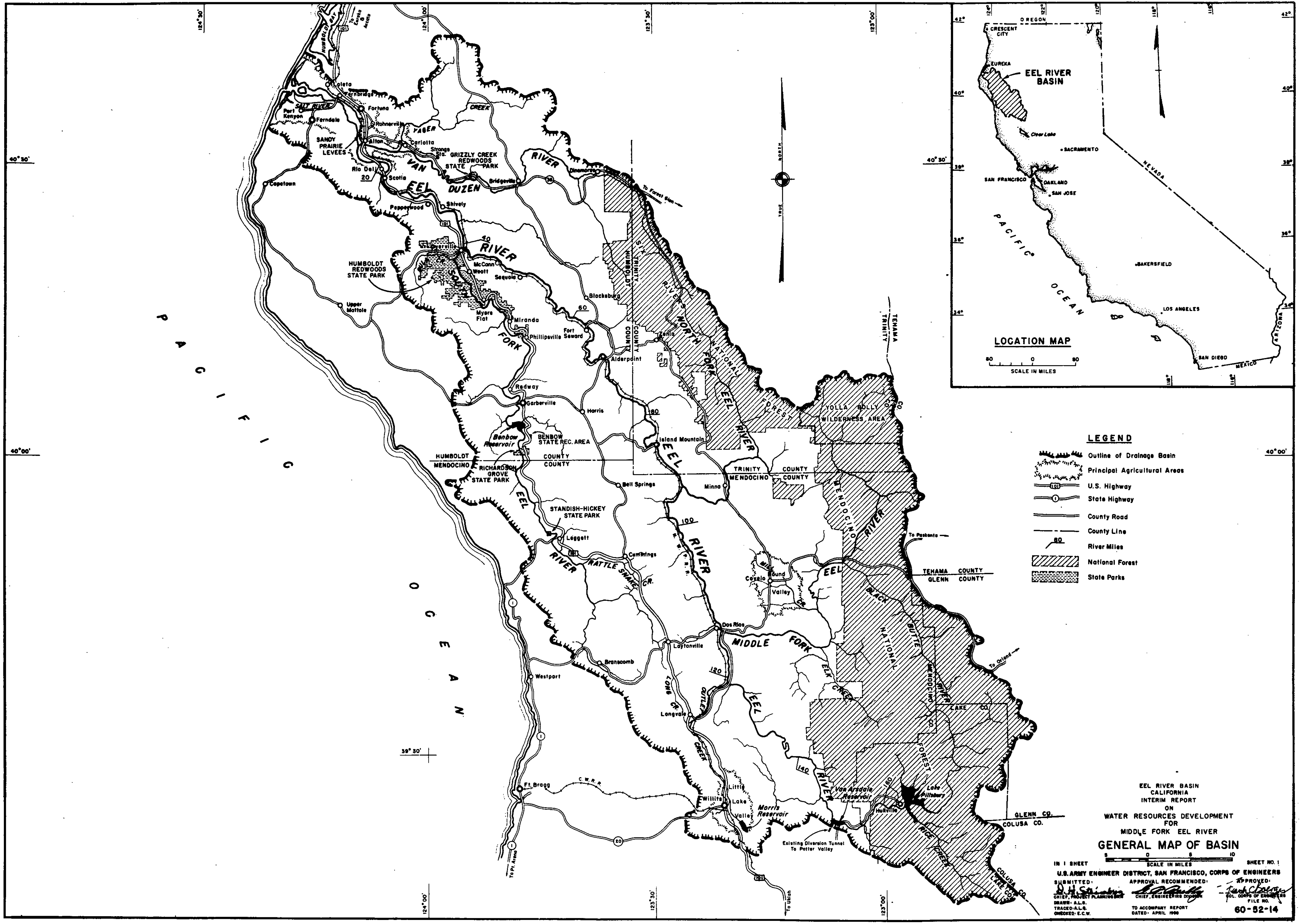


EEL RIVER BASIN
CALIFORNIA
INTERIM REPORT
ON
WATER RESOURCES DEVELOPMENT
FOR
MIDDLE FORK EEL RIVER

# GENERAL MAP OF BASIN

5 0 5 10
SCALE IN MILES

IN 1 SHEET

SHEET NO. 1

U.S. ARMY ENGINEER DISTRICT, SAN FRANCISCO, CORPS OF ENGINEERS

SUBMITTED:
D. H. Steinberg
CHIEF, PROJECT PLANNING BR.

APPROVAL RECOMMENDED:
CHIEF, ENGINEERING DIVISION

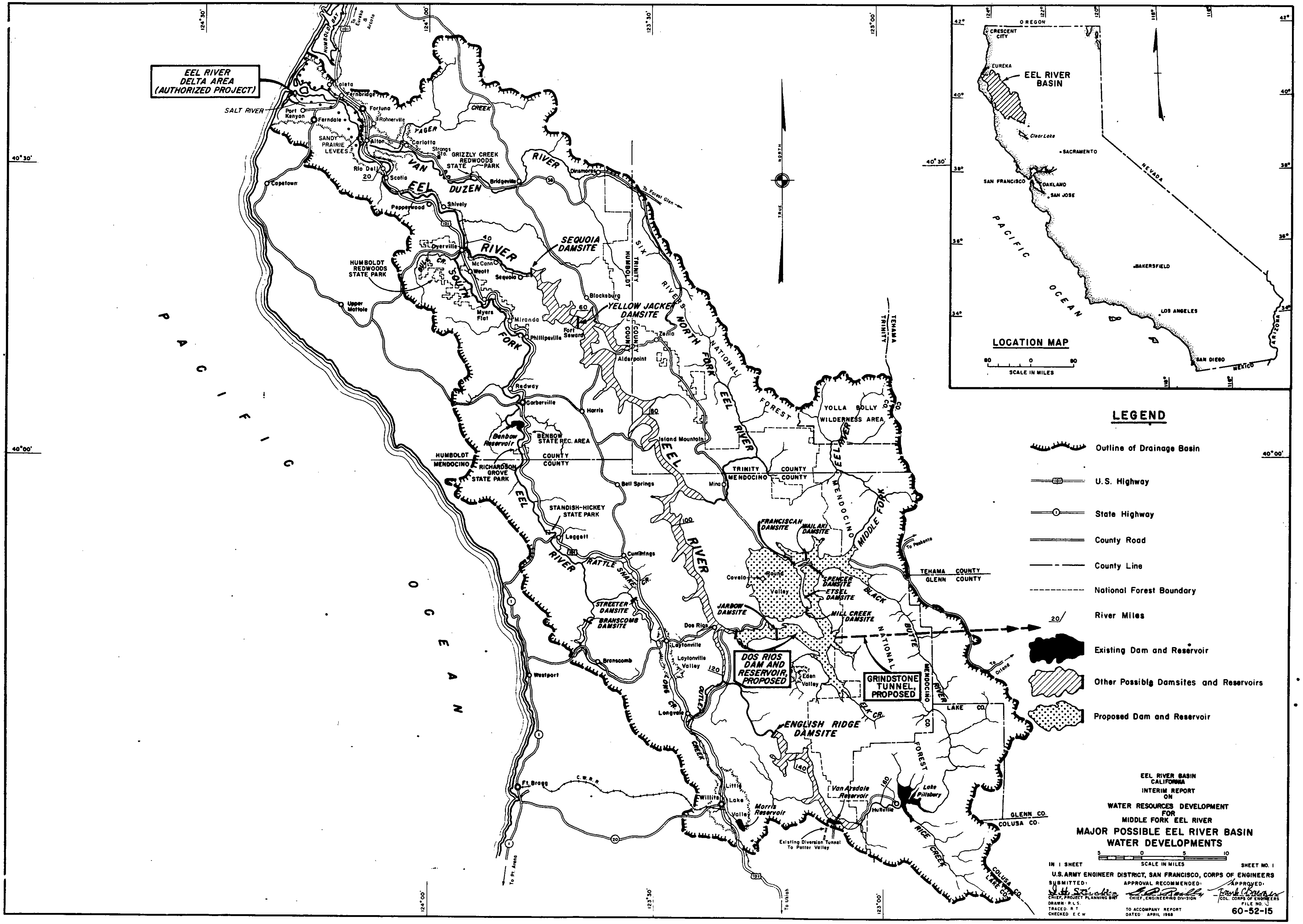
APPROVED:
Frank C. Boerger
COL. CORPS OF ENGINEERS

DRAWN: A.L.G.
TRACED: A.L.G.
CHECKED: E.C.W.

TO ACCOMPANY REPORT
DATED: APRIL 1960

FILE NO.
60-52-14

PLATE I



EEL RIVER BASIN
CALIFORNIA
INTERIM REPORT
ON
WATER RESOURCES DEVELOPMENT
FOR
MIDDLE FORK EEL RIVER

## MAJOR POSSIBLE EEL RIVER BASIN WATER DEVELOPMENTS

5 0 5 10
SCALE IN MILES

IN 1 SHEET
SHEET NO. 1

U.S. ARMY ENGINEER DISTRICT, SAN FRANCISCO, CORPS OF ENGINEERS

SUBMITTED:
CHIEF, PROJECT PLANNING BR.

