross pool elevation 473.5 feet MSL, below which a release rate not to exceed 15,000 cfs will be maintained until the pool has receded to the required amount of flood control space. Outlet and spillway rating curves are shown on Charts A-3 and A-4, respectively.

5. STANDING INSTRUCTIONS DURING FLOOD EMERGENCY

Flood Control operation is under the direction of the Reservoir Control Section, Corps of Engineers, Sacramento District. During flood periods close contact will be maintained between operating personnel at Black Butte Dam and the Reservoir Control Section in Sacramento. If communication is broken between the operating personnel and the Reservoir Control Section, continue releases in accordance with the last instructions from the Reservoir Control Section and make every attempt to reestablish communications. If communication cannot be reestablished, make releases in accordance with the Flood Control Diagram, Chart A-10.

6. OPERATIONAL RESPONSIBILITIES

The primary responsibilities for operating Black Butte Dam are delegated to units of Engineering Division and Construction-Operations Division of the Sacramento District, U.S. Army Corps of Engineers, as outlined below. Names and telephone numbers for the individuals whose responsibilities are outlined below are given at the front of this Exhibit and at the front of this Manual.

a. The Hydrology Section (Engineering Division).

(1) Obtain current hydrometeorological data and weather forecasts for the region.

(2) Maintain hydrologic equipment and supervise its operation.

(3) Supervise a program of water quality and sediment measurement.

b. The Reservoir Control Section (Engineering Division)

(1) Analyze current reservoir and hydrologic data, determine schedule under which the reservoir shall be operated, and issue appropriate operating instructions to the reservoir operator (except for day-to-day conservation operation).

(2) Prepare monthly operation and other special reports relative to the operation of the reservoir.

(3) Advise the District Engineer whenever there has been an unavoidable departure from these operating rules, or when there is a need for making temporary modification of these operating rules.

(4) Make and distribute the necessary revisions to this Water Control Manual.

c. The Park Manager (Construction-Operations Division)

(1) Keep well informed of the operating rules contained in this Water Control Manual and bring to the attention of the Reservoir Control Section any feature of the Manual that may require clarification or revision.

(2) Keep familiar with the operation of all recording and communication equipment.

(3) Accomplish the physical operation of the reservoir in accordance with instructions contained in the Water Control Manual or issued by the Reservoir Control Section.

(4) Calculate and maintain a record of inflows, outflows, storage, weather data, and other data specified by the Reservoir Control Section.

(5) Report data required in Paragraph 10 to Reservoir Control Section each day as required.

(6) Report to the Reservoir Control Section any unusual conditions which might interfere with the planned operation of the reservoirs.

(7) Maintain a log of gate or valve operations to include the date, time, and water surface elevation when such changes were made, and initials of the individual accomplishing the change.

(8) Make and record weekly checks on reservoir and outflow gage readings to assure proper operation of all recording equipment.

(9) Obtain samples for water quality and sedimentation analysis as required.

(10) Immediately after the end of each month, transmit to the Reservoir Control Section forms specified in Paragraph 10.

(11) Make emergency gate changes when contact with the Reservoir Control Section is broken and a clearly defined change occurs that warrants immediate action.

(12) Maintain records of instructions received from the Reservoir Control Section; and requests from the Orland Unit Water User's Association and U.S. Bureau of Reclamation.

7. COMPUTATION OF HYDROLOGIC DATA

During normal operation, computations are made daily by the reservoir operator to determine mean daily reservoir outflow, inflow, change in storage and evaporation. During flood control operations, these computations may be made more frequently as directed by the Reservoir Control Section.

Procedures to determine the required information are as follows:

a. Mean Daily Outflow from the Reservoir

(1) The total mean daily outflow is the sum of the outflow through the river outlets and over the spillway, and consists of the flows measured at the main outflow gage below the dam (Stony Creek below Black Butte Dam); the release to South Diversion Canal as measured at the South Diversion (data from Orland Unit Water User's Association).

(2) Check punch tape for errors in gage height and for time. Time is corrected to the current 15 minutes; gage height to the nearest .01 foot.

(3) Tabulate correct gage height readings at odd hours, starting with 0100 hours. Punch tape correction, if any, should be noted.

(4) Enter current outlet works stream gage rating table, using shifts as applicable, determine and list flow at each odd hour using the procedure indicated for mean daily flow in (6) below.

(5) Total the 12 flow readings so obtained and divide by 12. This is the mean daily outflow.

(6) Mean daily flow will be listed to nearest 0.1 cfs for flows up to 10 cfs and to the nearest 1 cfs for flows above 10 cfs.

(7) When calculating discharge from gage height with a (-) shift correction, enter rating table <u>below</u> the actual height, i.e., if observed gage height is 4.86 and shift is -.02, enter rating table a 4.84 to obtain discharge. For (+) shift, enter rating table <u>above</u> observed gage height.

b. Evaporation from the Reservoir

Lake evaporation in feet is equal to the pan evaporation in inches multiplied by the evaporation coefficient shown on Chart A-7. For this computation, pan evaporation measured at 0700 hours is used to compute lake evaporation for the previous day. Lake evaporation in cfs is computed using the following formula:

Lake evaporation dfs = Pan evaporation (inches) x $\frac{\text{Evaporation coefficient}}{12}$ x avg. Lake area (acres) x 0.50417*

*Coefficient shown is for 24-hour day. For 23-hour day (last Sunday of April each year) use 0.52609. For 25-hour day (last Sunday of October each year) use 0.48400.

Lake area used when computing evaporating will be the average area for the day; obtained by averaging the midnight areas at the beginning and ending of the period being computed.

c. Inflow to the Reservoir

Computed mean daily inflow to the lake will be taken as the Algebraic sum of the mean outflow, change in the lake storage, and evaporation from the lake surface.

8. OUTLET GATE OPERATION

Desired releases will be obtained by manipulating the gates until the appropriate downstream stages are obtained as indicated by the current rating curves for Stony Creek below the dam, shown on Chart A-6 and for the South Diversion Canal as shown on Chart A-5. The partial gate opening curves illustrated on Chart A-3 may be used as a guide in estimating gate openings for total releases. Operating experience has shown that when releases are required within the range of 4,000 cfs to 8,500 cfs (depending on reservoir storage) the gates should be operated in such a way as to force a hydraulic jump below the outlet portal by temporarily increasing the flow. This procedure reduces velocities below the outlet and minimizes the vibration of the outlet structure. It is suggested that the choice of gates to be opened be symmetrical about the center gate so as to produce smooth flow (not necessary uniform gate openings).

9. NORMAL OPERATION PROCEDURES

a. Irrigation

All inflow in excess of release required for downstream needs will be stored to the extent that conservation storage is available. Releases for conservation water including such Orland Project water as must be passed through Black Butte Lake will be in accordance with daily requirements as determined by the Bureau of Reclamation and/or the Orland Unit Water User's Association. Release of water for conservation purposes will be made only at a request from the agencies.

b. Flood Control Operation

A Flood Control Diagram for normal flood operation is presented on Chart A-10. Flood control release schedule associated with the flood control operation are also presented on Chart A-10. Flood control operation begins when storage in Black Butte Lake exceeds the flood control space required on the particular day as determined from the Flood Control Diagram. This diagram is the basic project document regarding operation for flood control. The diagram reflects a careful analysis of flood frequency, seasonal flood potential and downstream channel capacities consistent with project objectives and operating experiences.

The precipitation index is computed from the daily mean basin precipitation weighted according to station normal annual precipitation at the five hydrometeorological system gages. Unit weightings are indicated on the Flood Control Diagram. The index is used in conjunction with the current data to determine the required gross flood control storage. The required gross flood control reservation so determined may be reduced by creditable flood control space known to exist upstream in East Park and Stony Gorge Reservoirs. Computation of the daily precipitation index, required gross flood control space, and creditable flood control space in upstream reservoirs is accomplished daily by the Reservoir Control Section. See Chart A-10 (Flood Control Diagram) for example computation.

To minimize downstream erosion problems, flood control releases are based on percent of required flood control space that has been used, and inflow for the current event. See Paragraph 4 and Chart A-10 for further discussion.

c. Hydropower

When the required releases are sufficient for energy generation (greater than 200 cfs) the Santa Clara operator will set the flow

Initial flow, up to 200 cfs, will be passed through the bypass gate (gate Numbers 3 or 4). When the flow exceeds 200 cfs the turbine/generator will be started. After the unit is synchronized, the gate will be closed as the unit is loaded. On manual shutdown the gate will be opened, as the unit is unloaded, after a horn has sounded for 10 minutes. On automatic shutdown of the unit, the gate will be opened after the horn has sounded for 10 minutes.

As long as the plant is generating normally there will be no signal to bypass. If the plant is shut down by a City operator, he will concurrently initiate the bypass sequence described above. If the plant shuts down automatically due to detection of mechanical problems the following sequence of events will happen automatically:

(1) The signal to bypass will be received by the controller at the outlet works control structure.

(2) Movement of the preselected gate will be delayed for 10 minutes, while both an audible alarm and visible indicator are activated inside the outlet works control structure. An audible alarm will be mounted near the outlet portal of the tunnel. These alarms will alert any Corps personnel (or the general public) present that the Gate is going to open. Two large signs will be mounted near the outlet portal, visible to the general public, that water releases will occur after the audible alarm has sounded for 10 minutes.

(3) After the 10 minute delay, the gate controller determines the start position of the Gate, activates the gate; and begins measuring the gate movement.

(4) The electrical signal to begin gate movement actuates the hydraulic pump and operates the solenoid valves -- opening the gate.

(5) The audible alarm will shut off automatically. The visible indicator will remain lit until the bypass gate has reached its selected position and the hydraulic system is shut off.

(6) An analog signal of actual gate position and position indicating lights for this activity will be displayed at the City of Santa Clara's remote station, at Black Butte powerhouse, and at the outlet works control structure.

(7) When the gate opening matches the pre-programmed setting, the controller closes the solenoid valves and shuts off the hydraulic pump.

The automatic bypass system operation will also include three major safety mechanisms. The first, a limit switch, will be included to deactivate the system and send a trouble signal to the Santa Clara operator if the selected bypass gate reaches its maximum open position before the pre-programmed amount of movement is met. Second, there will be a timer to time the entire open or close operation of the gate. If the selected time limit expires before completion of the desired gate movement, the system will be deactivated and a trouble signal will be sent to the Santa Clara operator for coordination with the Corps. Third, an emergency stop command can be initiated by the City.

Corps of Engineers Manual Override of Bypass Operations

Control and Data Acquisition) message will be displayed at the City's remote [redacted] The City of Santa Clara will communicate with the Corps for coordination of operations.

10. REPORTS

The reservoir operator shall report the following data via the Hydrologic Automatic Data Acquisition Network to the Reservoir Control Section each day prior to 0730 hours:

a. Reservoir stage as of midnight.
b. Reservoir stage as of 0700 hours.
c. Pan evaporation as of 0700 hours..
d. Daily precipitation at the dam as measured at 0700 hours.
e. East Park Reservoir storage for current day.
f. Stony Gorge Reservoir storage for current day.
g. Stony Gorge Release for current day.
h. Downstream Glenn Colusa Irrigation District demand to Stony Creek.
i. Climate anemometer reading.
j. Minimum temperature observation previous day at Black Butte Dam.
k. Maximum temperature observation previous day at Black Butte Dam.
l. Stage Stony Creek below Black Butte stream gage as of 0700 hours.
m. Stage South Diversion below Dam stream gage as of 0700 hours.
n. Flow diverted by Wackerman Ranch Diversion.

More frequent reports of the above information and reports of other data will be made in the same manner when requested by Reservoir Control Section. Forms furnished to the operators are to be used in computing the above information.

Immediately after the end of each month, the reservoir operator will send to the Reservoir Control Section all original forms used for observations and computations.

11. SPECIAL WATER AND FLOOD REPORTS

During the flood season from 1 October to 1 May, the reservoir operator shall call the Reservoir Control Section whenever any of the following occurs:

a. One inch or more of rainfall occurs at the project during any 6-hour period or 1.5 inches of rainfall during any 24-hour period.

b. An increase of inflow of 3,000 cfs or more during any 8-hour period.

Any special report based on one of the above criteria should include the latest available data concerning the other two items. On non-working days or at night, these special reports should be telephoned directly to the Chief of the Reservoir Control Section or his designated alternative.

12. EMERGENCY NOTIFICATION

For serious emergencies such as eminent dam failure, an emergency notification plan is maintained at the Black Butte Dam Project Office. The park manager is responsible for implementing the emergency notification plan; however, such notification should be coordinated with the Reservoir Control Section, if possible.