APPROVAL RECOMMENDED:
CHIEF, ENGINEERING DIVISION

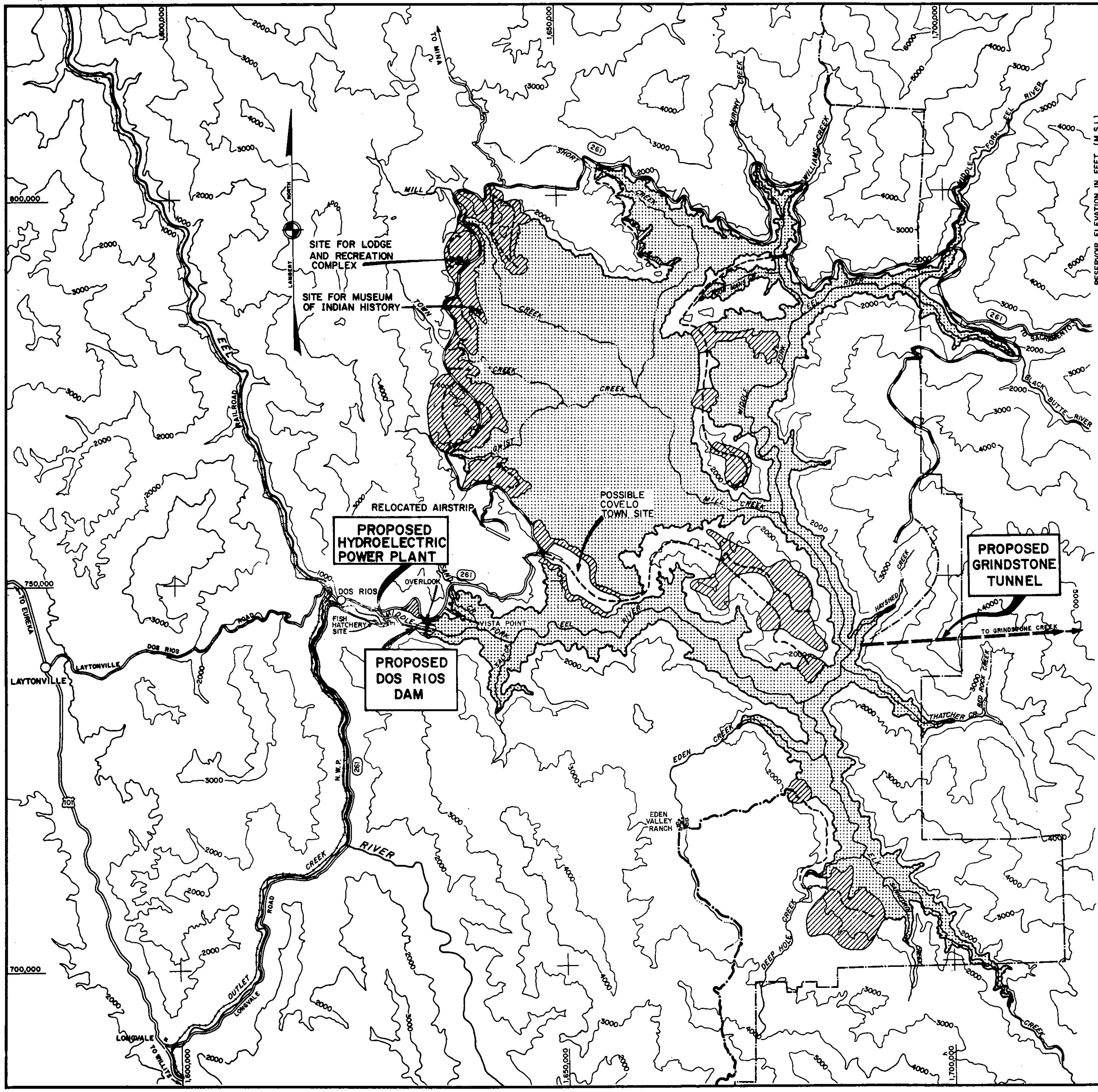
APPROVED:
COL. CORPS OF ENGINEERS

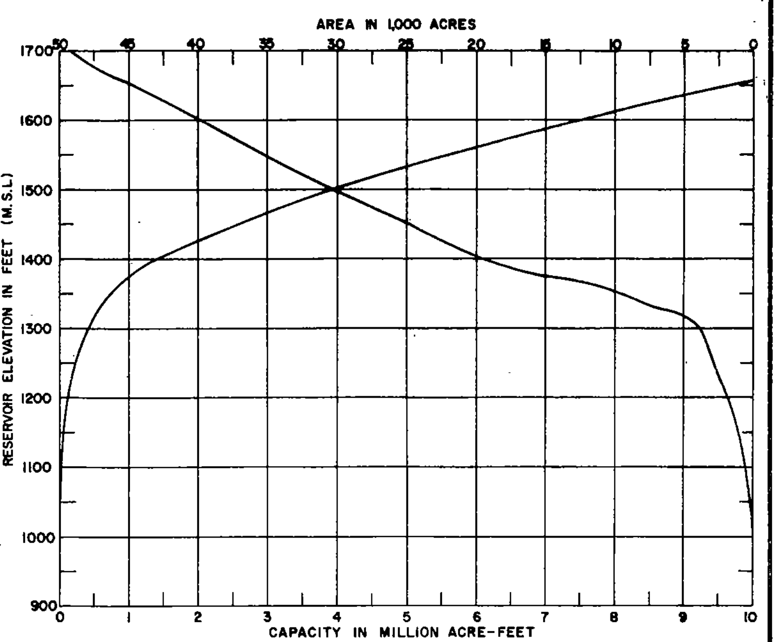
DRAWN: R.L.S.
TRACED: R.T.
CHECKED: E.C.W.

TO ACCOMPANY REPORT
DATED: APRIL 1968

FILE NO.
60-52-15

PLATE 2





AREA CAPACITY CURVE DOS RIOS RESERVOIR
(Including Round Valley)

## LEGEND

- 101 U.S. HIGHWAY
- 261 EXISTING ROAD (Proposed California State Legislative Route)
- —·— NATIONAL FOREST BOUNDARY
- ▒ RESERVOIR AREA
- ━ RELOCATED ROAD
- ▨ RECREATION SITE
- – – RECREATION ACCESS ROAD
- —·— PROPOSED ACCESS ROAD

EEL RIVER BASIN
CALIFORNIA

INTERIM REPORT

WATER RESOURCES DEVELOPMENT
FOR

MIDDLE FORK EEL RIVER

## DOS RIOS
## RESERVOIR MAP

3000 0 3000 6000 9000
SCALE IN FEET

IN 1 SHEET

SHEET NO. 1

U.S. ARMY ENGINEER DISTRICT, SAN FRANCISCO, CORPS OF ENGINEERS

SUBMITTED:
D. M. Steinberg
CHIEF, PROJECT PLANNING BR.

APPROVAL RECOMMENDED:
L. P. Reilly
CHIEF, ENGINEERING DIVISION

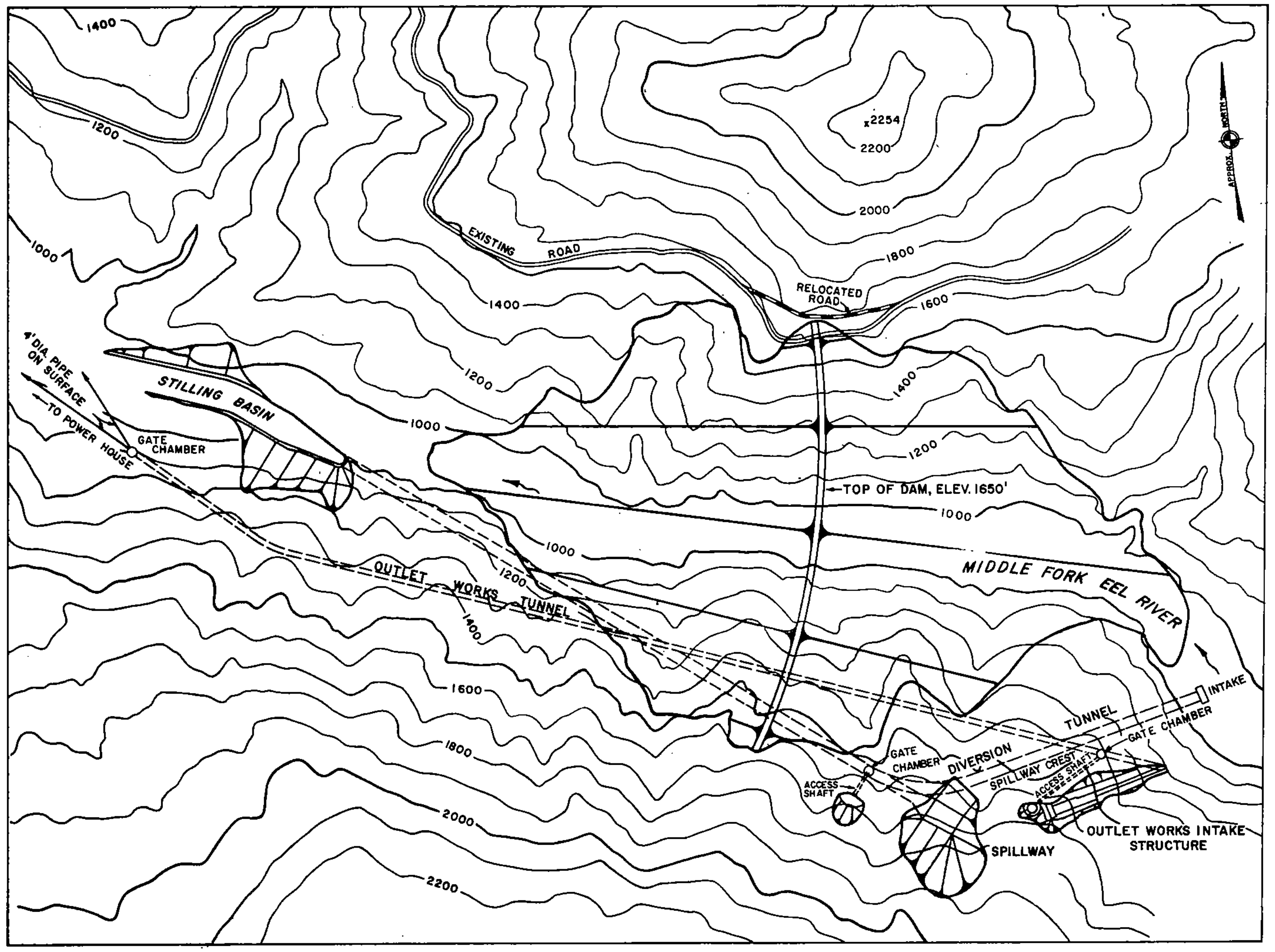
APPROVED:
Frank C. Boerger
COL. CORPS OF ENGINEERS

DRAWN: E.C.W.
TRACED: R.R.K. A.K.S.
CHECKED: E.C.W.

TO ACCOMPANY REPORT
DATED: APRIL 1968

FILE NO.
60-49-1

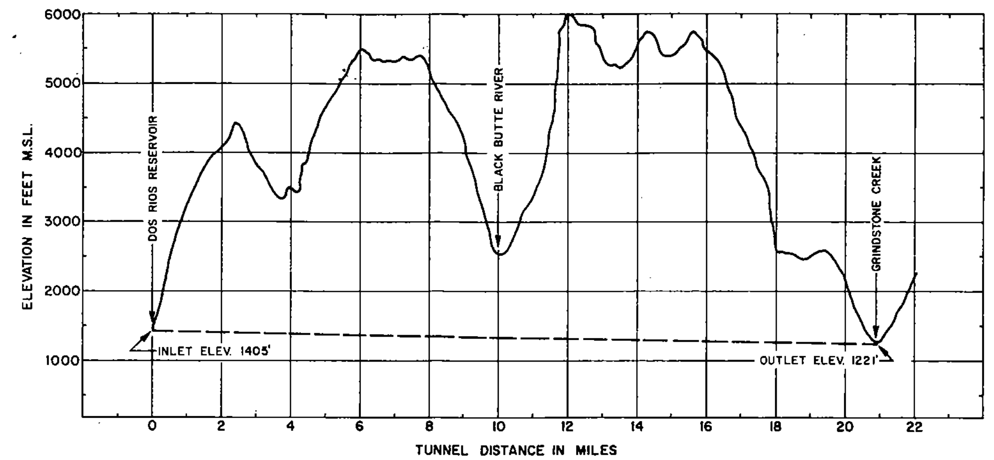
PLATE 3



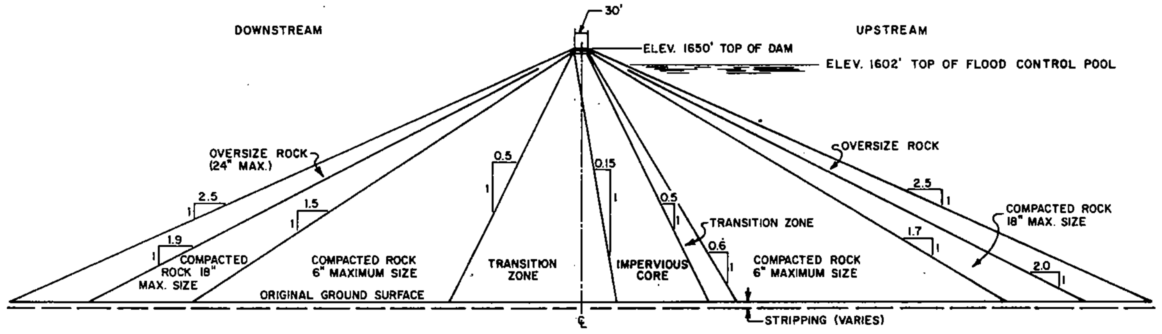
PLAN OF DAM

0 200 400 600
SCALE IN FEET

NOTE:
SEE PLATE 5 FOR LOCATION OF
FISH HATCHERY AND POWERHOUSE.