13. MODIFICATION OF REGULATIONS

The reservoir operator may take emergency departures from the regulations in this manual as required by operating equipment failures, accidents such as drownings, or other emergencies that require immediate action. The Reservoir Control Section of the Army Corps of Engineers, Sacramento District, should be notified of such departures as soon as possible. The District Engineer, Sacramento District, U.S. Army Corps of Engineers, may make temporary modifications to these regulations. Permanent changes are subject to approval by Division Engineer, South Pacific Division, U.S. Army Corps of Engineers.

AREA, in 1000 Acres

0 .4 .8 1.2 1.6 2.0 2.4 2.8 3.2 3.6 4.0 4.4 4.8 5.2 5.6 6.0 6.4 6.8

ELEVATION, in Feet, MSL

520 500 480 460 440 420 400 380 360

Top of Dam

Gross Pool

Inactive Pool
Elev. 414.6 ft

AREA

CAPACITY

0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300

CAPACITY, in 1000 Acre-Feet

BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

AREA AND CAPACITY CURVES
BLACK BUTTE LAKE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

CHART A-1-1

AREA, in 1000 Acres

0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60

860
840
820
800
780
760
740
720

ELEVATION, in Feet, MSL

Top of Dam

Gross Pool

AREA

CAPACITY

Inactive Pool
Elev. 744.23 ft.

0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60

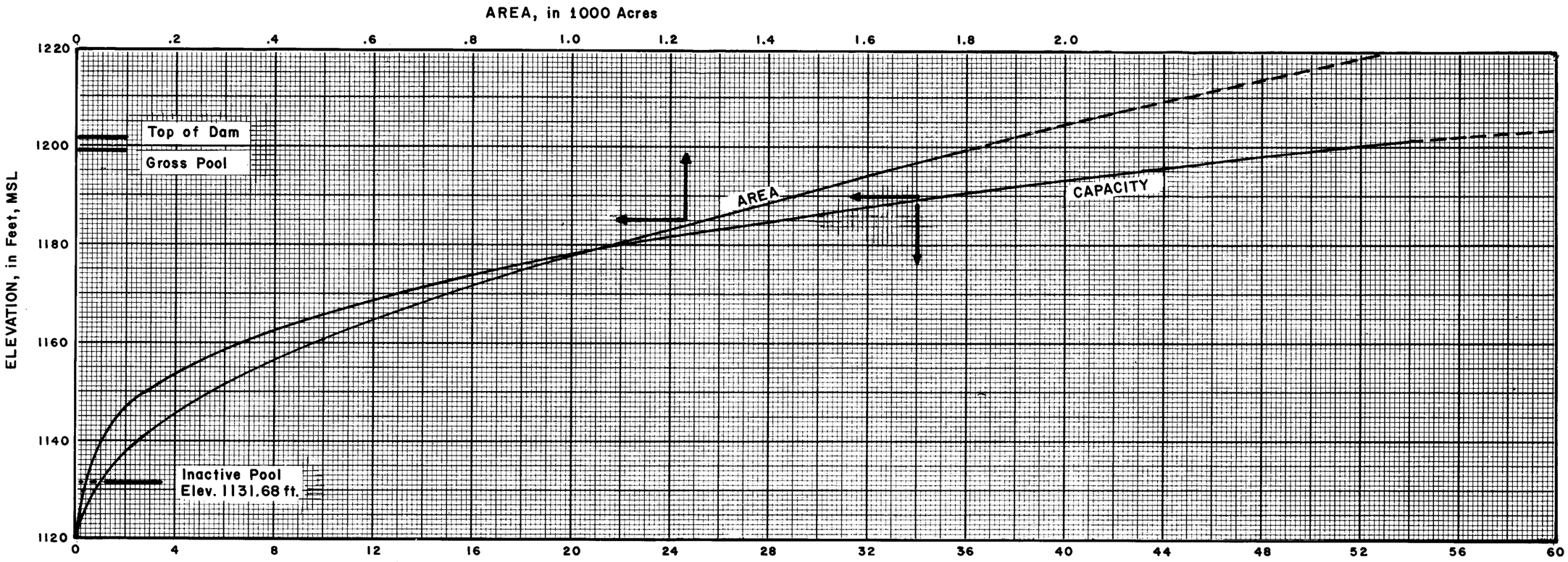
CAPACITY, in 1000 Acre-Feet

BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

**AREA AND CAPACITY CURVES
STONY GORGE RESERVOIR**

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

CHART A-1-2



BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

AREA AND CAPACITY CURVES
EAST PARK RESERVOIR

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

CHART A-1-3

BLACK BUTTE LAKE
AREA AND CAPACITY TABLE

CAPACITIES OF BLACK BUTTE LAKE — STONY CREEK, CALIFORNIA

ELEVATION FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	DIFF.
					ACRE-FEET						
380	4	5	5	6	6	7	8	8	9	10	7
381	11	11	12	13	14	15	16	17	18	19	9
382	20	21	23	24	25	26	28	29	31	32	14
383	34	35	37	39	40	42	44	46	48	50	18
384	52	54	56	58	60	62	65	67	69	72	22
385	74	77	80	82	85	88	91	94	97	100	29
386	103	106	109	112	116	119	122	126	130	133	34
387	137	141	145	149	153	157	161	165	169	173	41
388	178	182	187	191	196	201	206	211	216	221	48
389	226	231	236	242	247	253	258	264	270	276	56
390	282	288	294	300	306	313	319	326	332	339	64
391	346	353	360	367	374	382	389	396	404	412	73
392	419	427	435	443	452	460	468	477	485	494	84
393	503	512	521	530	539	548	558	567	577	587	94
394	597	607	617	627	637	648	658	669	680	691	105
395	702	713	724	736	747	759	771	783	795	807	118
396	820	832	845	857	870	883	896	910	923	937	130
397	950	964	978	992	1,007	1,021	1,036	1,050	1,065	1,080	145
398	1,095	1,111	1,126	1,142	1,158	1,174	1,190	1,206	1,222	1,239	161
399	1,256	1,273	1,290	1,307	1,324	1,342	1,360	1,377	1,396	1,414	176
400	1,432	1,451	1,470	1,488	1,508	1,527	1,546	1,566	1,586	1,606	194
401	1,626	1,646	1,667	1,688	1,709	1,730	1,751	1,773	1,794	1,816	212
402	1,838	1,861	1,883	1,906	1,929	1,952	1,975	1,999	2,022	2,046	232
403	2,070	2,095	2,119	2,144	2,169	2,194	2,220	2,245	2,271	2,297	253
404	2,323	2,350	2,377	2,404	2,431	2,458	2,486	2,514	2,542	2,570	276
405	2,599	2,627	2,656	2,686	2,715	2,745	2,775	2,805	2,836	2,866	298
406	2,897	2,929	2,960	2,992	3,024	3,056	3,088	3,121	3,154	3,187	324
407	3,221	3,255	3,289	3,323	3,358	3,392	3,427	3,463	3,498	3,534	350
408	3,571	3,607	3,644	3,681	3,718	3,756	3,794	3,832	3,870	3,909	377
409	3,948	3,987	4,027	4,067	4,107	4,148	4,188	4,229	4,271	4,312	407
410	4,355	4,397	4,439	4,482	4,525	4,569	4,613	4,657	4,701	4,746	436
411	4,791	4,837	4,883	4,929	4,975	5,022	5,069	5,116	5,164	5,212	469
412	5,260	5,309	5,358	5,407	5,457	5,507	5,558	5,608	5,659	5,711	503
413	5,763	5,815	5,867	5,920	5,973	6,027	6,081	6,135	6,189	6,244	537
414	6,300	6,355	6,412	6,468	6,525	6,582	6,640	6,697	6,756	6,814	574
415	6,874	6,933	6,993	7,053	7,113	7,174	7,236	7,298	7,360	7,422	611
416	7,485	7,548	7,612	7,676	7,741	7,806	7,871	7,936	8,002	8,069	651
417	8,136	8,203	8,271	8,339	8,408	8,477	8,546	8,616	8,686	8,757	692
418	8,828	8,899	8,971	9,044	9,116	9,190	9,263	9,337	9,412	9,487	734
419	9,562	9,638	9,714	9,791	9,868	9,946	10,024	10,102	10,181	10,260	778
420	10,340	10,420	10,501	10,582	10,664	10,746	10,829	10,912	10,995	11,079	824
421	11,164	11,248	11,334	11,420	11,506	11,593	11,680	11,768	11,856	11,945	870
422	12,034	12,123	12,214	12,304	12,395	12,487	12,579	12,672	12,764	12,858	918
423	12,952	13,047	13,142	13,237	13,333	13,430	13,527	13,625	13,722	13,821	968
424	13,920	14,020	14,120	14,220	14,322	14,423	14,525	14,628	14,731	14,835	1,019
425	14,939	15,044	15,149	15,255	15,361	15,468	15,575	15,683	15,792	15,901	1,071
426	16,010	16,120	16,231	16,342	16,454	16,566	16,679	16,792	16,906	17,020	1,125
427	17,135	17,251	17,367	17,483	17,601	17,718	17,836	17,955	18,075	18,195	1,180
428	18,315	18,436	18,558	18,680	18,803	18,926	19,050	19,174	19,299	19,425	1,236
429	19,551	19,678	19,805	19,933	20,062	20,191	20,320	20,450	20,581	20,713	1,294
430	20,845	20,977	21,110	21,244	21,378	21,513	21,649	21,785	21,921	22,059	1,352

BLACK BUTTE LAKE (CONT'D)
AREA AND CAPACITY TABLE

CAPACITIES OF BLACK BUTTE LAKE — STONY CREEK, CALIFORNIA

ELEVATION FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	DIFF.
					ACRE-FEET						
431	22,197	22,335	22,474	22,614	22,754	22,895	23,036	23,178	23,321	23,464	1,411
432	23,608	23,753	23,898	24,043	24,190	24,337	24,484	24,632	24,781	24,931	1,473
433	25,081	25,231	25,383	25,534	25,687	25,840	25,994	26,148	26,303	26,459	1,534
434	26,615	26,772	26,929	27,087	27,246	27,406	27,565	27,726	27,787	28,049	1,597
435	28,212	28,375	28,539	28,703	28,869	29,034	29,201	29,368	29,535	29,704	1,661
436	29,873	30,042	30,213	30,383	30,555	30,728	30,900	31,074	31,248	31,423	1,726
437	31,599	31,775	31,951	32,129	32,307	32,486	32,665	32,845	33,026	33,208	1,791
438	33,390	33,572	33,756	33,940	34,125	34,310	34,496	34,683	34,870	35,058	1,857
439	35,247	35,437	35,627	35,817	36,009	36,201	36,394	36,588	36,782	36,977	1,925
440	37,172	37,368	37,565	37,763	37,961	38,160	38,359	38,560	38,761	38,963	1,993
441	39,165	39,368	39,572	39,776	39,981	40,187	40,393	40,601	40,808	41,017	2,061
442	41,226	41,436	41,647	41,858	42,070	42,283	42,496	42,711	42,925	43,141	2,131
443	43,357	43,574	43,792	44,010	44,229	44,449	44,669	44,890	45,112	45,334	2,201
444	45,558	45,781	46,006	46,231	46,457	46,684	46,912	47,140	47,368	47,598	2,271
445	47,829	48,059	48,291	48,523	48,757	48,991	49,225	49,461	49,696	49,933	2,342
446	50,171	50,409	40,648	50,887	51,127	51,369	51,610	51,853	52,095	52,340	2,413
447	52,584	52,829	53,076	53,322	53,570	53,818	54,067	54,317	54,567	54,818	2,486
448	55,070	55,322	55,576	55,829	56,084	56,340	56,596	56,853	57,110	57,368	2,558
449	57,628	57,887	58,148	58,409	58,671	58,934	59,197	59,461	59,726	59,992	2,630
450	60,258	60,525	60,793	61,061	61,331	61,601	61,871	62,143	62,415	62,688	2,704
451	62,962	63,236	63,512	63,787	64,064	64,341	64,619	64,898	65,177	65,458	2,777
452	65,739	66,021	66,303	66,586	66,871	67,156	67,441	67,727	68,014	68,302	2,851
453	68,590	68,879	69,169	69,459	69,751	70,043	70,336	70,630	70,924	71,219	2,925
454	71,515	71,811	72,109	72,407	72,706	73,006	73,305	73,607	73,908	74,211	3,000
455	74,515	74,818	75,123	75,428	75,735	76,042	76,350	76,658	76,967	77,277	3,073
456	77,588	77,900	78,212	78,525	78,839	79,153	79,468	79,785	80,101	80,419	3,149
457	80,737	81,056	81,376	81,696	82,017	82,340	82,662	82,986	83,310	83,635	3,224
458	83,961	84,287	84,614	84,942	85,271	85,601	85,931	86,262	86,593	86,926	3,299
459	87,260	87,593	87,928	88,264	88,600	88,938	89,275	89,614	89,953	90,293	3,374
460	90,634	90,975	91,318	91,661	92,005	92,350	92,695	93,041	93,387	93,735	3,450
461	94,084	94,433	94,783	95,133	95,485	95,838	96,190	96,544	96,898	97,254	3,526
462	97,610	97,966	98,324	98,682	99,041	99,401	99,761	100,123	100,485	100,848	3,602
463	101,212	101,576	101,941	102,307	102,674	103,041	103,409	103,778	104,147	104,518	3,678
464	104,890	105,261	105,635	106,007	106,382	106,758	107,133	107,510	107,887	108,265	3,754
465	108,644	109,024	109,404	109,785	110,167	110,550	110,933	111,318	111,702	112,089	3,832
466	112,476	112,862	113,251	113,639	114,029	114,420	114,811	115,203	115,595	115,989	3,908
467	116,384	116,778	117,174	117,570	117,968	118,366	118,765	119,165	119,565	119,966	3,985
468	120,369	120,771	121,175	121,578	121,984	122,390	122,796	123,204	123,612	124,021	4,062
469	124,431	124,841	125,253	125,664	126,077	126,491	126,905	127,321	127,736	128,153	4,140
470	128,571	128,989	129,408	129,827	130,248	130,670	131,092	131,515	131,938	132,363	4,218
471	132,789	133,214	133,642	134,069	134,497	134,927	135,356	135,788	136,219	136,651	4,296
472	137,085	137,518	137,953	138,388	138,825	139,262	139,699	140,138	140,577	141,018	4,374
473	141,459	141,900	142,343	142,786	143,231	143,676	144,121	144,568	145,015	145,463	4,453
474	145,912	146,361	146,812	147,263	147,715	148,169	148,622	149,076	149,531	149,987	4,533
475	150,445	150,901	151,360	151,819	152,279	152,740	153,201	153,664	154,127	154,591	4,611
476	155,056	155,521	155,988	156,454	156,923	157,392	157,861	158,331	158,802	159,274	4,691
477	159,747	160,220	160,695	161,170	161,646	162,123	162,600	163,079	163,557	164,038	4,772
478	164,519	165,000	165,483	165,965	166,449	166,935	167,420	167,906	168,393	168,881	4,852
479	169,371	169,860	170,351	170,841	171,334	171,827	172,320	172,815	173,309	173,806	4,932
480	174,303	174,800	175,299	175,798	176,299	176,800	177,301	177,804	178,307	178,812	5,014