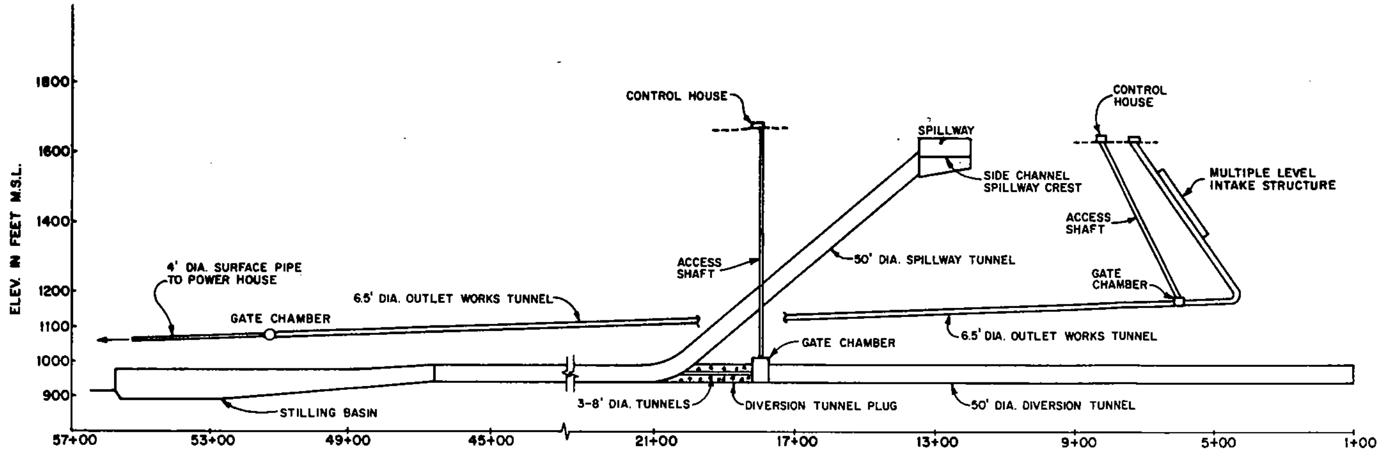


PROFILE OF GRINDSTONE TUNNEL



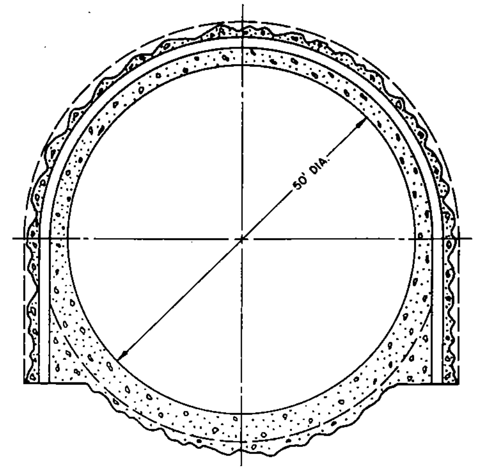
EMBANKMENT ZONING

0 200 400
SCALE IN FEET



PROFILE OF OUTLET TUNNEL AND SPILLWAY AND DIVERSION TUNNEL

0 200 400
SCALE IN FEET (APPROX.)



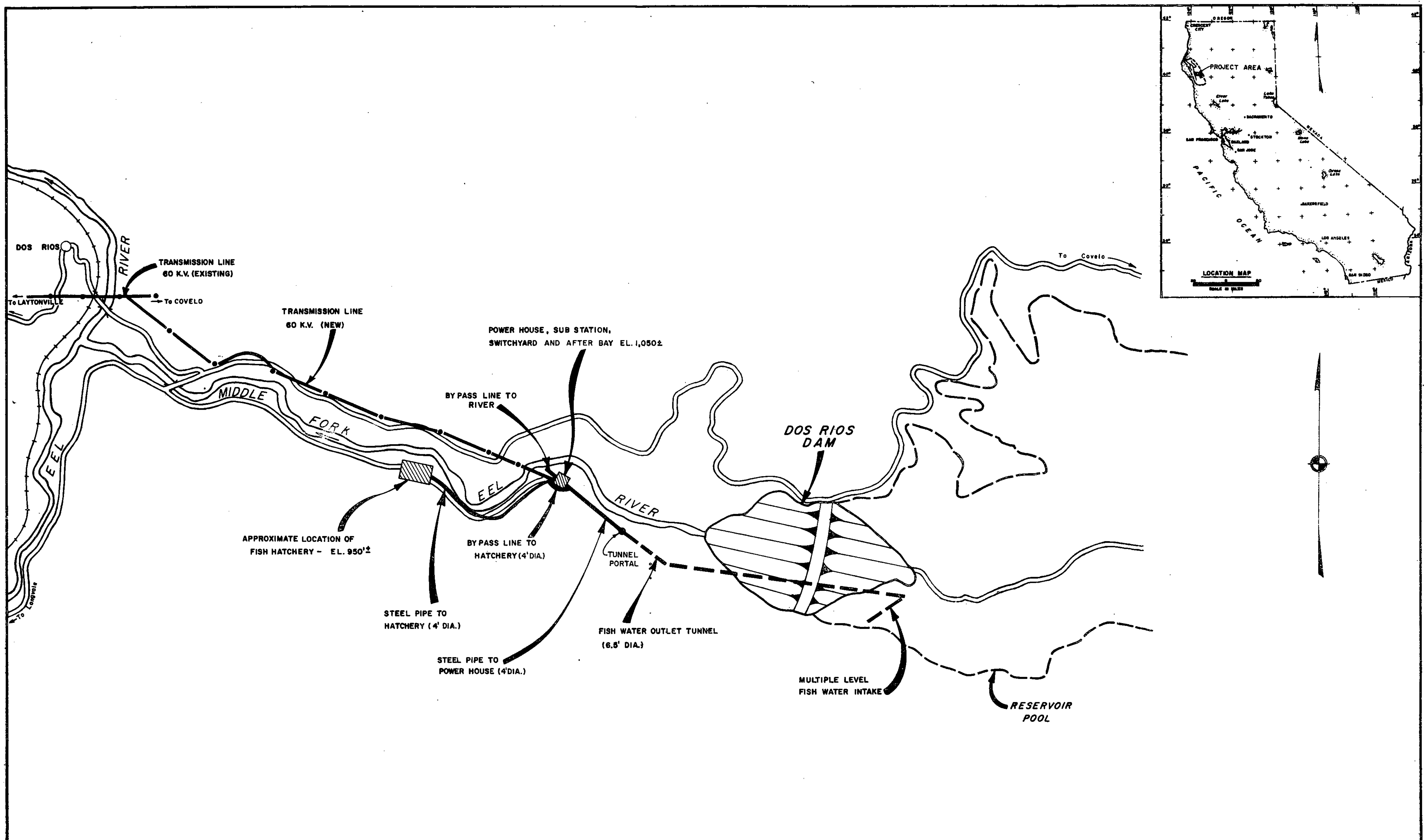
SPILLWAY AND DIVERSION TUNNEL CROSS SECTION

0 10 20
SCALE IN FEET

EEL RIVER BASIN
CALIFORNIA
INTERIM REPORT
ON
WATER RESOURCES DEVELOPMENT
FOR
MIDDLE FORK EEL RIVER

## DOS RIOS RESERVOIR
## PLAN OF IMPROVEMENT

IN 1 SHEET
SCALE AS SHOWN
SHEET NO. 1
U.S. ARMY ENGINEER DISTRICT, SAN FRANCISCO, CORPS OF ENGINEERS
SUBMITTED:
APPROVAL RECOMMENDED:
APPROVED:
I. H. Steinberg
CHIEF, PROJECT PLANNING BR.
CHIEF, ENGINEERING DIVISION
Frank C. Boerger
COL. CORPS OF ENGINEERS
DRAWN: R.L.S.
TRACED: R.R.K.
CHECKED: E.C.W.
TO ACCOMPANY REPORT
DATED: APRIL 1968
FILE NO.
60-49-2



EEL RIVER BASIN
CALIFORNIA

**INTERIM REPORT**

WATER RESOURCES DEVELOPMENT
FOR
MIDDLE FORK EEL RIVER

## LOCATION MAP
## POWER HOUSE AND FISH HATCHERY

1000 0 1000
SCALE IN FEET

IN 1 SHEET

SHEET NO. 1

U.S. ARMY ENGINEER DISTRICT, SAN FRANCISCO, CORPS OF ENGINEERS

SUBMITTED:
CHIEF, PROJECT PLANNING BR.

APPROVAL RECOMMENDED:
CHIEF, ENGINEERING DIVISION

APPROVED:
COL. CORPS OF ENGINEERS

DRAWN: O.J.P.
TRACED: D.E.P.
CHECKED: O.J.P.

TO ACCOMPANY REPORT
DATED: APRIL 1968

FILE NO.
60-49-3

PLATE 5

# EEL RIVER BASIN, CALIFORNIA

# INTERIM REPORT
# ON
# WATER RESOURCES DEVELOPMENT
# FOR
# MIDDLE FORK EEL RIVER

APRIL 1968

## ATTACHMENT I

Information called for by
Senate Resolution 148, 85th Congress
Adopted 28 January 1958

## TABLE OF CONTENTS

## TABLES

# EEL RIVER BASIN, CALIFORNIA

# INTERIM REPORT
ON
WATER RESOURCES DEVELOPMENT
FOR
MIDDLE FORK EEL RIVER

APRIL 1968

## ATTACHMENT I

Information called for by
Senate Resolution 148, 85th Congress
Adopted 28 January 1958

## 1. PROJECT DESCRIPTION AND ECONOMIC LIFE

The Dos Rios multiple-purpose dam and reservoir project is proposed as the next step in the development of water resources of the Eel River Basin. The proposed project would be located in Mendocino County, California, about three miles upstream of the town of Dos Rios on the Middle Fork Eel River. The dam and appurtenances would be composed of a rock-fill embankment 730 feet high and 2,100 feet long at the crest, a side channel spillway gated to regulate flood control releases, an outlet works for fishery releases and downstream flow regulation, and a low level outlet works system for emergency draining of the reservoir. The multiple-purpose reservoir created by the dam would have a total storage capacity of 7,600,000 acre-feet consisting of 5,000,000 acre-feet of active storage, 600,000 acre-feet for flood control storage and a minimum pool of 2,000,000 acre-feet as determined by consideration of sedimentation, potential slides and aesthetics. The reservoir would contain storage for the purposes of flood control, water conservation, recreation, power generation and fishing habitat. The proposed project would: regulate runoff from 745 square miles of the Eel River Basin and effect substantial reduction in peak flows along the main Eel River; provide an annual water supply yield of about 900,000 acre-feet for the California State Water Project; provide 4,800 kilowatts of year-round full capacity hydroelectric power from releases for fish with no withdrawals from reservoir storage specifically for power purposes; and provide recreation facilities for an estimated initial 1,000,000 activity-days with an increase to 7,000,000 activity-days by the end of the economic life of the project. Proposed conveyance of water into the Sacramento River Basin for the California State Water Project would be by means of the Grindstone Tunnel about 21 miles long and about 17 feet in diameter, generally on an east-west alignment. The State of California Department of Water Resources would construct the Grindstone Tunnel. Because of the conditions created by construction of the reservoir, provisions are proposed to mitigate fishery and wildlife losses; to adjust for disturbance to the Indian Community and economy; and, if desired by local interests, to relocate the town of Covelo. A 100-year life is used in the report as a basis for economic analysis. Certain items of construction have physical lives ranging between 25 and 50 years and would require replacements during the project economic life.