BLACK BUTTE LAKE - (CONT'D)
AREA AND CAPACITY TABLE

CAPACITIES OF BLACK BUTTE LAKE — STONY CREEK, CALIFORNIA

ELEVATION FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	DIFF.
						ACRE-FEET					
481	179,317	179,822	180,329	180,836	181,345	181,855	182,364	182,875	183,386	183,899	5,095
482	184,412	184,926	185,441	185,956	186,473	186,991	187,508	188,027	188,546	189,067	5,177
483	189,589	190,111	190,634	191,157	191,683	192,209	192,734	193,262	193,789	194,318	5,260
484	194,849	195,378	195,910	196,441	196,975	197,509	198,043	198,579	199,114	199,652	5,341
485	200,190	200,728	201,268	201,808	202,349	202,892	203,434	203,978	204,552	205,068	5,424
486	205,614	206,160	206,709	207,257	207,807	208,357	208,908	209,460	210,012	210,566	5,507
487	211,121	211,676	212,232	212,788	213,347	213,906	214,464	215,025	215,585	216,148	5,590
488	216,711	217,274	217,839	218,403	218,970	219,537	220,104	220,673	221,242	221,813	5,673
489	222,384	222,955	223,528	224,101	224,676	225,252	225,827	226,404	226,981	227,560	5,756
490	228,140	228,719	229,301	229,882	230,465	231,049	231,633	232,218	232,804	233,391	5,839
491	233,979	234,567	235,157	235,746	236,337	236,930	237,521	238,115	238,709	239,304	5,922
492	239,901	240,497	241,095	241,692	242,292	242,893	243,492	244,095	244,696	245,300	6,004
493	245,905	246,509	247,115	247,721	248,329	248,938	249,546	250,156	250,766	251,378	6,086
494	251,991	252,603	253,217	253,831	254,447	255,064	255,681	256,299	256,917	257,537	6,167
495	258,158	258,778	259,401	260,023	260,647	261,272	261,896	262,523	263,149	263,777	6,248
496	264,406	265,034	265,665	266,294	266,927	267,559	268,192	268,826	269,460	270,096	6,327
497	270,733	271,369	272,008	272,645	273,285	273,926	274,566	275,208	275,850	276,494	6,405
498	277,138	277,782	278,428	279,074	279,722	280,370	281,018	281,668	282,317	282,968	6,483
499	283,621	284,272	284,926	285,579	286,234	286,890	287,545	288,203	288,859	289,518	

STONY GORGE RESERVOIR
AREA AND CAPACITY TABLE

CAPACITIES OF STONY GORGE RESERVOIR — STONY CREEK, CALIFORNIA

ELEVATION FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	DIFF.
					ACRE-FEET						
728	0	0	0	0	0	0	0	0	0	0	0
729	0	0	0	0	0	0	0	0	1	1	0
730	1	1	1	1	1	1	1	1	1	1	0
731	1	2	2	2	2	2	2	2	2	3	2
732	3	3	3	3	3	3	4	4	4	4	1
733	4	4	5	5	5	5	5	5	6	6	2
734	6	6	6	7	7	7	7	7	8	8	2
735	8	8	9	9	9	9	10	10	10	10	3
736	11	11	11	11	12	12	12	13	13	13	2
737	13	14	14	14	15	15	15	16	16	16	4
738	17	17	17	18	18	18	19	19	19	20	3
739	20	21	21	21	22	22	22	23	23	24	4
740	24	24	25	25	26	26	27	27	28	28	5
741	29	29	30	31	31	32	33	33	34	35	7
742	36	36	37	38	39	40	40	41	42	43	8
743	44	45	46	47	48	49	50	51	52	53	10
744	54	56	57	58	59	60	61	63	64	65	12
745	66	68	69	70	72	73	75	76	77	79	14
746	80	82	83	85	86	88	90	91	93	94	16
747	96	98	99	101	103	105	106	108	110	112	18
748	114	115	117	119	121	123	125	127	129	131	19
749	133	135	137	139	141	143	145	147	150	152	21
750	154	156	158	161	163	166	168	171	173	176	24
751	178	181	184	187	190	193	196	199	202	205	30
752	208	211	214	218	221	225	228	232	235	239	34
753	242	246	250	254	258	262	266	270	274	278	40
754	282	286	290	295	299	304	308	313	317	322	44
755	326	331	336	341	346	351	356	361	366	371	50
756	376	381	386	392	397	403	408	414	419	425	54
757	430	436	442	448	454	460	466	472	478	484	60
758	490	496	502	509	515	522	528	535	541	548	64
759	554	561	568	575	582	589	596	603	610	617	70
760	624	631	639	646	654	661	669	677	685	692	77
761	701	709	717	725	734	742	751	760	768	777	85
762	786	795	804	814	823	832	842	852	861	871	95
763	881	891	901	911	921	932	942	953	963	974	104
764	985	996	1,007	1,018	1,029	1,040	1,051	1,063	1,074	1,086	113
765	1,098	1,110	1,121	1,133	1,145	1,158	1,170	1,182	1,195	1,207	122
766	1,220	1,233	1,245	1,258	1,271	1,284	1,297	1,311	1,324	1,337	131
767	1,351	1,365	1,378	1,392	1,406	1,420	1,434	1,448	1,462	1,477	140
768	1,491	1,506	1,520	1,535	1,550	1,565	1,580	1,595	1,610	1,625	150
769	1,641	1,656	1,672	1,687	1,703	1,719	1,735	1,751	1,767	1,783	158
770	1,799	1,815	1,832	1,848	1,865	1,882	1,899	1,916	1,933	1,951	169
771	1,968	1,986	2,003	2,021	2,039	2,057	2,075	2,094	2,112	2,131	181
772	2,149	2,168	2,187	2,206	2,225	2,244	2,264	2,283	2,303	2,323	193
773	2,342	2,362	2,383	2,403	2,423	2,444	2,464	2,485	2,506	2,527	206
774	2,548	2,569	2,590	2,612	2,633	2,655	2,677	2,699	2,721	2,743	217
775	2,765	2,788	2,810	2,833	2,856	2,879	2,902	2,925	2,948	2,971	230
776	2,995	3,018	3,042	3,066	3,090	3,114	3,138	3,163	3,187	3,212	241
777	3,236	3,261	3,286	3,311	3,336	3,362	3,387	3,413	3,438	3,464	254
778	3,490	3,516	3,542	3,569	3,595	3,622	3,648	3,675	3,702	3,729	266
779	3,756	3,783	3,811	3,838	3,866	3,894	3,921	3,949	3,977	4,006	278
780	4,034	4,062	4,091	4,120	4,149	4,178	4,207	4,236	4,265	4,295	290

STONY GORGE RESERVOIR — (CONT'D)
AREA AND CAPACITY TABLE

CAPACITIES OF STONY GORGE RESERVOIR — STONY CREEK, CALIFORNIA

ELEVATION FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	DIFF.
					ACRE-FEET						
781	4,324	4,354	4,384	4,413	4,443	4,474	4,504	4,534	4,565	4,595	302
782	4,626	4,657	4,688	4,719	4,750	4,782	4,813	4,845	4,877	4,908	314
783	4,940	4,973	5,005	5,037	5,070	5,102	5,135	5,168	5,201	5,234	327
784	5,267	5,300	5,334	5,367	5,401	5,435	5,468	5,502	5,537	5,571	338
785	5,605	5,640	5,674	5,709	5,744	5,779	5,814	5,849	5,885	5,920	351
786	5,956	5,992	6,027	6,063	6,099	6,136	6,172	6,208	6,245	6,287	362
787	6,318	6,355	6,392	6,430	6,467	6,504	6,542	6,580	6,617	6,655	375
788	6,693	6,731	6,770	6,808	6,846	6,885	6,924	6,963	7,002	7,041	387
789	7,080	7,119	7,159	7,198	7,238	7,278	7,318	7,358	7,398	7,439	399
790	7,479	7,520	7,560	7,601	7,642	7,684	7,725	7,767	7,808	7,850	413
791	7,892	7,935	7,977	8,020	8,062	8,105	8,148	8,191	8,235	8,278	430
792	8,322	8,366	8,410	8,454	8,499	8,543	8,588	8,633	8,678	8,723	447
793	8,769	8,814	8,860	8,906	8,952	8,998	9,045	9,091	9,138	9,185	463
794	9,232	9,279	9,326	9,374	9,422	9,470	9,518	9,566	9,614	9,663	479
795	9,711	9,760	9,809	9,859	9,908	9,958	10,007	10,057	10,107	10,157	497
796	10,208	10,258	10,309	10,360	10,411	10,462	10,514	10,565	10,617	10,669	513
797	10,721	10,773	10,825	10,878	10,931	10,983	11,036	11,090	11,143	11,197	529
798	11,250	11,304	11,358	11,412	11,467	11,521	11,576	11,631	11,686	11,741	546
799	11,796	11,852	11,908	11,963	12,019	12,076	12,132	12,188	12,245	12,302	563
800	12,359	12,416	12,474	12,531	12,589	12,647	12,705	12,763	12,821	12,880	579
801	12,938	12,997	13,056	13,115	13,174	13,234	13,293	13,353	13,413	13,473	596
802	13,534	13,594	13,655	13,715	13,776	13,837	13,899	13,960	14,022	14,083	611
803	14,145	14,207	14,270	14,332	14,395	14,457	14,520	14,583	14,646	14,710	628
804	14,773	14,837	14,901	14,965	15,029	15,094	15,158	15,223	15,288	15,353	645
805	15,418	15,483	15,549	15,614	15,680	15,746	15,812	15,878	15,945	16,012	660
806	16,078	16,145	16,212	16,280	16,347	16,415	16,483	16,551	16,619	16,687	677
807	16,755	16,824	16,893	16,962	17,031	17,100	17,169	17,239	17,309	17,379	694
808	17,449	17,519	17,589	17,660	17,730	17,801	17,872	17,944	18,015	18,086	709
809	18,158	18,230	18,302	18,374	18,447	18,519	18,592	18,665	18,738	18,811	726
810	18,884	18,957	19,031	19,105	19,179	19,253	19,328	19,402	19,477	19,552	743
811	19,627	19,702	19,778	19,854	19,929	20,005	20,082	20,158	20,235	20,311	761
812	20,388	20,466	20,543	20,620	20,698	20,776	20,854	20,932	21,011	21,089	780
813	21,168	21,247	21,326	21,405	21,485	21,564	21,644	21,724	21,805	21,885	798
814	21,966	22,046	22,127	22,208	22,290	22,371	22,453	22,535	22,617	22,699	815
815	22,781	22,864	22,947	23,030	23,113	23,196	23,280	23,363	23,447	23,531	835
816	23,616	23,700	23,785	23,869	23,954	24,039	24,125	24,210	24,296	24,382	852
817	24,468	24,554	24,641	24,727	24,814	24,901	24,988	25,075	25,163	25,251	870
818	25,338	25,426	25,515	25,603	25,692	25,780	25,869	25,959	26,048	26,137	889
819	26,227	26,317	26,407	26,497	26,588	26,678	26,769	26,860	26,951	27,042	907
820	27,134	27,226	27,318	27,410	27,502	27,594	27,687	27,780	27,873	27,966	925
821	28,059	28,153	28,246	28,340	28,434	28,528	28,623	28,717	28,812	28,907	943
822	29,002	29,098	29,193	29,289	29,385	29,481	29,577	29,674	29,770	29,867	962
823	29,964	30,061	30,158	30,256	30,354	30,451	30,550	30,648	30,746	30,845	980
824	30,944	31,043	31,147	31,241	31,341	31,440	31,540	31,640	31,740	31,841	997
825	31,941	32,042	32,143	32,244	32,346	32,447	32,549	32,651	32,753	32,855	1,017
826	32,958	33,060	33,163	33,266	33,369	33,472	33,576	33,680	33,784	33,888	1,034
827	33,992	34,096	34,201	34,306	34,411	34,516	34,621	34,727	34,832	34,938	1,052
828	35,044	35,151	35,257	35,364	35,470	35,577	35,685	35,792	35,900	36,007	1,071
829	36,115	36,223	36,331	36,440	36,548	36,657	36,766	36,875	36,985	37,094	1,089
830	37,204	37,314	37,424	37,534	37,645	37,755	37,866	37,977	38,088	38,200	1,107

STONY GORGE RESERVOIR — (CONT'D)
AREA AND CAPACITY TABLE

CAPACITIES OF STONY GORGE RESERVOIR — STONY CREEK, CALIFORNIA

ELEVATION FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	DIFF.
					ACRE-FEET						
831	38,311	38,423	38,535	38,647	38,759	38,871	38,984	39,097	39,210	39,323	1,125
832	39,436	39,550	39,664	39,778	39,892	40,006	40,120	40,235	40,350	40,465	1,144
833	40,580	40,695	40,811	40,926	41,042	41,158	41,275	41,391	41,508	41,625	1,162
834	41,742	41,859	41,976	42,094	42,211	42,329	42,447	42,566	42,684	42,803	1,179
835	42,921	43,040	43,160	43,279	43,399	43,518	43,639	43,758	43,879	43,999	1,199
836	44,120	44,240	44,361	44,483	44,604	44,725	44,847	44,969	45,091	45,213	1,216
837	45,336	45,459	45,581	45,704	45,828	45,951	46,074	46,198	46,322	46,445	1,234
838	46,570	46,685	46,819	46,944	47,069	47,194	47,320	47,445	47,571	47,697	1,253
839	47,823	47,949	48,076	48,202	48,329	48,456	48,583	48,711	48,838	48,966	1,271
840	49,094	49,222	49,350	49,479	49,607	49,736	49,865	49,994	50,124	50,253	1,289
841	50,383	50,513	50,643	50,773	50,904	51,034	51,165	51,296	51,427	51,559	1,307
842	51,690	51,822	51,954	52,086	52,218	52,351	52,484	52,616	52,749	52,883	1,326
843	53,016	53,149	53,283	53,417	53,551	53,685	53,820	53,955	54,089	54,224	1,344
844	54,360	54,495	54,631	54,766	54,902	55,038	55,175	55,311	55,448	55,584	1,361
845	55,721	55,859	55,996	56,134	56,271	56,409	56,547	56,686	56,824	56,963	1,381
846	57,102	57,241	57,380	57,519	57,659	57,798	57,938	58,078	58,219	58,359	1,398
847	58,500										

EAST PARK RESERVOIR
AREA AND CAPACITY TABLE

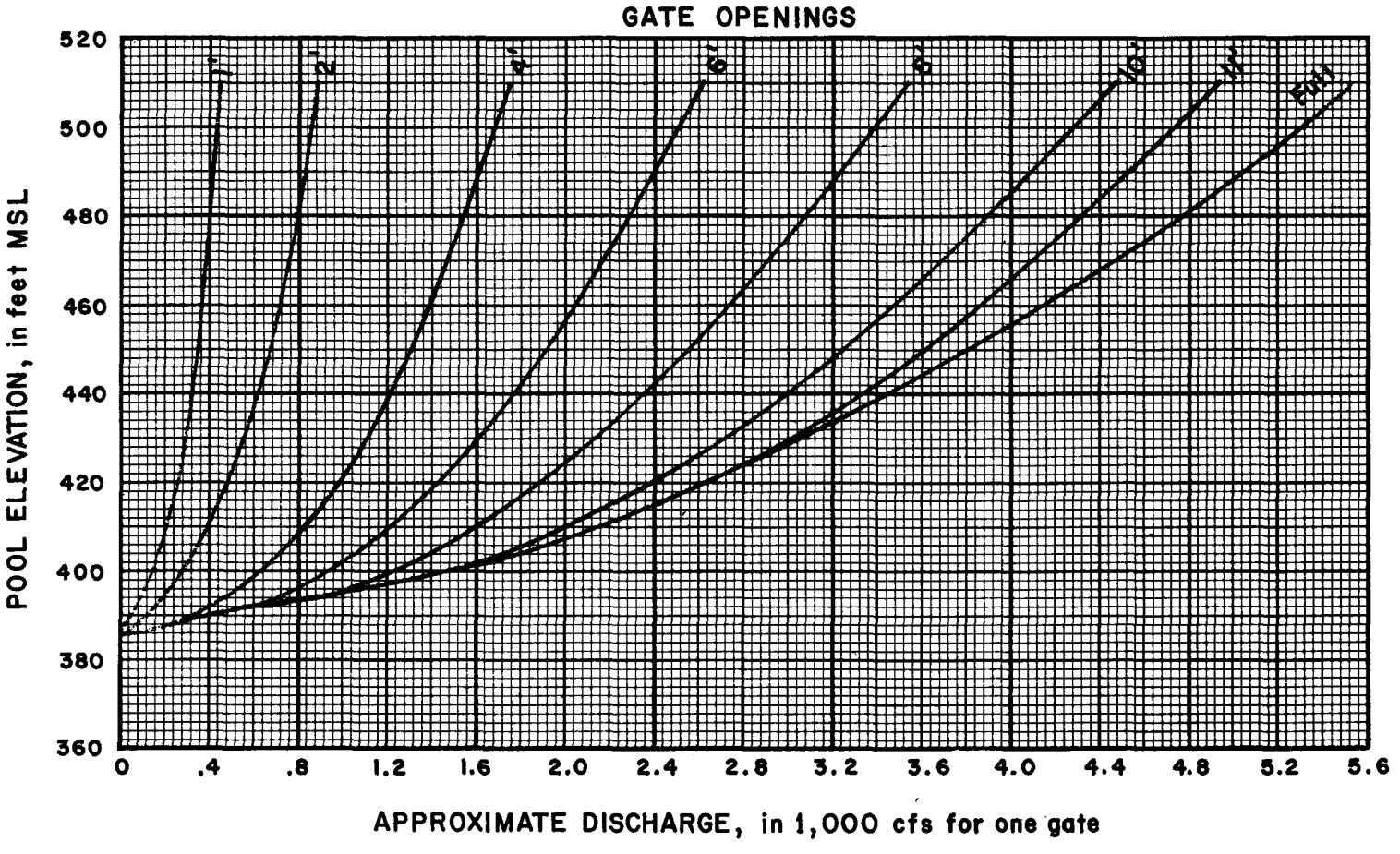
CAPACITIES OF EAST PARK RESERVOIR — STONY CREEK, CALIFORNIA

ELEVATION FEET	.0	.1	.2	.3	.4	.5	.6	7	.8	.9	DIFF.
					ACRE-FEET						
1,130	212	215	219	222	226	230	233	237	241	245	37
1,131	249	253	258	262	266	271	275	280	285	290	45
1,132	294	299	304	310	315	320	325	331	336	342	54
1,133	348	353	359	365	371	377	383	390	396	402	61
1,134	409	415	422	429	436	442	449	456	464	471	69
1,135	478	485	493	500	508	516	524	532	540	548	79
1,136	557	565	574	582	591	600	609	618	627	636	89
1,137	646	655	665	675	685	694	705	715	725	735	100
1,138	746	756	767	778	789	800	811	822	834	845	111
1,139	857	868	880	892	904	916	928	940	953	965	121
1,140	978	991	1,004	1,017	1,030	1,043	1,057	1,070	1,084	1,098	134
1,141	1,112	1,126	1,140	1,155	1,169	1,184	1,199	1,214	1,229	1,244	148
1,142	1,260	1,275	1,291	1,307	1,323	1,339	1,355	1,372	1,388	1,405	162
1,143	1,422	1,439	1,456	1,473	1,491	1,508	1,526	1,544	1,561	1,580	176
1,144	1,598	1,616	1,635	1,653	1,672	1,691	1,710	1,729	1,749	1,768	190
1,145	1,788	1,808	1,828	1,848	1,868	1,889	1,909	1,930	1,951	1,972	206
1,146	1,994	2,057	2,037	2,059	2,081	2,103	2,126	2,148	2,171	2,194	223
1,147	2,217	2,240	2,263	2,287	2,311	2,335	2,359	2,383	2,408	2,432	240
1,148	2,457	2,482	2,507	2,532	2,558	2,584	2,609	2,635	2,662	2,688	257
1,149	2,714	2,741	2,768	2,795	2,822	2,850	2,877	2,905	2,933	2,961	275
1,150	2,989	3,017	3,046	3,075	3,104	3,133	3,163	3,192	3,222	3,252	294
1,151	3,283	3,313	3,344	3,375	3,406	3,437	3,469	3,501	3,533	3,565	314
1,152	3,597	3,630	3,663	3,696	3,729	3,762	3,796	3,830	3,864	3,898	335
1,153	3,932	3,967	4,002	4,037	4,072	4,108	4,144	4,180	4,216	4,252	357
1,154	4,289	4,325	4,362	4,400	4,437	4,475	4,512	4,550	4,589	4,627	377
1,155	4,666	4,705	4,744	4,783	4,823	4,862	4,902	4,943	4,983	5,024	399
1,156	5,065	5,106	5,147	5,189	5,231	5,273	5,315	5,357	5,400	5,443	421
1,157	5,486	5,530	5,573	5,617	5,661	5,706	5,750	5,795	5,840	5,885	445
1,158	5,931	5,977	6,022	6,069	6,115	6,162	6,208	6,256	6,303	6,350	467
1,159	6,398	6,446	6,494	6,543	6,591	6,640	6,689	6,739	6,788	6,838	490
1,160	6,888	6,939	6,989	7,040	7,091	7,142	7,194	7,245	7,297	7,350	514
1,161	7,402	7,455	7,508	7,561	7,614	7,668	7,722	7,776	7,831	7,885	538
1,162	7,940	7,996	8,051	8,107	8,163	8,219	8,275	8,332	8,389	8,446	563
1,163	8,503	8,561	8,619	8,677	8,735	8,794	8,853	8,912	8,971	9,031	588
1,164	9,091	9,151	9,211	9,272	9,332	9,393	9,455	9,516	9,578	9,640	611
1,165	9,702	9,765	9,828	9,891	9,954	10,018	10,082	10,146	10,211	10,275	638
1,166	10,340	10,405	10,471	10,537	10,603	10,669	10,736	10,803	10,870	10,937	665
1,167	11,005	11,073	11,141	11,210	11,279	11,348	11,417	11,486	11,556	11,626	692
1,168	11,697	11,768	11,838	11,910	11,981	12,053	12,125	12,197	12,270	12,343	719
1,169	12,416	12,489	12,563	12,637	12,711	12,785	12,860	12,935	13,010	13,086	746
1,170	13,162	13,238	13,314	13,391	13,468	13,545	13,623	13,701	13,779	13,858	775
1,171	13,937	14,016	14,096	14,176	14,256	14,336	14,417	14,498	14,580	14,661	806
1,172	14,743	14,826	14,908	14,991	15,075	15,158	15,242	15,326	15,411	15,496	838
1,173	15,581	15,667	15,752	15,839	15,925	16,012	16,099	16,186	16,274	16,362	869
1,174	16,450	16,539	16,628	16,717	16,807	16,896	16,987	17,077	17,168	17,259	901
1,175	17,351	17,443	17,535	17,627	17,720	17,813	17,907	18,000	18,095	18,189	933
1,176	18,284	18,379	18,475	18,571	18,667	18,764	18,861	18,958	19,056	19,154	968
1,177	19,252	19,351	19,450	19,549	19,649	19,749	19,850	19,951	20,052	20,154	1,004
1,178	20,256	20,358	20,460	20,563	20,667	20,770	20,875	20,979	21,084	21,189	1,038
1,179	21,294	21,400	21,506	21,613	21,719	21,827	21,934	22,042	22,150	22,259	1,074
1,180	22,368	22,477	22,587	22,697	22,807	22,918	23,029	23,141	23,252	23,365	1,109