## 2. PROJECT COST

The estimates in this attachment, as in the report, are based on prices prevailing in September 1967. All estimates include allowances for contingencies, engineering, design, supervision and administration. The first costs associated with construction items and the annual charges for interest and amortization calculated therefrom, are determined using an interest rate of three and one-quarter percent. This rate is also used for estimating the equivalent annual cost of future major replacement. The remaining annual charges are composed of operation and maintenance costs. Summarized below are project costs and annual charges, for the Dos Rios Dam and Reservoir, the Grindstone Tunnel and a composite of the two.

### ANNUAL CHARGES
### DAM AND RESERVOIR
(Thousands of Dollars)

| Project Life in years | Total First Cost | Interest and Amortization | Maintenance and Operation and Replacement | Total Annual Charges |
|---|---|---|---|---|
| 50 | $245,000 | $10,925 | $537 | $11,462 |
| 100 | $245,000 | $ 9,100 | $570 | $ 9,670 |
| | | GRINDSTONE TUNNEL | | |
| 50 | $153,000 | $ 6,920 | $ 90 | $ 7,010 |
| 100 | $153,000 | $ 5,780 | $ 90 | $ 5,870 |
| | | COMPOSITE DAM AND TUNNEL | | |
| 50 | $398,000 | $17,845 | $627 | $18,472 |
| 100 | $398,000 | $14,880 | $660 | $15,540 |

The first cost for 50- and 100-year project life is the same since the storage requirements for sediment and potential slides, minimum pool, flood control, and water supply are essentially the same and would not materially change the cost estimate and in addition both projects deliver the same yields.

## 3. BENEFIT-COST-RATIO

As a multiple-purpose project, the proposed plan would provide benefits from: (1) reduction in flood damages; (2) benefits from water supply developed for the State of California Water Project; (3) benefits from hydroelectric power generation; and, (4) benefits from the use of the project reservoir and adjacent shore areas for recreation purposes. Benefits, costs and the benefit-cost-ratio, based on both 50-year and 100-year project life, using a three and one-quarter percent rate of interest are summarized in the following tabulation:

| | Project Life | |
|---|---|---|
| | 50-years | 100-years |
| Average Annual Benefits | $28,830,000 | $29,030,000 |
| Average Annual Cost | $18,480,000 | $15,540,000 |
| Benefit-Cost-Ratio | 1.5 | 1.9 |

## 4. PHYSICAL FEASIBILITY AND COST OF PROVIDING FOR FUTURE NEEDS

Because of the rapid growth in the State's population and the general economy, the water resources of the State must continue to be developed in order to satisfy the ever growing water and water related needs of the State. Hence, the Dos Rios Dam and Reservoir is proposed as the next step in the orderly development of the State's water resources.

a. Flood Control. The flood control storage of 600,000 acre-feet provided in the reservoir in conjunction with surcharge storage and a Delta levee system designed to contain a flow in the magnitude of 600,000 cubic feet per second would provide an optimum measure of control against floodflows of the magnitude of the flood of record, that of December 1964, of 840,000 cubic feet per second. The effect of the Dos Rios reservoir would be to reduce the December 1964 discharge in the Delta to 650,000 cubic feet per second. Furthermore, with other possible upper Eel developments, namely the English Ridge Project, the peak could be further reduced to 580,000 cubic feet per second. The combined effect of the two reservoirs would reduce the standard project flood discharge in the Delta from 920,000 cubic feet per second to 620,000 cubic feet per second.

b. Water Conservation. Water conservation storage in the proposed project would provide a portion of the additional water supplies required under the California State Water Project. The State of California estimates that an additional 900,000 acre-feet of firm annual yield is required in the Sacramento-San Joaquin Delta pool by about 1985 to meet its commitments under the State Water Project. The 5,000,000 acre-feet of active storage in Dos Rios can provide this amount of yield as measured in the Delta pool, in addition to making in-basin releases for fish-mitigative measures. The in-basin requirements for water quality will be met by fish releases until 2080. The provision of storage to provide the 900,000 acre-feet yield in Dos Rios is less costly than at any other known site in the upper Eel River Basin. Thus, the 5,000,000 acre-feet of active water supply storage has been adopted for water supply purposes.

c. Recreation. The ultimate potential of the reservoir for accommodating recreational visitation assuming no constraints is estimated at 7,000,000 recreational-days, annually. However, initially because of limited road access to the reservoir area the magnitude of the recreation development as a project purpose has been limited to 2,000,000 visitor-days. Of these 2,000,000 visitor-days, approximately one-half, or 1,000,000 visitor-days would be related to and accommodated by the Indian Community development as a mitigative measure in providing a substitute economy. Therefore, initial facilities for which benefits and allocations have been derived, are based on the 1,000,000 visitation days as limited by the constraint of access roads to the proposed project. All lands which would be required for full recreation development of the project, that is to accommodate 7,000,000 visitor-days annually, would be acquired initially in accordance with provisions contained in the Federal Water Project Recreation Act of 1965.

d. Hydroelectric power. The potential for development of hydroelectric power at the Dos Rios Project was found to be limited to utilization of in-basin water releases for fish-mitigation and available head. The power developed would depend entirely upon the releases for fish with no withdrawals from the reservoir storage specifically for power purposes. The optimum development for hydropower would consist of a plant with an installed capacity of 4,800 kilowatts operating as a continuous base load at full capacity. The base load plant, operating under a fixed 200 cubic feet per second discharge and a head of 340 feet is the optimum development that can be justified on an incremental basis to utilize fish releases. Consideration was given to providing specific storage in the reservoir for development of hydroelectric power, however, it could not be economically justified.

## 5. ALLOCATION AND APPORTIONMENT OF COSTS

The "Separable Costs-Remaining Benefits" method of allocation was used in the report to determine the distribution of project cost among purposes. The apportionment of State costs between Federal and non-Federal interests was based on existing Federal legislation. In allocationg costs, the following purposes were considered: flood control, water supply, recreation and hydroelectric power. Allocations were made for both 50- and 100-year economic lives. In addition to the "Separable Costs-Remaining Benefits" method, allocations were also made using the "Priority of Use" and "Incremental Cost" methods. The results of all allocations are shown on Table 1.

## 6. EXTENT OF INTEREST IN PROJECT

The proposed Dos Rios Dam and Reservoir has generated widespread interests throughout the eleven northwestern counties of California that are members of the Eel River Flood Control and Water Conservation Association, a local public entity, whose primary purpose is to promote the development of water resources of the Eel River and related watersheds within the northwestern portion of California. The counties that are members of the Association are: Humboldt, Lake, Marin, Mendocino, Napa, Solano, Sonoma, Yolo, Contra Costa, Del Norte, and Trinity. The Eel River Flood Control and Water Conservation Association, through its member counties, passed and adopted Resolution No. 1-68, presented in Appendix G, on 12 January 1968, indorsing for authorization the construction by the Federal Government at the earliest possible date of the Dos Rios Dam and Reservoir and appurtenance features, exclusive of conveyance facilities. Also and in addition, many of the counties' Board of Supervisors adopted resolutions expressing their views on the Dos Rios Dam and conveyance facilities and a summary of these resolutions follow: Humboldt County, the county that would realize the major flood control benefits from the proposed dam or any dam in the Eel River Basin urges and desires early action on the Dos Rios Dam. Hence, their County Board of Supervisors adopted Resolution No. 68-1, on 9 January 1968 supporting the plan of development. The Lake County Board of Supervisors did not pass or adopt a county resolution even though they voted in favor of the Association's Resolution. Lake County has two principal interests in the development of water resources in the upper Eel, namely that routing of additional flows of water from Dos Rios Reservoir are vitally necessary to algae control and water quality in Clear Lake and that an easterly conveyance route would deprive the county of future water supplies. Marin County is not directly affected by Dos Rios Dam and Reservoir or the conveyance facilities and voted in favor of the Eel River Association Resolution, however by separate communication the Board of Supervisors expressed its concern over Lake County's problems of conveyance and requested that authorizing language for the dam and reservoir be such as to permit further investigation of conveyance facilities routing. The proposed Dos Rios Dam and Reservoir is located in Mendocino County, thus, the county's principal concern is loss of agricultural lands in the reservoir area; possible unfavorable economic impact because of this; loss of taxes from reservoir flooded lands; dislocation of residents from reservoir area; and apprehension as to whether the county could sponsor recreation for the project. Mendocino County was not in favor of the Eel River Association's Resolution. Subsequently, the Board of Supervisors of Mendocino County adopted Resolution No. 68-11 on 16 January 1968 relative to the matter of recreational development for Dos Rios Dam and Reservoir. This resolution is presented in Appendix G. Sonoma County is not directly affected by the plan of development and thus, voted in favor of the Eel River Association's resolution. Furthermore, the county adopted a resolution on 15 January 1968, strongly supporting the Dos Rios Dam and Reservoir subject to authorizing legislation allowing construction of an alternate conveyance route, should one be found that would be more feasible. Yolo County was in favor of the resolution adopted by the Association and the County also passed a resolution requesting an examination in detail of all alternatives to routing Eel River water through Clear Lake and Cache Creek in Yolo County. Napa County is not directly affected by the proposed dam and reservoir and voted in favor of the Eel River Association's resolution. The remaining counties, Solano, Contra Costa, Del Norte and Trinity, did not adopt individual county resolutions for the plan of improvement, however, Solano and Contra Costa voted in favor of and Trinity County voted against the Eel River Association's Resolution. Colusa County, not a member of the Eel River Association, expressed concern about possible seepage problems along the Sacramento River, if water from the proposed reservoir is diverted easterly through the Grindstone Tunnel.

7. The Bureau of Indian Affairs, the Federal Agency responsible for coordinating the affairs of the Indian people, offered no objection at this time for the proposed project, provided the project is not objectionable to the Council and members of the Round Valley tribe. The agency concurred in that the Corps of Engineers should assume full responsibility for conducting negotiations with the Indian tribe relevant to the project. The State of California, the local sponsoring agency, through its Resources Agency, endorsed the Dos Rios Dam and Reservoir and will provide the necessary items of local cooperation. The assurances of local cooperation to be provided by responsible local interests prior to construction and subject to final allocation, based on conditions prevailing at the time of construction and actual costs incurred are:

a. Give assurances satisfactory to the Secretary of the Army that they will:

(1) Hold and save the United States free from damages due to the construction and operation of the works specifically required to deliver water to the areas of need.

(2) Adjust all claims concerning water rights arising from the construction and operation of the improvements, including the acquisition of water rights needed for preservation of fish and wildlife resources affected by the project.

(3) Determine the manner in which the releases will be regulated for water supply.

(4) Prevent any encroachments which would interfere with the proper functioning of the improvements or lessen their beneficial effects.

(5) Design and construct the necessary conveyance facilities, under their own method of financing, in a scheduled manner that would insure its timely completion consistent with that for the dam and its appurtenant works. Further details of the requirements of local cooperation and of the non-Federal costs involved are contained in the main report.

## 8. REPAYMENT SCHEDULES

Non-Federal interests would be required to repay a portion of the investment costs and to meet portion of the annual payments for operation and maintenance in accordance with existing laws and which at present are as follows:

a. Water supply. Non-Federal interests would repay to the United States the investment costs and to meet the annual payments for operation and maintenance and the payment of replacement costs, when incurred, which are allocated to water supply in the project, all in accordance with the terms of the Water Supply Act of 1958 (Title III of Public Law 85-500). Prior to initiation of project construction, non-Federal interests must complete a contract or contracts providing for repayment of the water supply costs over the life of the project.

b. Recreation. Local interests would repay to the United States one-half of the separable costs of the project allocated to recreation. Such repayment could be made within 50 years of first use of the project recreation facilities. Local interests would also be responsible for maintenance and operation and make major replacements of the recreation facilities.