EAST PARK RESERVOIR — (CONT'D)
AREA AND CAPACITY TABLE

CAPACITIES OF EAST PARK RESERVOIR — STONY CREEK, CALIFORNIA

ELEVATION FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	DIFF.
					ACRE-FEET						
1,181	23,477	23,590	23,713	23,817	23,930	24,045	24,159	24,274	24,390	24,505	1,144
1,182	24,621	24,738	24,854	24,971	25,089	25,207	25,325	25,448	25,562	25,681	1,180
1,183	25,801	25,921	26,041	26,161	26,282	26,404	26,525	26,647	26,769	26,892	1,214
1,184	27,015	27,139	27,262	27,386	27,511	27,636	27,761	27,886	28,012	28,138	1,250
1,185	28,265	28,391	28,518	28,646	28,774	28,903	29,032	29,161	29,291	29,421	1,287
1,186	29,552	29,683	29,814	29,945	30,077	30,210	30,342	30,475	30,609	30,743	1,325
1,187	30,877	31,011	31,146	31,282	31,417	31,553	31,690	31,826	31,963	32,101	1,362
1,188	32,239	32,377	32,516	32,655	32,794	32,934	33,074	33,214	33,355	33,496	1,399
1,189	33,638	33,780	33,922	34,065	34,208	34,351	34,495	34,639	34,784	34,929	1,436
1,190	35,074	35,220	35,366	35,512	35,659	35,806	35,954	36,101	36,250	36,398	1,473
1,191	36,547	36,697	36,846	36,996	37,147	37,298	37,449	37,600	37,752	37,905	1,510
1,192	38,057	38,210	38,364	38,518	38,672	38,826	38,981	39,136	39,292	39,448	1,547
1,193	39,604	39,761	39,918	40,076	40,234	40,392	40,551	40,709	40,869	41,029	1,585
1,194	41,189	41,349	41,510	41,671	41,833	41,995	42,157	42,320	42,483	42,646	1,621
1,195	42,810	42,974	43,138	43,303	43,469	43,634	43,800	43,967	44,133	44,300	1,650
1,196	44,468	44,636	44,804	44,973	45,142	45,311	45,481	45,651	45,821	45,992	1,695
1,197	46,163	46,335	46,507	46,679	46,852	47,025	47,198	47,372	47,546	47,720	1,732
1,198	47,895	48,071	48,246	48,422	48,599	48,775	48,952	49,130	49,308	49,486	1,770
1,199	49,665	49,844	50,023	50,203	50,383	50,563	50,744	50,925	51,107	51,289	1,806
1,200	51,471	51,653	51,836	52,020	52,204	52,388	52,572	52,757	52,942	53,128	1,843
1,201	53,314										



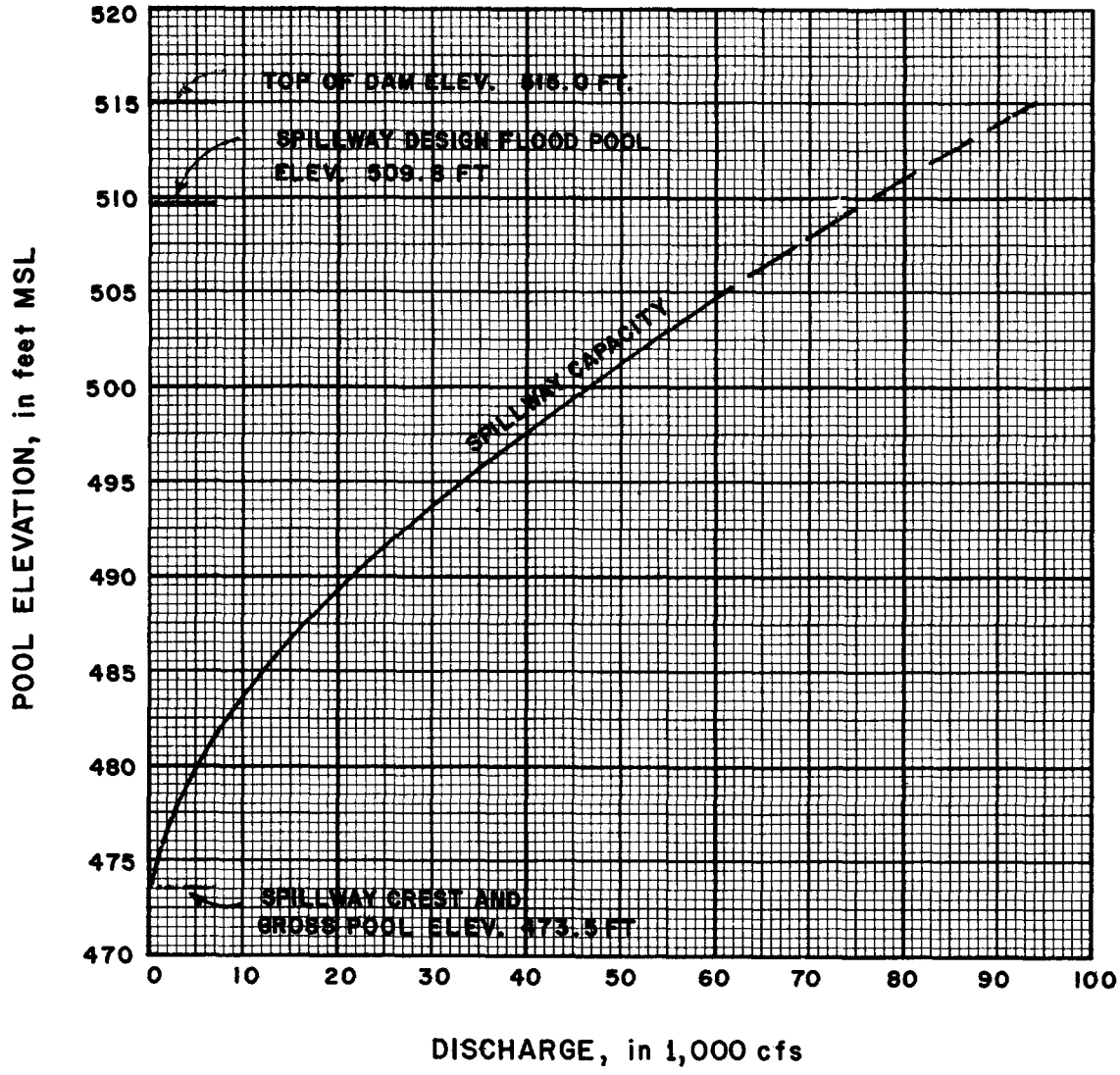
NOTE: To obtain gate opening for any discharge at the existing pool elevation, plot gate openings against discharge and read gate opening required. Curves based on 1/5 of total discharge from 5 gates with equal openings. Curves are subject to revision, and should be used as a guide to plotting actual flow points from operational gaging weir measurements.

BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

OUTLET WORKS
DISCHARGE RATING CURVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

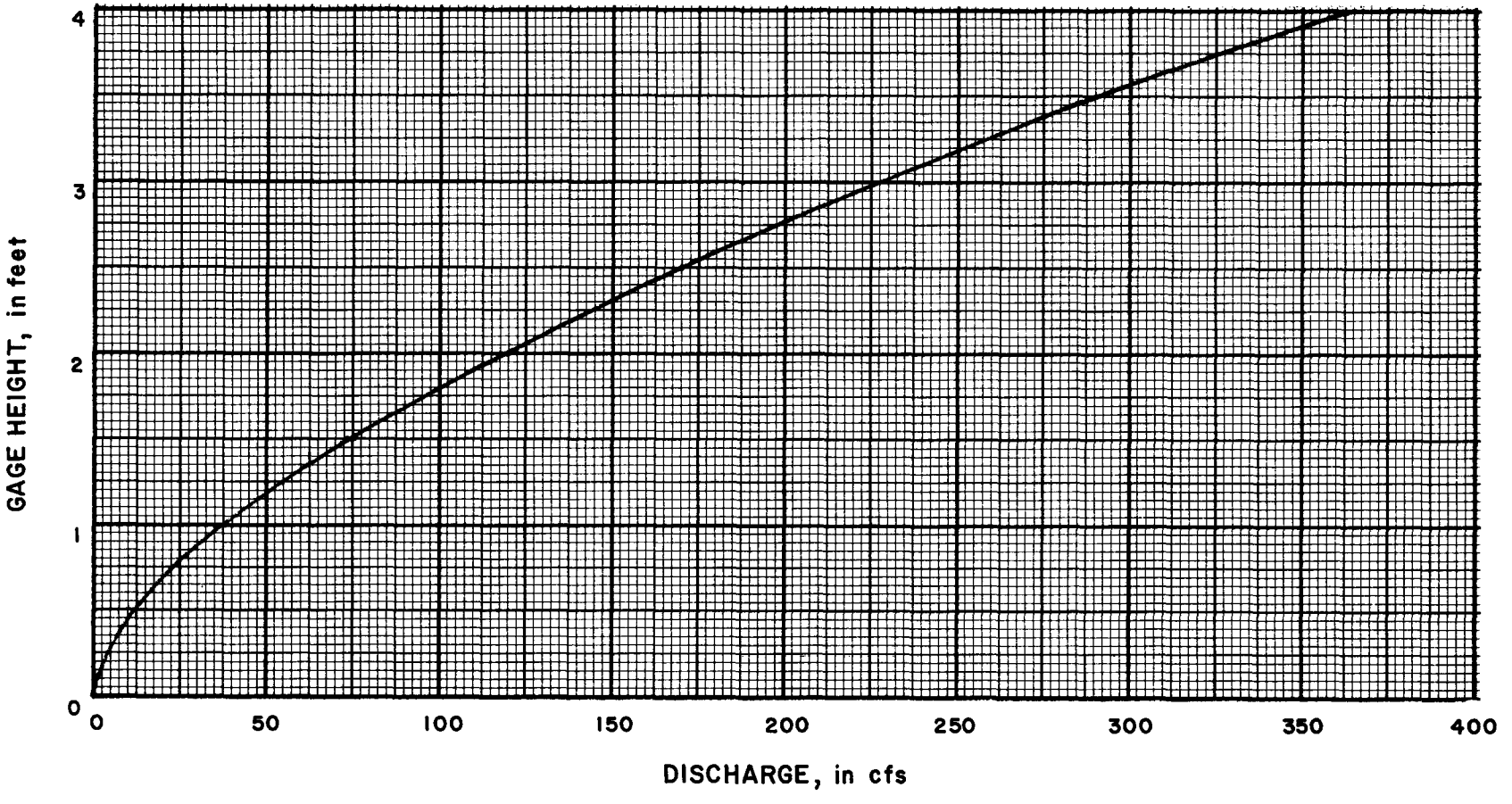
CHART A-3



BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

SPILLWAY RATING CURVE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



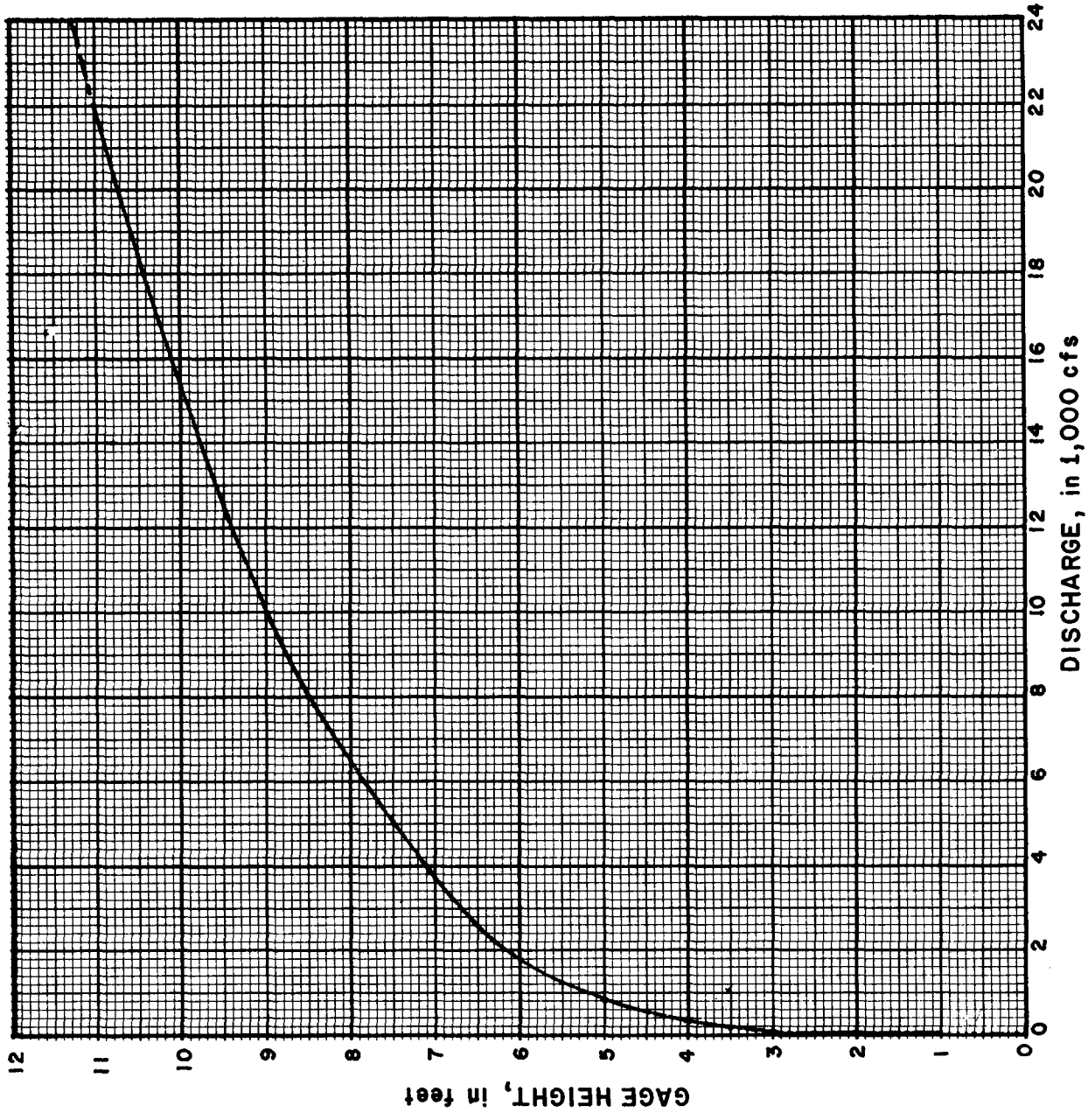
NOTE: RATING FOR UNSUBMERGED PARSHALL FLUME, 10-FT THROAT

BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

DISCHARGE RATING CURVE
SOUTH DIVERSION CANAL
NEAR ORLAND, CA.

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

CHART A-5

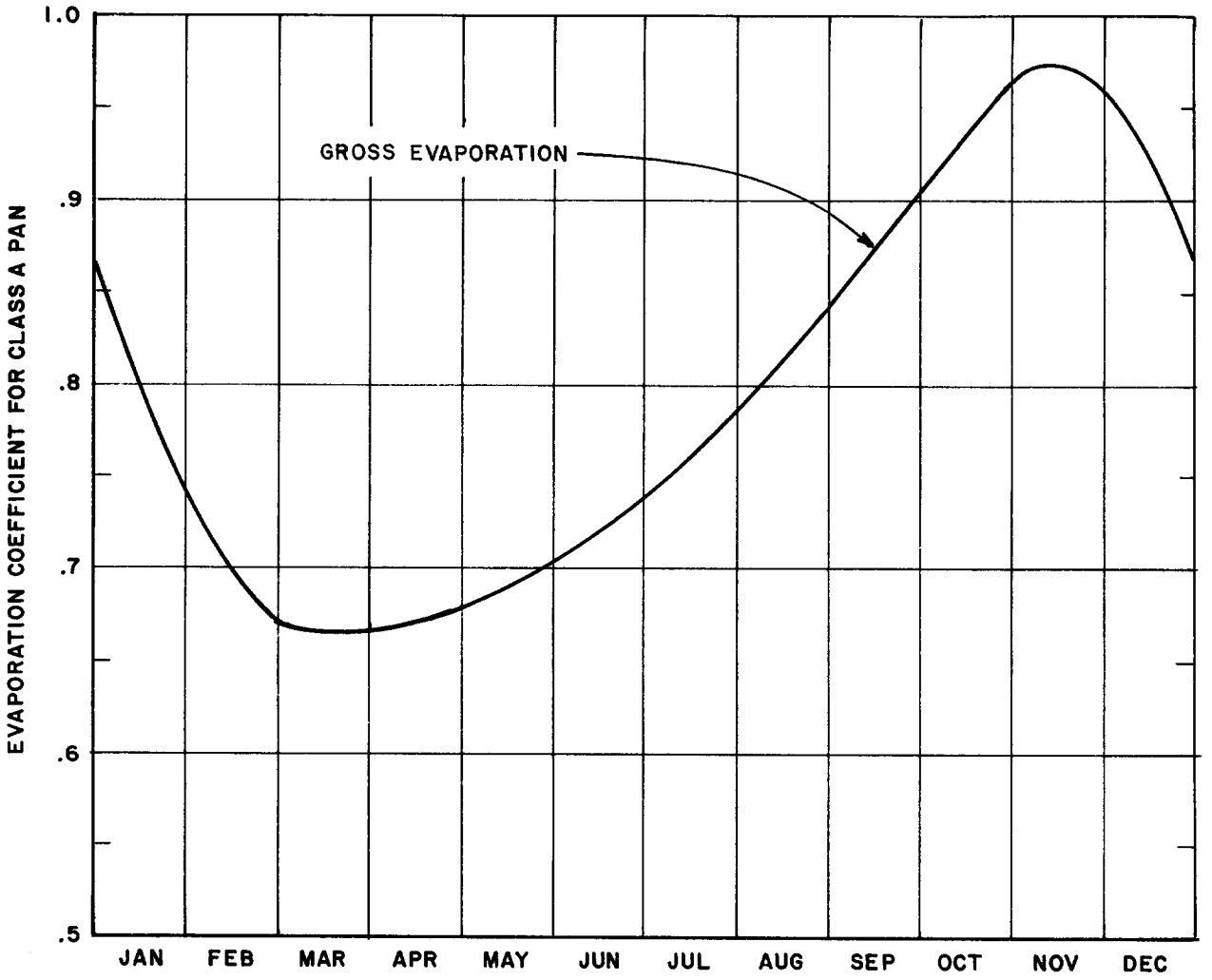


BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

DISCHARGE RATING CURVE
STONY CREEK BELOW BLACK BUTTE
DAM NEAR ORLAND, CA.

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

CHART A-6

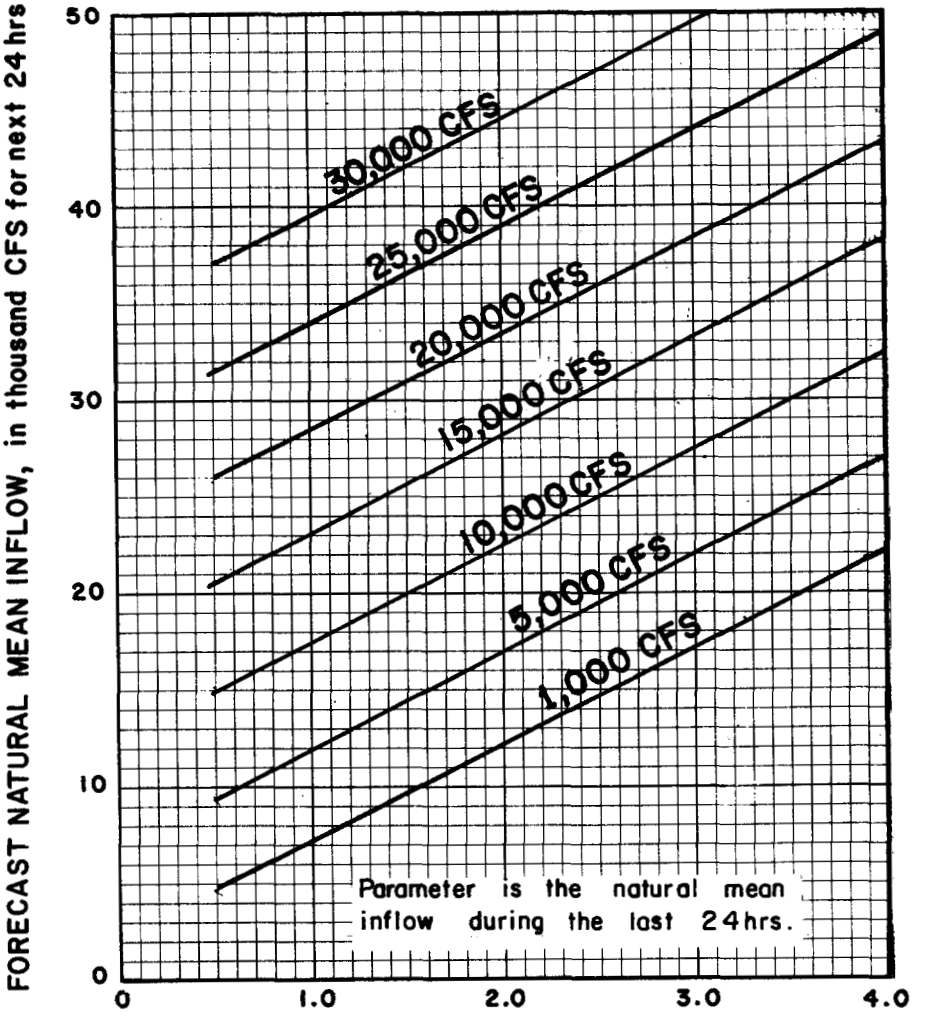


BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

EVAPORATION COEFFICIENTS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

CHART A-7

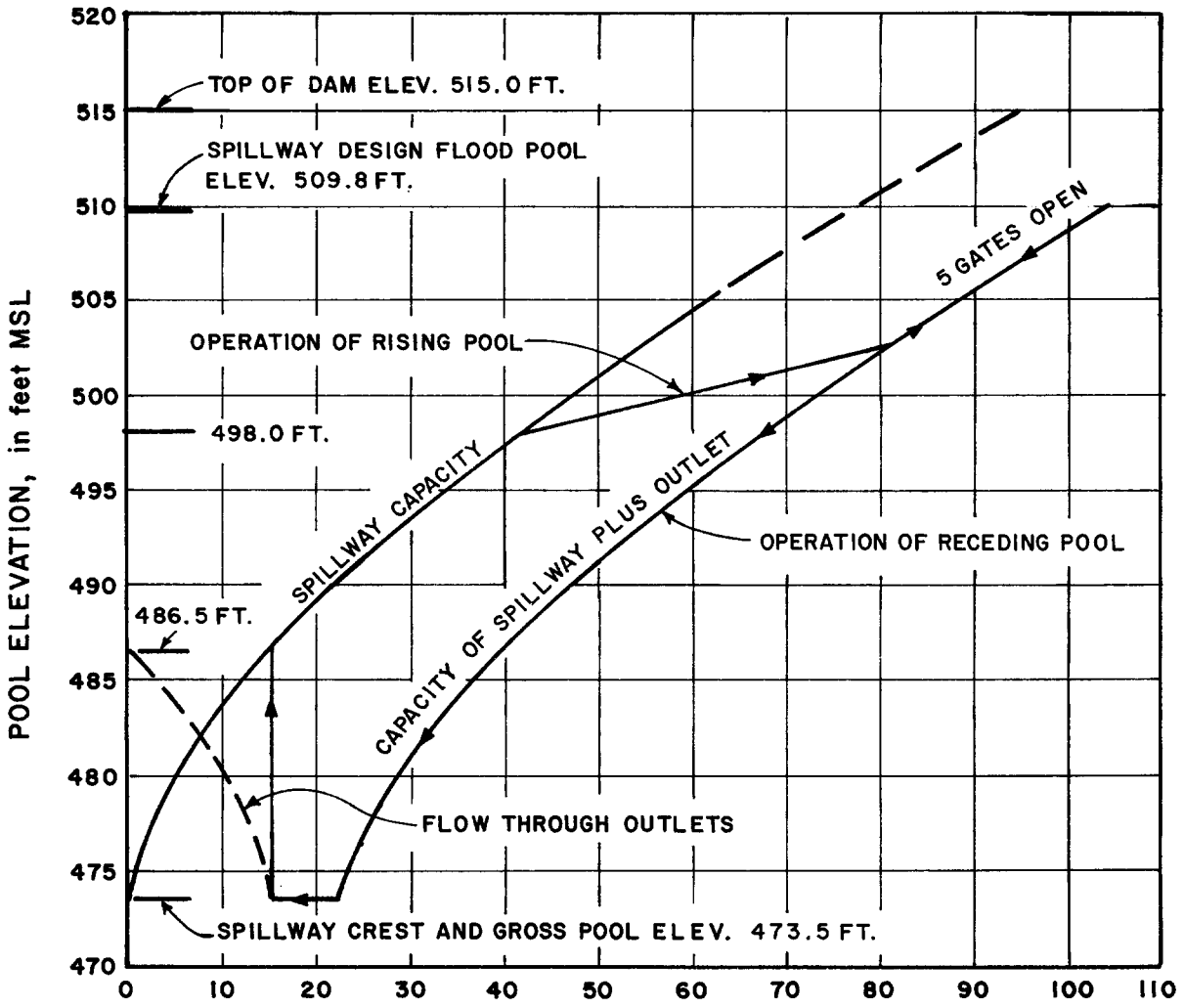


FORECAST BASIN MEAN PRECIPITATION, in inches for next 24 hrs.

BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

RAIN FLOOD FORECAST CRITERIA

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



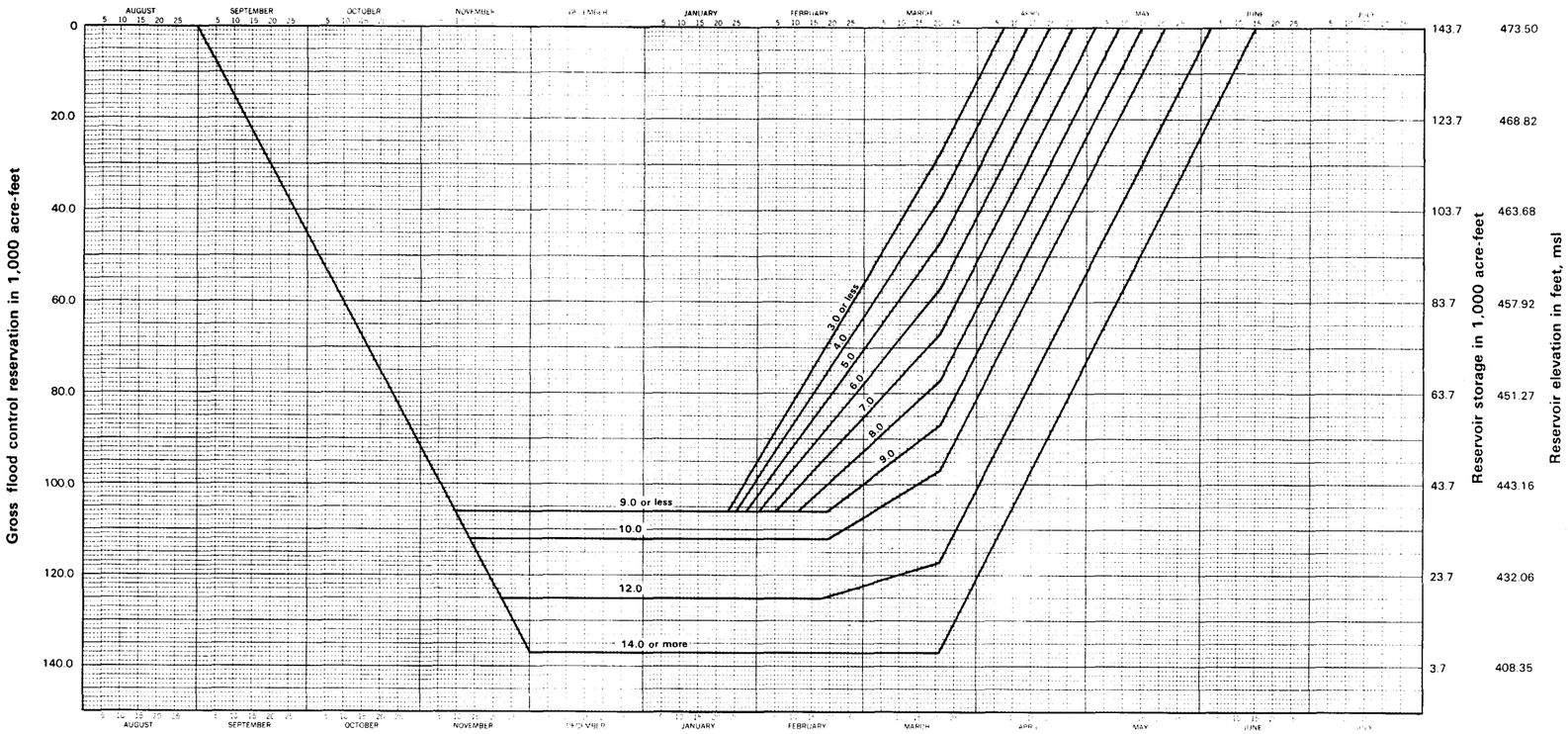
NOTE:

ON RECEDING RESERVOIR STAGES, GATE OPENINGS WILL REMAIN CONSTANT UNTIL GROSS POOL ELEVATION OR 15,000 CFS OUTFLOW IS REACHED.

BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

EMERGENCY OPERATION OF OUTLET GATES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



USE OF DIAGRAM

1. Rain flood parameters define the **gross flood control reservation** required on any given day and are computed daily from the weighted accumulation of the seasonal basin mean precipitation by adding the current day's precipitation in inches to 97 percent of the parameter computed the preceding day. Sample calculation of required space is shown below.

2. Required gross flood control reservation in Black Butte Lake may be reduced by creditable flood control space known to exist in East Park and Stony Gorge Reservoirs.

3. **Creditable transfer flood control space** for East Park and Stony Gorge Reservoirs is determined as follows:

   a. The amount of creditable flood control transfer space in East Park Reservoir is computed by taking the smaller of:

   (1) 48,200 acre-feet minus the present storage at East Park or

   (2) 10,000 acre-feet.

   b. The amount of creditable flood control transfer space in Stony Gorge Reservoir is computed by the following:

   (1) Between 1 September and 1 February — 28,400 acre-feet (storage at spillway crest) minus the present storage at Stony Gorge.

   (2) Remainder of flood control season — 28,400 acre-feet minus the present storage at Stony Gorge, but not less than zero.

   c. Total creditable transfer space is equal to the summation of items 3a and 3b but not to exceed 40,000 acre-feet.

4. The flood control requirement in Black Butte Reservoir is equal to the gross flood control reservation minus the total creditable transfer space.

5. When space available for flood control is less than required, as determined above, water shall be released from Black Butte Lake as rapidly as possible, subject to the following conditions:

   a. That releases are made according to the RELEASE SCHEDULE hereon.

   b. That flows in Stony Creek below Black Butte Dam do not exceed 15,000 cfs.

   c. When Sacramento River flows at the latitude of Ord Ferry are forecasted to exceed 130,000 cfs (a stage of 116.2 feet at the Ord Ferry gage), releases from Black Butte should not be greater than inflow.

   d. That no level of release above 1,000 cfs shall be held for more than 18 hours.

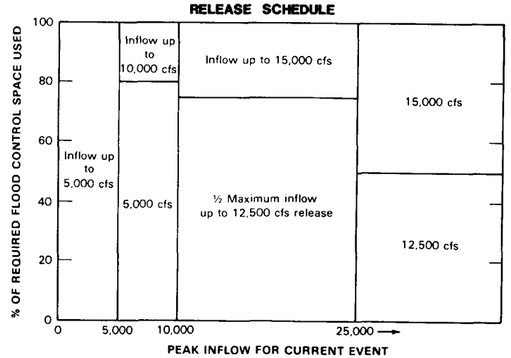
   e. That rate of change for an increase in release shall not be more than 2,000 cfs in any 2-hour interval.

   f. That the rate of change for a decrease in release shall be as follows:

   (1) When existing release is between 15,000 cfs and 5,000 cfs, outflow shall be reduced in 1,000 cfs increments, with no release sustained for less than 2 hours.

   (2) When existing release is between 5,000 cfs and 50 cfs, outflow shall be reduced in 500 cfs increments, with no release sustained for less than 2 hours.

RELEASE SCHEDULE



NOTES

1. Black Butte Lake shall be operated for flood control in accordance with this Flood Control Diagram.

2. Flood control reservation increases uniformly from a zero requirement on 1 September up to a maximum reservation of 137,000 acre-feet by 30 November (a minimum reservation of 106,400 acre-feet is required from 10 November to 23 January). Conditional flood control reservation up to a maximum of 137,000 acre-feet from 30 November to 20 March, decreasing again to zero on 15 June. The required reservation is determined by use of a ground wetness index during this period.

3. Gross flood control reservation is the total storage required for flood control operations within the Stony Creek Basin reservoir system.

4. Transferable space is that amount of space the required flood control reservation can be reduced by available space in upstream reservoirs—East Park and Stony Gorge. The amount of available space that can be credited to transferable space is discussed in the USE OF DIAGRAM.

SAMPLE COMPUTATION OF REQUIRED FLOOD CONTROL SPACE

1. Computation of today's basin precipitation (P) for Black Butte Lake:

PRECIPITATION STATIONS	NAP (IN.)	PRECIPITATION TODAY (P) (IN.)
Black Butte Dam	17.0	.99
Log Springs	34.0	3.00
Trough Springs	49.0	5.10
Noel Springs	42.0	1.40
Alder Springs	34.0	4.00
TOTAL	176.0(SNAP)	14.49(STAP)

Basin Normal Annual Precipitation (BNAP) = 32.0 in.

Basin precipitation computation for today:

$$P = \frac{BNAP}{SNAP}(STAP) = \frac{32.0}{176.0}(14.49)$$

P = 2.63 in.

2. Parameter and Required Flood Control Space Computation

   a. PAR = P + 0.97 PAR'

   where PAR is today's parameter

   PAR' is yesterday's parameter

   P is today's basin precipitation

MONTH	DAY	P (IN.)	PAR' (IN.)	PAR (IN.)	REQUIRED FLOOD CONTROL SPACE* (1,000 A.F.)
OCT	4	—	—	0	50.3
	5	1.78	0	1.78	51.8
	6	1.20	1.78	2.93	53.3
	7	0	2.93	2.84	54.8
DEC	19	—	—	2.49	106.4
	20	.45	2.49	2.87	106.4
	21	1.39	2.87	4.17	106.4
	22	3.83	4.17	7.88	106.4
	23	2.96	7.88	10.60	116.2
	24	.80	10.60	11.08	119.2

*Determined from flood control diagram

BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

FLOOD CONTROL DIAGRAM

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

BLACK BUTTE DAM AND LAKE

STONY CREEK, CALIFORNIA

WATER CONTROL MANUAL

MAY 1987

EXHIBIT B

GENERAL OPERATING OBJECTIVES

STONY CREEK RESERVOIRS

MAY 1971

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

GENERAL OPERATING OBJECTIVES

STONY CREEK RESERVOIRS

The purpose of this statement is to provide general objectives that the U. S. Bureau of Reclamation, in conjunction with the Corps of Engineers and the Orland Unit Water Users' Association will attempt to follow in the operation of Black Butte and Stony Gorge Reservoirs on Stony Creek and East Park Reservoir on Little Stony Creek. These objectives are aimed at providing maximum enhancement to recreation potential and fisheries, maintenance of some minimum stream release and coordinating water releases with local operating interests, subject however, to limitations noted herein.

A. Black Butte Reservoir

1. Black Butte Reservoir level when entering the irrigation season will be the maximum height allowed by flood control regulations (prescribed by the Corps of Engineers) and carry over storage.

2. Releases will be made from Black Butte Reservoir to the Glenn-Colusa Irrigation District (G.C.I.D.) up to 500 c.f.s. for flooding rice fields during the required 3 to 4 weeks (usually in April-May). An attempt will be made to control the fluctuations or change in stream in any 24-hour period to no more than 50 c.f.s. throughout the irrigation season.