## 9. EFFECT OF PROJECT ON STATE AND LOCAL GOVERNMENTS

It is considered that the proposed project would have no adverse effects upon the State and local governments. However, Mendocino County, the county in which the dam and reservoir would be located, contends that the project would adversely effect its economic well-being. The county through its Board of Supervisors adopted a resolution outlining their concern relative to the project plan. Their principal concerns are: The loss of agricultural lands in the reservoir area and thus, possibly resulting in an unfavorable economic impact; loss of taxes from the flood reservoir lands, relocation of residents in the reservoir area; and apprehension on the county's part as to whether it could sponsor and furnish the assurances of local cooperation relative to recreation. A study was undertaken and a report was prepared by this office to evaluate the effects of the Dos Rios project on several economic aspects of Round Valley and the surrounding area. This study concluded that the proposed project would result in economic benefits exceeding those obtainable without a project and that any declines which may occur immediately after project completion are offset within six years by the development of a major recreation area. By year 2000 economic benefits with the proposed project exceed those without a project by substantial amounts: $15 to $23 million in the value of private lands and improvements; 195 more persons in employment; an increase of 720 in population and $1,200,000 more in annual personal income.

10. The project would augment the California Water Plan and is in conformance with this plan. The water supply to be provided by the project is needed and required by the State to help support the rapidly expanding population and economy of the State. The project would provide much needed and desired flood control within the Eel River Basin, including Mendocino County, and any loss of property taxes in the project reservoir area is expected to be more than offset through increased valuation of the lands surrounding and adjacent to the reservoir area, thus, creating additional local tax revenues. Project recreation developments would bring new income into the area and new ancillary facilities into the area and taxes therefrom would benefit the local, State and Federal Governments. The hydroelectric power developed by the project would assist in augmenting the ever-growing need for hydroelectric power in Federal Power Area 46.

## 11. INFORMATION ON ALTERNATIVE PROJECTS

Subsequent to publication of House Document No. 234, extensive studies of reservoirs and conveyance systems for exporting water from the headwaters of the Eel River were undertaken by the joint California State-Federal Interagency Group. One of the conclusions resulting from these studies and investigation was that initial development of the Eel River Basin should be on the Middle Fork Eel River and the Dos Rios Project was selected as having the most favorable capability of meeting the water resources needs of the area compared to the potential projects. Numerous multiple-purpose dam and reservoir sites were considered for developing the water resources of the Middle Fork Eel River. These sites were: Spencer, Franciscan, Etsel (Upper and lower), Jarbow, Wailaki, a small dam at the Dos Rios site, a large dam at the Dos Rios site that would not flood Round Valley, and a large dam at the Dos Rios site that would flood Round Valley, the selected project. In all instances, except at the Dos Rios site, the other potential damsites had to be eliminated from consideration, primarily due to poor geological conditions. A small dam at the Dos Rios site was eliminated from consideration since this dam was considered in conjunction with other dams mentioned above, and since these dams were eliminated, a small dam at the Dos Rios site could not optimally develop the Middle Fork's water resources. A large dam at the Dos Rios site that would not flood Round Valley was eliminated from consideration since a multiple-purpose dam at this site would only develop about one-half of the water supply that could be developed with the adopted project. Thus, there was little choice of alternative projects other than single-purpose projects that could be constructed at or near the multiple-purpose project site. The State of California will be seeking future development of all major sources of water supply within the State to meet future anticipated needs and are considering and building extensive conveyance systems to provide water for areas of need from areas of supply. It is considered, therefore, that no true alternatives to the Dos Rios exist on the Middle Fork Eel River and it is only a matter of timing when practically all other developable sites within the North Coastal Area will be utilized. Information on the single-purpose alternative projects at the Dos Rios site are discussed below:

a. Project description and economic life. Pertinent data relating to the single-purpose projects is shown below for each. In all cases, an economic life of 100 years has been adopted for purposes of the report. Annual costs were estimated, also, for an economic life of 50 years for use in preparing this attachment.

(1) A single-purpose flood control dam and reservoir at the Dos Rios site, to provide the same benefits as the multiple-purpose project cannot be economically justified and its annual cost would far exceed the benefits produced. This is true also for any other reservoir or local protection projects that would provide the same degree of protection to the same areas. There is, therefore, no true alternative for the flood control that would be provided by the multiple-purpose project.

(2) A single-purpose water supply reservoir and dam at the same site selected for the multiple-purpose project. Storage in the reservoir project would total 7,000,000 acre-feet consisting of 2,000,000 acre-feet as a minimum pool which also would serve for sediment, potential slide storage and economical transbasin tunnel costs, and 5,000,000 acre-feet for water conservation storage. This project is similar to the multiple-purpose project except that it would not contain storage for flood control and recreation facilities.

(3) A single-purpose dam and reservoir for recreation at the Dos Rios site, to provide the same benefits as the multiple-purpose project cannot be economically justified and its annual cost far exceeds the benefits produced. This would also be true for any other reservoir project that would provide the same amount of benefits that the multiple-purpose project would provide. Therefore, there is no true alternative for the recreation that would be provided by the multiple-purpose project.

(4) The costs of developing a single-purpose hydropower project of the scope considered herein, for that purpose alone, would be economically unfeasible by a wide margin. It is considered, therefore, that the alternative cost of power, produced in an equivalent Federally-financed steam plant, would control allocations to hydropower. Therefore, no estimate has been prepared for a single-purpose hydropower project.

b. Costs of single-purpose alternative projects. The estimates of first costs, annual charges and benefit-cost-ratios are summarized below. All estimates include allowances for contingencies, engineering and design, supervision and administration. Annual charges include interest and amortization of project investment costs at three and one-quarter percent over an economic life period of 100 years, and annual costs for operation, maintenance and major replacements. For water supply, the estimated annual benefits of $26,100,000 have been reduced by $5,870,000, the estimated annual cost of the Grindstone Tunnel, to give $20,230,000 for the dam.

| Description | First Cost | Annual Charges | Annual Benefits | Benefit-cost-ratio |
|---|---|---|---|---|
| Single-purpose flood control | $167,000,000 | $6,630,000 | $ 1,510,000 | 0.44 |
| Single-purpose water supply | $229,000,000 | $9,030,000 | $20,230,000 | 2.2 |
| Single-purpose recreation | $194,000,000 | $8,180,000 | $ 1,210,000 | 0.15 |
| Single-purpose hydropower | None formulated | | | Unfavorable |

c. Discussion of alternative projects. The most feasible plan of improvement was found to be the multiple-purpose project at the Dos Rios site on the Middle Fork Eel River to provide the much needed flood control for the Eel River Basin, to meet future demands for water supply, to meet the expected demands for outdoor recreation and to supplement the growing need for hydroelectric power. The multiple-purpose project would, furthermore, provide these benefits at a savings in cost over single-purpose projects.

(1) A single-purpose flood control project cannot be economically justified at this time and was considered only for purpose of comparison. Equal benefits could be obtained from the multiple-purpose project at a lesser cost.

(2) A single-purpose water supply project is economically feasible to construct providing it remains the least expensive alternative means of developing the needed water supply. Because of the expected future need to develop all practical major sources of water supply in California to meet rapidly expanding demands, it is expected that single-purpose projects would remain the least expensive alternative to multiple-purpose developments. However, a single-purpose project would not, at the Dos Rios site, realize the full potential for water resources development since they contain no provisions for flood control, recreation and hydropower.

(3) A single-purpose project for recreation at the Dos Rios site cannot be economically justified and was considered only for purpose of comparison. Equal benefits could be obtained for recreation from constructing the multiple-purpose project at a lesser cost.

d. Allocation of costs and repayment schedules. Projects constructed for municipal and industrial water supply are considered to be primarily the responsibility of State or local interests. However, when water supply is included as one of the purposes in a multiple-purpose project, it may share equitably in the cost savings of multiple-purpose construction and the share of the project costs it must bear are determined by allocation. These costs allocated to water supply are entirely reimbursable and repayment of Federal expenditures for this purpose must be assumed by responsible non-Federal interests. There would be no Federal participation in a project constructed solely for water conservation to provide water supplies for municipal and industrial purposes. The inception, construction and cost of such a project would be entirely a non-Federal responsibility.

(1) A single-purpose project for flood control at the Dos Rios site would be entirely a Federal responsibility. Benefits from

such a project would be considered as widespread and non local in nature. There are no channel improvements contemplated as part of such a project, so there would be no contribution required from non-Federal interest for lands, easements and rights-of-way or for relocation or modification of roads, bridges or utilities.

(2) A project developed solely for recreation would probably be financed by local and State interests. Federal interest in recreation is limited to its inclusion in multiple-purpose projects to the extent that the other purposes to be served in themselves afford a functional basis for Federal participation, and the benefits creditable to them are equal to 50 percent or more of the total cost in order that total allocations to recreation will not exceed one-half of such total cost. In multiple-purpose projects, however, the Federal Government, under the Federal Water Project Recreation Act of 1965 can assume all first costs for recreation and fish and wildlife enhancement up to a maximum of 50 percent of the separable cost for this purpose. Remaining costs, including annual operation, maintenance and replacements associated with this purpose are borne by non-Federal interests.

e. Effects on State and local governments. Effects would be similar to those discussed for the multiple-purpose project in paragraph 9. Local interests would be less favorable inclined toward single-purpose projects since it is anticipated there would be future needs for all of the purposes included in the multiple-purpose project, that is, flood control, water conservation, recreation and hydropower and any lesser degree of development would not utilize the full potential of the site.

TABLE 1

## ALLOCATION OF COST, DOS RIOS PROJECT

Allocation to Project Purposes, in $1,000

| Item No. | Item | 50-Year Project Life | | | | | 100-Year Project Life | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Project Purpose | | | | | Project Purpose | | | | |
| | | Flood Control | Water Supply | Recreation | Hydro-Power | Total | Flood Control | Water Supply | Recreation | Hydro-Power | Total |
| | | "SEPARABLE COSTS - REMAINING BENEFITS" METHOD | | | | | | | | | |
| 1 | Average annual benefits | 1,350 | 20,230 | 1,170 | 210 | 22,960 | 1,510 | 20,230 | 1,210 | 210 | 23,160 |
| 2 | Alternate costs | 7,858 | 10,718 | 9 216 | 204 | 27,996 | 6,630 | 9,030 | 8,180 | 170 | 24,010 |
| 3 | Limits of benefits | 1,350 | 10,718 | 1,170 | 204 | 13,442 | 1,510 | 9,030 | 1,210 | 170 | 11,920 |
| 4 | Separable cost | 230 | 2,270 | 308 | 178 | 2,986 | 230 | 1,900 | 260 | 150 | 2,540 |
| 5 | Remaining benefits | 1,120 | 8,448 | 862 | 26 | 10,456 | 1,280 | 7,130 | 950 | 20 | 9,380 |
| 6 | Percent for allocation of joint costs | 10.7 | 80.7 | 8.2 | 0.4 | 100.0 | 13.7 | 76.0 | 10.1 | 0.2 | 100.0 |
| 7 | Allocation of joint costs | 906 | 6,840 | 695 | 35 | 8,476 | 980 | 5,410 | 720 | 20 | 7,130 |
| 8 | Allocation of total annual cost | 1,136 | 9,110 | 1,003 | 213 | 11,462 | 1,210 | 7,310 | 980 | 170 | 9,670 |
| | | "PRIORITY OF USE" METHOD | | | | | | | | | |
| 1 | Justifiable expenditures | 1,350 | 10,718 | 1,170 | 204 | 13,442 | 1,510 | 9,030 | 1,210 | 170 | 11,920 |
| 2 | Specific costs | 0 | 0 | 245 | 130 | 375 | 0 | 0 | 220 | 131 | 351 |
| 3 | Remaining expenditures | 1,350 | 10,718 | 925 | 74 | 13,067 | 1,510 | 9,030 | 990 | 39 | 11,569 |
| 4 | Allocation of joint costs [1] | 1,350 | 8,812 | 925 | 0 | 11,087 | 1,510 | 6,819 | 990 | 0 | 9,319 |
| 5 | Total, project allocation | 1,350 | 8,812 | 1,170 | 130 | 11,462 | 1,510 | 6,819 | 1,210 | 131 | 9,670 |
| | | "INCREMENTAL COST" METHOD | | | | | | | | | |
| 1 | Separable cost | 230 | 2,270 | 308 | 178 | 2,986 | 230 | 1,900 | 260 | 150 | 2,540 |
| 2 | Allocation of joint costs | 8,476 | 0 | 0 | 0 | 8,476 | 7,130 | 0 | 0 | 0 | 7,130 |
| 3 | Total, project allocation | 8,706 | 2,270 | 308 | 178 | 11,462 | 7,360 | 1,900 | 260 | 150 | 9,670 |

---

[1] Remaining costs assigned to purpose by following priority: Flood Control, Recreation and Water Supply.

# EEL RIVER BASIN, CALIFORNIA

# INTERIM REPORT
# ON
# WATER RESOURCES DEVELOPMENT
# FOR
# MIDDLE FORK EEL RIVER

APRIL 1968

## APPENDIX A

## ECONOMIC ENVIRONMENT OF THE EEL RIVER BASIN

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## APPENDIX A

## ECONOMIC ENVIRONMENT OF THE EEL RIVER BASIN

### GENERAL

### A-1. PURPOSE AND SCOPE

This appendix presents information and data on the Eel River Basin economy as a basis for reaching decisions on development of the Dos Rios Project, the key unit of the Middle Fork. The appendix traces the historic development of the basin, analyzes the structure of the present economy, and evaluates recent growth trends. Based upon these findings the structure of the future economy is projected and related to expected changes in land use. This forecast of the ultimate economic growth of the entire basin provides a basis for analysis of long-term water needs of the basin and the effect of exportation of Middle Fork surplus water on meeting these needs. The report also includes an economic evaluation of plans to utilize Round Valley as part of the proposed reservoir on the Middle Fork. The scope of the analysis is basinwide, focusing primarily on Humboldt County and parts of Mendocino County, in which almost all economic activity of the basin is located. The study period extends to year 2080, or approximately 100 years beyond the expected date of completion of the proposed Dos Rios project.

### A-2. ECONOMIC STUDY AREA

The Eel River Basin comprises approximately 3,600 square miles of drainage area and includes parts of five California counties. Figure A-1 indicates the relationship of the basin to county boundaries and adjacent population centers affecting the basin economy. As shown, about 75 percent of the basin is situated within Humboldt and Mendocino Counties. The remaining 25 percent, located in Trinity, Glenn and Lake Counties, consists mostly of undeveloped foothills. Most of this land is in forest preserves or is not suitable for crop production. Field crops, such as hay and pasture, and livestock, such as cattle and sheep, are produced on land not suitable for row crop production. Most of the crop land in the basin is contained in valleys such as Round Valley (16,000 acres), Little Lake Valley (8,900 acres), Long Valley and Leggett (2,300 acres), Eden Valley (1,000 acres), Sherwood Valley (700 acres) and the Eel River Delta (25,000 acres). Included in the economic study area are two external centers of population, industry, commerce and county government which affect economic growth of the basin. Because of its proximity to the flood plain, Eureka in Humboldt County is important to the Eel River Basin economy. Ukiah in Mendocino County has less economic linkage to the basin because of natural barriers. The density of population per square mile in Humboldt County has been about twice the density of Mendocino County since 1930 as indicated in the following tabulation:

DENSITY OF POPULATION
PER SQUARE MILE

1930-1966

| | HUMBOLDT COUNTY | MENDOCINO COUNTY |
|---|---|---|
| Year | Persons per square mile | Persons per square mile |
| 1930 | 12.1 | 6.6 |
| 1940 | 12.2 | 7.9 |
| 1950 | 19.3 | 11.6 |
| 1960 | 29.2 | 14.5 |
| 1966 | 29.6 | 14.6 |

Source: Population data, Department of Finance, State of California County Areas, "Economic Survey of California and Its Counties," California State Chamber of Commerce.

Since most published economic statistics are collected on a county-wide basis, study data include all of Humboldt and Mendocino Counties. Although parts of these counties are outside the basin, these statistics provide a general indication of local economic trends affecting the basin.

## A-3. BACKGROUND—MIDDLE FORK PROJECT

The North Coastal Area of California, in which the Eel River Basin is located, contains the next large block of surplus water for distribution to the semi-arid part of the State. The mean seasonal runoff of this area is about 28,900,000 acre-feet, or 41 percent of the water resources in the State. This runoff is essentially unregulated and excessive flows during large storms caused disastrous floods such as those which occurred in December 1955 and in December 1964. A long-range plan for developing the water resources of the North Coastal Area has been prepared by the State and is being studied also by the Corps of Engineers and other Federal agencies. Surplus runoff from this area is to be conserved and transported southward to augment the Sacramento-San Joaquin Delta Pool, from where the water is to be conveyed to areas of need, mostly in the southern part of the State. The initial phase of the State system in the North Coastal Area is the Eel River Basin, which yields 20 percent of the runoff in the area. Runoff approximates 6,600,000 acre-feet annually or about 10 percent of the water resources in California. Supplying water deficient areas of the State from this source is of immediate importance because of the recent United States Supreme Court decision reducing the amount of Colorado River water previously considered available in California. Construction of a reservoir project for this purpose also makes possible inclusion of a multi-purpose features, such as much needed flood control and added recreation facilities. Water deficient areas of the State are scheduled to receive supplies from the Eel River by 1985. The largest source of surplus water in the basin is the Middle Fork and it has been designated by the State for immediate development, as a feature of the State Water Project. This tributary encompasses 750 square miles and has a runoff of approximately 1 million acre-feet annually. The Middle Fork was selected because it appears to offer the most economical means of developing supplemental water supplies for exportation under the State Water Plan, as discussed in the main report. The principal unit of the plan for improvement of the Eel River Basin is the Dos Rios Dam and Reservoir. The Dos Rios project is a multi-purpose development, giving full consideration to all beneficial uses in the basin and to exportation of surplus flows. Exploration in the foundation area of the Dos Rios damsite indicated it is geologically and topographically the best damsite on the Middle Fork and is capable of supporting an unusually high dam. As discussed in the main report, the dam being considered would be some 750 feet high and would impound approximately 7,600,000 acre-feet in a reservoir of approximately 40,000 acres in area at this capacity.

## A-4. RESOURCE BASE

The Eel River Basin contains diverse natural resources aand to attain the economic growth potential of the basin, optimum development and utilization of these assets are required. The river itself provides a habitat for fish and wildlife which contributes to both recreation and commercial fishing. More than 60 percent of the drainage area is covered with timber and a substantial amount of economic activity in the basin is forest-based. About 20 percent of the basin consists of grazing lands which support dairying and livestock production. The area of greatest potential growth in the basin is the Delta which contains rich soils and flat lands suitable for both intensive agriculture and further urban development.

## A-5. HISTORIC DEVELOPMENT

Mining and agriculture gave impetus to the initial growth of the basin in the 1850's. Development of significant consequence began initially in the Humboldt Bay area with the inception of the extractive industries. The towns of Eureka and Arcata, contiguous to the Eel River Basin, were established during this formative stage and have since become the centers of economic activities adjacent to the northern portion of the basin. In the 1860's and 70's lumber industries were developed and grew at a moderate pace. During the same period, population in the basin and Eureka rose to some 13,500 persons, 80 percent of whom were within Humboldt County. By 1900, extensive lumbering was underway and the population increased to approximately 24,000 persons. Further growth in the forest products industry throughout the 1900's was accelerated by construction of the Northwestern Pacific Railroad. Contiguous urban and industrial growth has been very closely related to the development of the forest products industry of the basin. Historically, agriculture in the Delta area has been a significant activity since the late 1850's. Production for local demand consisted of meat, dairy products, potatoes, etc., and feed for livestock. This agricultural pattern continued for some 70 years. After 1900, dairying and beef-raising were well established as the primary farm activities. At present, approximately 90 percent of the agricultural lands is devoted to integrated pasture-dairy cattle operations. Recreation land use development of the area was not rapid in the formative period but increased substantially in more recent years.

## PRESENT ECONOMY

## A-6. STRUCTURE AND GROWTH

The economy of the Eel River Basin is presently relatively underdeveloped in comparison with the State as a whole, and the area is essentially rural in character. However, the basin is shifting through a transitional state of more intensive growth in which the predominance of resource-based extractive industries is giving way to a more diversified economic base oriented to external markets. The structure and growth of the basin economy are reflected in employment data shown in Tables A-1, A-2, and A-3. These tables indicate absolute and percentage changes by major categories in Humboldt and Mendocino Counties. The following discussion, derived from these data, concerns relative changes in the five major generators of economic activity: lumbering, recreation, agriculture, fishing and trade and services.

## A-7. LUMBERING

Although commercial timber resources are the mainstay of the present economy, a clear trend toward a decline in employment in this sector is evident. The industry is shifting toward more intensive use of raw material and integrated operations which include processing as well as sustained yield cutting. Investment in manufacturing is evident in two pulp mills established recently on the Samoa Peninsula. The trend toward more capital intensive operations is also reflected in the 25 percent decline in employment in Humboldt County between 1959-65, shown in Table A-1. In Mendocino County, employment in the lumbering industry declined from 6,000 to approximately 4,000 from 1955 to 1961. In 1940, Mendocino County was, in terms of employment, an agricultural county. Farming ranked first as a source of employment, followed by wood products, then retail trade. In 1950, agriculture ranked second to the forest products industry, but by 1960 agriculture had dropped to sixth place. Forest products were still predominant, followed by professional services, and transportation, communication and utilities. It should be noted, however, that in 1960 most of the employment in the logging and sawmills category was represented by employment in a new plant utilizing wood in its manufactured product.

## A-8. RECREATION

Recreation is presently second in economic importance to the forest products industry. The growth trend stemming from recreation cannot be directly derived from available data, since they are not collected under this classification. However, industries indirectly associated with recreation, for example, trade and services, government, finance, insurance and real estate, show a gradual increase since 1959. The low level of present recreation facilities and anticipated substantial increment of new recreation development indicate a steep climb in recreation-related activity. The extent of recreation-related activity is discussed under trade and services.