3. When the water surface temperature reaches 60 degrees Fahrenheit in the spring, the Black Butte storage level will be limited to a drawdown of 2 feet for a period of 3 weeks. This operation will facilitate the crappie spawning period. In order to accomplish this, a water exchange will be made with the Orland Unit Water Users' Association to replace water released for G.C.I.D. needs or that required for a minimum release beyond the 2-foot allowable drawdown.

4. Except for short term dam or channel maintenance, minimum releases will be made for the maintenance of a live stream downstream for Black Butte. This live stream applys to those periods when higher releases are not required for irrigation or flood control. This minimum release will be in the magnitude of 30 c.f.s. during the next few years.

5. The reservoir will experience a gradual drawdown during the months of June, July and August to satisfy G.C.I.D. irrigation demands. After August 1, to the extent reasonably possible, releases will not exceed 150 c.f.s. when extensive crop harvesting is being accomplished and the creek must be forded.

6. To the extent possible, a minimum reservoir storage of 40,000 acre-feet will be the objective until Labor Day.

7. When water is available and not earmarked for other uses, an exchange will be made with the Orland Unit Water Users' Association transferring 5,000 acre-feet of Bureau of Reclamation water from Black Butte to both East Park and Stony Gorge Reservoirs. This transfer is intended to maintain these reservoirs at the stated minimum pools between the period of irrigation drawdown and the fall rains for fishery enhancement and recreation. This provision is subject to limitations discussed elsewhere herein.

8. A minimum reservoir level of 20,000 acre-feet at Black Butte will be maintained during fall months after Labor Day provided flood parameters or carryover storage do not dictate lower levels. The minimum reservoir level under any condition shall be 6,700 acre-feet.

B. East Park and Stony Gorge

1. When endeavoring to limit Black Butte Reservoir fluctuations to 2-feet as discussed in A. 3, above, necessary exchanges of water will be made with the Orland Unit Water Users' Association. These exchanges are subject, however, to their availability in the Orland Reservoirs.

2. Minimum reservoir levels of 5,000 acre-feet will be the objective storage in East Park and Stony Gorge Reservoirs between the period of irrigation drawdown and the fall rains for fishery enhancement and recreation except in years of water shortage.

3. The maintenance of minimum pools at East Park and Stony Gorge Reservoirs will be accomplished in accordance with the following:

   a. The drawdown of East Park and Stony Gorge will proceed according to irrigation requirements until a content of 5,200 acre-feet is reached in each reservoir (Note: a reservoir content of 5,200-acre-feet should satisfy evaporation and other losses during the period of initation and the fall rains) while maintaining a minimum of 5,000 acre-feet.

b. The Bureau of Reclamation will transfer water from Black Butte Reservoir up to 5,000 acre-feet to each Orland Reservoir to maintain the minimum pools.

c. This operation will be placed into effect each succeeding year provided a dry cycle is not experienced.

d. The first year it is apparent that the entire content of East Park Reservoir can be evacuated (excluding dead storage), Maintenance on the slide gates in the outlet tower will be accomplished. Interested parties will be notified by June 1 of the year the maintenance is planned.

e. It must be understood that the above operation plan does not constitute a right nor is it permanent. Scheduled maintenance at East Park and Stony Gorge Dams and other requirements affecting dam safety may prevent or seriously limit the capability of maintaining 5,000 acre-feet minimum pools in both reservoirs.

BLACK BUTTE DAM AND LAKE

STONY CREEK, CALIFORNIA

WATER CONTROL MANUAL

MAY 1987

EXHIBIT C

INTERIM FLOOD CONTROL PLAN FOR

BLACK BUTTE RESERVOIR DURING IMPLEMENTATION

OF COMPLETE SPILLWAY FIX

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

EXHIBIT C

INTERIM FLOOD CONTROL PLAN FOR
BLACK BUTTE RESERVOIR DURING IMPLEMENTATION
OF COMPLETE SPILLWAY FIX

CONTENTS

CHARTS

BLACK BUTTE DAM AND LAKE
STONY CREEK, CALIFORNIA
WATER CONTROL MANUAL

EXHIBIT C

INTERIM FLOOD CONTROL PLAN FOR BLACK BUTTE RESERVOIR DURING IMPLEMENTATION OF COMPLETE SPILLWAY FIX

1. PURPOSE

This Exhibit provides an interim operational plan for use while a plan for a complete spillway fix at Black Butte Dam is being developed and implemented. Upon completion of the spillway repair this Exhibit is considered superseded and is to be discarded.

2. GENERAL

Two spillway flows have occurred at Black Butte Lake since the dam was constructed. The first spillway flow occurred from 2 March to 5 March 1983 with a peak flow of 1,600 cfs. The second spill occurred during the period 17-20 February 1986 with a maximum flow over the spillway of 3,900 cfs on the 18th. Severe erosion damage to the spillway resulted from these two relatively minor flows. Damage is limited to that portion of the spillway downstream of the concrete sill. However, headward erosion of the spillway is inevitable and could eventually threaten the sill itself.

Geologically large blocks of basalt are being undermined and continued erosion will lead to slumping. Major points are deeply eroded and occasionally expose the underlying volcanic breccia. Continued erosion will create additional large isolated blocks. A substantial amount of the highly fractured basalt has been plucked from the spillway chute. Moreover, the weathering of the cementing agents in the fracture has accelerated this process.

3. CORRECTIVE ACTION

The erosional damage would most likely continue during any future flow over the spillway and eventually the large point blocks of basalt would be undermined. The subsequent headward erosion could ultimately threaten the sill. To slow the erosion of the remaining spillway surface, should any additional flow occur, and insure spillway viability should a long term flood event occur, dental measures are being undertaken during the spring and summer of 1987.

The dental measures consists of partial filling the major joints with concrete to limit further weathering of the cementing agents. In addition, a concrete cutoff will be constructed at the bottom of spillway chute to restrict future headward erosion. These measures will be accomplished during the 1987 construction season.

An investigation report for a complete spillway fix has been initiated and will be completed as soon as practical. At this time complete repair of the spillway is thought to involve a roller compacted concrete chute with an energy dissipator. The report will also examine the cost trade-offs of complete spillway repair versus downstream damages should the spillway fail.

4. INTERIM OPERATION PLAN

In order to lessen the probability of additional spillway flows and resultant erosion a modified reservoir operation plan for flood control was developed for use until a complete fix of the spillway can be accomplished. The interim plan calls for modification of release schedule as contained in Exhibit A, paragraph 9, Charts A-9 and A-10; and paragraph 7-05 in this Manual.

a. Flood Control Operation

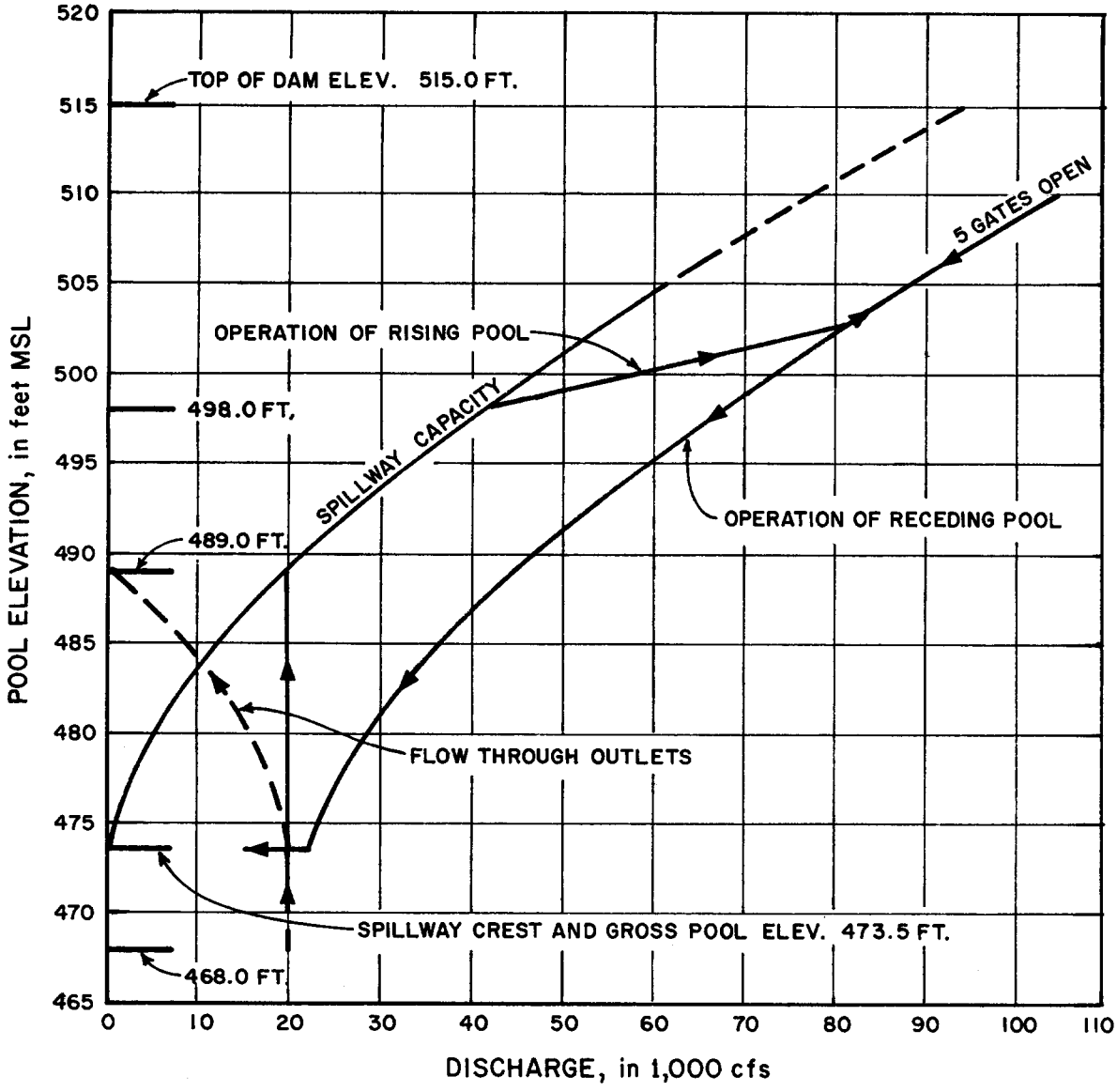
The interim operational plan calls for increasing releases above the 15,000 cfs channel capacity before reaching surcharge operations. When the reservoir pool elevation is below elevation 468.0 feet MSL, approximately 20,000 acre feet below gross pool, flood control operation and releases will be made in accordance with the Flood Control Diagram, Chart A-10. Whenever 0.50 inch or more precipitation has occurred in the last 6 hours, inflow is 15,000 cfs and increasing, and the storage is at elevation 468.0 feet MSL or higher, outflow will be increased to 20,000 cfs.

During floods in which flow over the spillway occurs, the outlet will be operated by gradually closing the outlet gates as the pool rises above gross pool in order to control the total outflow from the spillway and outlet to 20,000 cfs as long as possible (See Chart C-1). When the pool reaches elevation 489.0 feet MSL the gates will be closed. Reservoir regulation will follow surcharge operations when the pool exceeds 498.0 feet MSL and transfer to Flood Control Operation when the pool reaches gross pool elevation 473.5 feet MSL.

b. Surcharge Operation

(1) When the reservoir pool is above elevation 489.0 feet MSL the outlet gates, including the penstock will be closed. Outlet gates will remain closed until the spillway flow exceeds 40,000 cfs, the flow at which appreciable damage begins to the City of Orland. If the pool is expected to continue rising, the outlet gates will be opened one by one at the rate of 20 percent of the total capacity per foot of pool stage rise, beginning at pool stage elevation 498.0 feet MSL. When the pool reaches elevation 503.0 feet MSL the gates will be fully open. (See Chart C-1).

(2) For receding pool, outlet openings will remain constant until a total release of 15,000 cfs (spillway plus outlets) is reached or the reservoir stage has receded to gross pool elevation of 473.5 feet MSL, below which a release rate not to exceed 15,000 cfs will be maintained until the pool has receded to required amount of flood control space.



NOTE:

ON RECEDING RESERVOIR STAGES, GATE OPENINGS WILL REMAIN CONSTANT UNTIL GROSS POOL ELEVATION OR 15,000 CFS OUTFLOW IS REACHED.

BLACK BUTTE LAKE
STONY CREEK, CALIFORNIA

EMERGENCY OPERATION OF OUTLET GATES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

GPO 785-068/76485

CHART C-1