## A-9. AGRICULTURE

Agriculture is another major industry in the basin and is concentrated in the productive bottom lands of the Eel River Delta Area. Dairy pasture is the principal form of agricultural activity and milk production represents about half the total value of agricultural activity and milk production represents about half the total value of agricultural products produced in the basin. Table A-4 shows that the value of agricultural products has remained fairly constant from 1961 through 1965. Agriculture employed about five percent of the labor force in Humboldt County and remained constant in the period 1959 through 1965. In Mendocino County agricultural employment declined in importance. The total dropped from 2,100 to 1,100 during the period between 1940 and 1960. The decline in agriculture employment was associated in large measure with the abandonment of hops production, located mainly in the adjacent Russian River Basin. In addition there was greater efficiency in agricultural methods, with the consolidation of some small farms and the elimination of jobs through mechanization. To the extent that this trend occurs in the Eel Basin, such declines will be applicable. However, data are not available to determine exact declines, but the consolidation of small farms into larger farms and increases in farming efficiency are occurring throughout the industry.

## A-10. COMMERCIAL FISHING

An average of 400 people, mostly in the Eureka area, was employed in the fishing industry in recent years and, as shown in Tables A-1 and A-2, employment in this sector is a minor part of the total labor force. The trend shows a consistent decline in the number of persons engaged in fishing and indicates that the commercial fishing industry will become a smaller part of the basin economy.

## A-11. TRADE AND SERVICES

Urban-centered trade and services linked to the expansion of recreation and manufacturing are becoming increasingly important as the basin economy diversifies. Table A-1 indicates that employment in trade and services shows gradual increases in Humboldt County. The same trend is also evident in Mendocino County where employment in this sector increased from 3,900 to 8,800 in the period 1940-1960, representing an increase of some 47 percent. Table A-5 on taxable sales is another indication of the increasing importance of the trade and services sector. Taxable sales in Humboldt and Mendocino Counties increased from $84 million and $38 million in 1950 to $181 million and $74 million in 1965 for the two counties, respectively.

## A-12. SUMMARY OF PRESENT ECONOMY

In summary, the present economy of the basin shows a steady decline in agricultural employment, the beginning of a decline in primary lumbering employment and in cuttings, and a rise in the manufacture of lumber products. Trade and services show a gradual increase in Humboldt County and a more definite rise in Mendocino County. These trends are expected to continue in the future and are discussed below in the section of projected growth.

## PROJECTED GROWTH

### A-13. RELATION TO STATE AND NATION

These sections discuss expected economic growth in the Eel River Basin in relation to basin economic development anticipated for the nation and State.

### A-14. BASES FOR PROJECTIONS

Figures A-2, A-3 and A-4 show population, employment and per capita income projections to the year 2080 for the nation, State and basin. These projections are derived from extrapolations of data prepared by numerous governmental[1/] and non-governmental agencies. Precision cannot be expected in economic projections extending beyond 50 years. Margins of error increase rapidly with the number of years included in the study. Projections in the second 50 years of a 100-year study period should be regarded primarily as ultimate limits of trends, rather than predictions of probable levels of development. The following are the major assumptions made with regard to the national, State and basin projections: (1) large scale nuclear war will be avoided and U.S. Defense Operations will be maintained at approximately their present level in relation to the total economy throughout the study period; (2) individual leisure time will increase but no large scale withdrawal from the work force or reduction in the work week will occur; (3) relatively high levels of employment and increases in productivity will be maintained; (4) adequate water supply and transportation systems will be available in the State and basin.

a. Population. Figure A-2 projects population growth of the nation, State and basin. State population is projected to increase at a faster rate than those of the nation and the basin. Population growth in the basin, especially after 2020, reflects increasing urbanization of the Eel River Basin, particularly in the Delta area.

b. Employment. Figure A-3 on employment follows the same trends of population growth. In all cases the ratio of employment and population will drop because of increases in the number of older persons in the population and early retirements. The trend is particularly evident in the basin and is expected to continue.

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[1/] U.S. Bureau of the Census, Series B, 1960-2020
Corps of Engineers' projection, 2020-2080

c. Per Capita Income. Figure A-4 on per capita income shows that basin income is well below that of the State and nation, reflecting the rural nature of the basin. Per capita income for Mendocino and Humboldt Counties is somewhat less than that of the nation, but is expected in increase faster and become comparable to the nation as a whole. A rapid increase in per capita income in the basin will occur as the basin becomes urbanized. California per capita income has traditionally been above the national level and this trend is expected to continue over the study period. In the future, State per capita income is expected to remain greater but to increase at a slower rate than that of the nation.

## A-15. NATIONAL AND STATE GROWTH

National and State projections in Figures A-2 and A-4 provide the economic basis for formulating water resources in development of the Eel River Basin. Growth of economic activity in the State and nation increases the probable future demand for products and potential products of the Eel River Basin, especially demand for lumber-based products and dairy products. Substantial expansion of the State economy projected in Figures A-2, A-3 and A-4 is dependent in large part upon an adequate water supply. It is planned that a portion of the needed water will be supplied from the Eel River Basin. Finally, State and national increases in population and per capita income will increase the demand for recreation facilities in the Eel River Basin in which five State parks and many stands of redwood trees are located.

## A-16. BASIN EMPLOYMENT AND POPULATION

The discussion below concerns sectoral changes in the basin economy:

a. Table A-8a reflects major changes in the composition and level of economic activity that is expected in the Eel River Basin over the 100-year study period. Urbanization, particularly in the Delta Area, is indicated in the increases in total population and the decline in the number of persons employed in agriculture. A shift away from reliance on the lumbering industry for employment toward a more diversified economy is foreseen. In 1960, for example, the ratio of those employed in services to those employed in industry was 0.8 to 1. By 2080, this ratio is projected to change to 2.6 to 1.

b. The relative decline of the industrial sector does not mean that the lumbering industry will not be a major sector of the basin economy over the long term. It can be expected to remain important in value of production and in employment particularly as it shifts to integrated cutting and processing operations. Lumber and lumber-based products are expected to remain the dominant item exported from the basin during the study period.

c. The substantial increase expected in employment in the service sector is attributable to many factors including rising per capita income, increasing numbers of tourists and vacationers, and demands for supporting services (such as transportation and wholesaling) stemming from intensive secondary manufacturing of lumber-based products. The substantial rise in recreation uses in the Eel River Basin is summarized in Table A-7. These projections indicate that basin recreation use increases from 868,000 visitor-days in 1960 to 98,000,000 in 2080. The major factor underlying this rise is the attractiveness of the basin for recreation use by urban residents throughout the State, particularly in the San Francisco Bay Area. The redwood forests, wilderness areas, warm climate and existing transporation facilities, such as U.S. Highway 101, are expected to attract large numbers of out-of-basin visitors. In this connection the Dos Rios project is expected to have a favorable impact on commercial establishments along U.S. Highway 101 as it is the only main highway within 20 miles of the proposed dam and reservoir. This trend is expected to accelerate around 1985, upon utilization of maximum recreation potential of the Russian River Basin, located between the Eel Basin and the San Francisco Bay Area. The ultimate recreation potential of the Eel River Basin depends, to a large extent, upon construction of reservoirs for water recreation use and adequate means of access, thereto.

## A-17. LAND USE CHANGES

This section consists of information on the physical extent of the Eel River Basin economy. Long-range changes in land use resulting from population increases and expansion of economic activities are shown in Tables A-8, A-8a and A-8b, and accompanying land use maps, Figures A-5 through A-11, which project changes over duo-decade periods to the year 2080. Considerable change in the mix of basin land uses is foreseen. Most of the change over the 100-year study period will result from the conversion of agricultural land to urban uses. A decline of about 60 percent in agricultural land use is anticipated. At full development approximately 40,000 acres is expected to be converted to urban uses. Residential and commercial land use are expected to increase by 81,300 acres or 485 percent. Industrial use will increase 3,700 acres or 170 percent. Public and reserved land will increase by 44,500 acres or 150 percent. A slight decline in commercial timberland (42,000 acres) is expected. The foregoing changes in land use do not take into account flooding of Round Valley by construction of Dos Rios Reservoir. This area accounts for about 16,000 acres in the basin. These aggregate changes in the distribution of land uses reflect the transition in the economic base of the basin set forth previously. Expansion of the regional economy will result from more intensive use of natural resources and complementary growth of the trade and services sector.

## WATER RESOURCES PROBLEMS

### A-18. INTRODUCTION

The future growth of the Eel River Basin economy is contingent, to a great extent, on water resources development. At present, private investment in development of the downstream area is retarded by the constant risk of flood damage. The entire economy of the basin was disrupted in 1955 and again in 1964. The possible recurrence of this destruction is a constant deterrent to development of the basin. Until flood protection is provided, the area will have considerable difficulty recovering from these economic losses and advancing to higher levels of economic growth. To sustain regional economic growth adequate water supplies must be assured.

### A-19. BASIN WATER REQUIREMENT

Topography limits potential service areas to the Eel River Delta and communities contiguous to it. These communities are Ferndale, Fortuna and Scotia, which presently obtain urban supplies from ground water sources. Table A-9 indicates present and projected water requirements in these areas from 1960 to 2080. Municipal and industrial requirements are derived from United States Public Health Service projections and irrigation needs are based upon estimates of the California State Department of Water Resources and the U.S. Bureau of Reclamation. Municipal and industrial requirements in 1960 were about 5,000 acre-feet, and are projected to increase gradually to 95,000 acre-feet by the year 2080. Irrigation in 1960 used about 19,000 acre-feet, all from ground water. These needs increase to a maximum of 38,000 acre-feet in 2000 and thereafter decline gradually to 31,000 acre-feet in 2080. Combined urban and agricultural uses were about 24,000 acre-feet in 1960 and increases to 126,000 by 2080. The Bureau of Reclamation estimates that the ground water basin can yield 30,000 acre-feet annually on a sustained yield basis. In Table A-9 this amount was deducted from the total requirement to indicate supplemental water requirements. In 1960 after supplying municipal and industrial needs and irrigation, there was a surplus of 6,300 acre-feet in the ground water basin. By 1980 the ground water basin will be overdrawn and a supplemental requirement of 9,300 acre-feet must be provided from surface sources. This supplemental requirement increases an average of 15,000 acre-feet and each duo-decade until by 2080 a supplemental flow of 96,000 acre-feet is needed. Maximum in-basin water requirements by 2080 are approximately 135,000 acre-feet. This represents only about 2 percent of the annual runoff in the basin. The proposed Dos Rios project would export 650,000 to 700,000 acre-feet annually, or about 10 percent of the total basin runoff. Development of this supply for export would permit full use of the Middle Fork for multiple-purposes which would have a beneficial stimulus on the economy of the Eel River Basin. Flood protection is likely to intensify economic development in the Delta and creation of a 40,000-acre lake for recreation will also generate new investment and employment opportunities.

## A-20. ANALYSIS OF ROUND VALLEY

The proposed Dos Rios Project would form a reservoir in the Middle Fork Eel River which would inundate Round Valley, a tributary area in northwestern Mendocino County. The valley is a closed basin, 26 square miles in area, which has an economy based mainly on agriculture. In formulating the plan of improvement on the Middle Fork, two alternative storage plans were considered. A common feature to both would be a high dam at Dos Rios. One plan would protect the valley and the other would flood it for storage purposes. These plans are discussed fully in Appendix F. In order to estimate the economic loss of flooding Round Valley, the maximum possible development was investigated. The ultimate pattern of development in Round Valley was projected recently by the State Department of Water Resources and the Bureau of Reclamation. These findings and estimated economic losses by flooding are described below.

A-21. In a memorandum report prepared in 1962 the California Department of Water Resources found Round Valley suitable for further development of intensive agriculture and a ten-fold increase in population. These changes were considered contingent on development of a full irrigation supply and adequate transportation to markets in the Sacramento Valley and the North Coastal Area. The report indicated that irrigation would be extended considerably in the near future by further development of ground water and/or surface supplies. The Department found that in 1960, of 16,000 acres in agricultural use, about 1,100 were irrigated. By the year 2020 irrigated lands in the valley were forecast to increase to about 13,200 acres. Diversified crop pattern of feed crops and orchards would be produced with a full irrigation supply, as projected in Table A-10. Net crop incomes under present and future conditions were not estimated.

A-22. In a report published in 1964, the Bureau of Reclamation investigated the feasibility of developing a multiple-purpose water project for Round Valley. The Bureau found that the 1962 crop pattern yielded annual net crop incomes of $133,000 and estimated that with supplemental irrigation, net crop income would increase to about $1,232,000, or about eight times the present level. Changes in net crop income with and without a full irrigation supply, as extracted from the report by the Bureau are shown below:

| | With Project | Without Project | Difference Due To Project |
|---|---|---|---|
| Hay and Forage | $ 434,200 | --- | $ 434,200 |
| Grain | 128,900 | --- | 128,900 |
| Walnuts | 756,800 | --- | 756,800 |
| Livestock | 2,165,000 | $1,293,400 | 871,600 |
| Farm Perquisites | 141,600 | 81,400 | 60,200 |
| Gross Farm Income | $3,626,500 | $1,374,800 | $2,251,700 |
| Farm Expenses | 2,394,400 | 1,242,200 | 1,152,200 |
| | $1,232,100 | $ 132,600 | $1,099,500 |
| | | | Say $1,100,000 |

Water supply improvements necessary to realize this added net income were estimated to cost about $14,000,000. The proposed irrigation system would consist of three dams, two pumping plants, 23 deep wells and a distribution system. The cost of these facilities is itemized below:

SUMMARY OF CAPITAL COST 1/
(October 1962 prices)

| | |
|---|---|
| Franciscan Dam and Reservoir | $ 5,042,000 |
| Williams Creek Diversion Dam | 373,000 |
| Williams Canal | 201,000 |
| Middle Fork Eel Pumping Plant and associated works | 742,000 |
| Eel Canal | 182,000 |
| Covelo Canal | 1,989,000 |
| Deep Project Wells | 675,000 |
| Mill Creek Diversion Dam | 634,000 |
| Mill Creek Pumping Plant and associated works | 314,000 |
| Dingman Canal | 217,000 |
| Distribution System | 2,995,000 |
| Drainage System | 199,000 |
| Total Capital Cost | $13,553,000 |
| Interest during construction | 610,000 |
| TOTAL | $14,163,000 |

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1/ U.S. Bureau of Reclamation, "Round Valley Unit, North Coast Project, California, A Status Report of an Investigation of Possibilities For Irrigation Development," March 1964

A-23. Project costs were allocated to irrigation, municipal and industrial water service, flood control and area redevelopment functions by the separable cost-remaining benefit method. Costs associated in the mitigation of fish and wildlife damages were assigned as non-reimbursable expenses.[1] Allocated construction costs were adjusted to compensate for charging all operation, maintenance, and replacement expenses - both reimbursable and non-reimbursable - to the reimbursable functions. The resultant construction cost allocation was:

| | Allocated costs | |
|---|---|---|
| | Main Features | Distribution System |
| Irrigation | $ 9,861,000 | $3,184,000 |
| Municipal & Industrial Water Service | 30,000 | |
| Flood Control | 256,000 | |
| Area Redevelopment | 704,000 | |
| Fish & Wildlife Mitigation | 907,000 | |
| | $11,758,000 | $3,184,000 |

It should be noted that of the total allocated cost, $14,932,000, about $13 million was allocated to agriculture. The effective irrigation repayment capacity, based upon the payment capability of class 2 and 3 pasture lands and a 20 percent incentive allowance, was estimated to be $20 per acre or $6.35 per acre-foot of water. This would be sufficient to meet operation, maintenance, and replacement expenses; retire the distribution system construction costs over a 40-year period; and repay about $65,000, or less than one percent, towards retirement of the capital costs of project works allocated to the irrigation function. Financial aid in the amount of about $10,000,000 would be required to retire the balance of the costs of the main project facilities allocated to irrigation, or $4.87 per acre-foot.[2] At the time of the Bureau report the

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1/ Under more recent Federal legislation such costs are to be included as a project cost and subject to allocation purposes.

2/ This indicates total cost of water at $11.22 per acre foot. Cost of water from a Dos Rios project which would exclude the flooding of Round Valley would exceed this figure by a large amount.

local water supply from ground water was two to three times as great as the requirement of the existing crop pattern. On this basis the Bureau recommended that further studies of Round Valley be deferred until feasibility investigations of the Etsel Unit, Eel River Division, are underway.

A-24. Round Valley is situated in a relatively isolated, sparsely populated area. The only town in the Valley is the community of Covelo which has a population of about 600. Projections by the Corps of Engineers shown in Table A-8a, indicate that population growth in the Covelo-Laytonville Area (the census tract in which Round Valley is located) would increase ultimately from 4,900 to 12,000, or about 2.5 times. This estimate is somewhat less than that of the Department of Water Resources. Flooding Round Valley would result in no sustained loss in urban economic activities because of proposed measures to relocate the town of Covelo and the Indian population. Net agricultural production losses which would result from flooding Round Valley are estimated to be $569,000. This sum was derived as follows: based on the crop pattern projected by the Bureau of Reclamation total net crop income, assuming full irrigation development would amount to $1,232,000. Certain deductions were made in order to derive net losses associated with the inundation of the valley. The potential irrigable area of 13,200 acres was estimated to be worth $3,330,000. This was derived by capitalizing the estimated present net crop income of $133,000 at a five percent interest rate plus an allowance of 25 percent for contingencies to provide for rising price levels, possible severance damage, etc. Investment of this amount ($3,330,000) at the project interest rate of 3.25 percent would yield $108,000, and would be received by present owners of valley lands. In addition, the cost of water and power associated with the projected crop pattern were deducted. The cost of water was estimated to be $35.30 per acre (based on 3.15 acre-feet per acre at $11.22 per acre-foot) or $466,000 for the 13,200 acres plus $89,000 for power, which are costs associated with supplying irrigation water. This cost was not included in the data on increases in net crop incomes. The total deductions of $663,000 from the projected total net crop income result in a loss of land productivity of $569,000, if as indicated above, full irrigation development would be undertaken. It is this figure which was used in the evaluation of the effects of flooding Round Valley. In the economic evaluation of the loss of productivity in the valley, the return on the estimated value of the land was used rather than the estimated present crop income. Round Valley has numerous development problems and it is likely that the potential economic loss resulting from flooding may be less than this estimate. Since the Bureau of Reclamation study the water supply of the valley and crop pattern have remained essentially unchanged and it is uncertain that capital expenditures for the proposed improvements will be made. At the current price level the estimated cost of these improvements would increase from $14 million to about $16.5 million. Moreover, recent reconnaissance investigation indicates that the geology of the proposed Franciscan damsite may present structural problems which could further increase development costs. These added costs would necessitate greater financial assistance to the project than $10 million initially estimated. The cost of water from a Dos Rios project which would protect Round Valley from flooding would be substantially higher and therefore would not be considered as an economical alternative source. The magnitude of expenditures necessary to gain added income cannot be financed with the amount of revenue generated in Round Valley. If this is the case, the area would develop without extensive improvements and the ultimate level of growth is likely to increase only about three to five times the present level.

## A-25. IMPACT OF RECREATION AT DOS RIOS RESERVOIR ON LOCAL ECONOMY

This and subsequent paragraphs analyze the impact on the local area of providing recreation facilities as a purpose of the proposed Dos Rios project. As explained in Appendix D, "Recreation, Fish and Wildlife" and in the main report, the reservoir has a potential attendance of 7 million annually. Due to constraints of adequate highway access, provisions for recreation facilities are planned to accommodate an annual attendance of 2 million. The analysis includes the effect of full potential development as well as of the proposed recreation development.

## A-26. IMPACT OF FULL RECREATION POTENTIAL ON LOCAL AREA

This paragraph considers the impact upon the local area of developing Dos Rios reservoir recreation facilities to their full potential without relation to the constraint imposed by the access to the reservoir area. The local area considered is the area within commuting distance of the reservoir. In order to compute the impact the following criteria were adopted:

a. Attendance at Dos Rios Reservoir would reach 5,000,000 by 2030, the 50th year of the project, and 7,000,000 by the 100th year.

b. The average expenditure per visitor in the area of the reservoir is $3.00 per day. This expenditure represents purchases made by people who would not have been in the area without the proposed reservoir, including visitors to the Indian facilities. Hence, expenditures made by residents of Humboldt and Mendocino Counties and by casual sightseers were not included. Similarly, where tourists were expected to be in the area as a result of both the reservoir and also other recreation sites, only a portion of their expenditures were attributed to the reservoir.

A-27. Table A-11 shows the tourist expenditures and employment directly attributable to Dos Rios Reservoir by decades for a 100-year study period. Expenditures would increase from $6 million in 1990 to $21 million in 2080. Employment would range from 240 in 1990 to 840 in 2080. Table A-12 allocates total tourist expenditures and employment among categories of retail stores for project years 10, 50 and 100. Restaurants and lodging places are expected to obtain about half of all visitor expenditures. Substantial expenditures and employment are expected also in grocery stores, service stations, and drug stores.

A-28. Data in Tables A-11 and A-12 indicate the maximum direct effect of a reservoir at Dos Rios on employment in the local area. In addition, there are two indirect effects of the reservoir on local employment. They are: (1) additional employment created by the needs of the employees and their families directly attributable to the reservoir, and (2) additional employment created by service and support businesses, such as real estate, finance, repairs, transportation and utilities. No attempt was made to allocate such occupations by type, because of the great variety of possible types of business. However, overall increases in indirect employment attributable to the reservoir were estimated using a ratio of one indirect job for each direct job. An estimate of the effect of an unlimited access reservoir on population was made assuming a ratio of 3.3 people per employee. Results are presented for selected years in the following tabulation:

### TOTAL EMPLOYMENT AND POPULATION ATTRIBUTABLE TO DOS RIOS RESERVOIR

| | Employment | Population |
|---|---|---|
| 1990 | 440 | 1,450 |
| 2030 | 1,200 | 4,000 |
| 2080 | 1,680 | 5,500 |

A-29. IMPACT OF PROPOSED RECREATION DEVELOPMENT ON LOCAL AREA

This paragraph considers the impact upon the local area of presently proposed recreation development at Dos Rios Reservoir. The following criteria were adopted:

a. Ultimate development would occur by 1990.

b. Ultimate annual attendance would be 2 million of which about one-half would be attributable to facilities which might be provided at the relocated Indian community.

c. Daily expenditures per visitor would be $3.00.

A-30. Ultimate visitor expenditures of $6 million per year are expected by 1990. Direct employment associated with visitor expenditures in 1990 would approximate 240, total employment, 440 and population, 1450.

## A-31. IMPACT OF RECREATION AT DOS RIOS RESERVOIR ON COVELO

The proposed reservoir would flood Round Valley including the urban area of Covelo. For purposes of analysis it was assumed that Covelo would relocate on high ground near the reservoir where it would service the needs of recreationists. The impact upon the relocated town of Covelo associated with development of Dos Rios Reservoir recreation facilities to their full potential was determined under the following criteria:

a. Annual attendance on Indian lands would ultimately equal 1.8 million. Expenditures by visitors on Indian lands were excluded from further consideration. Total attendance would reach 5 million by 2030 and 7 million by 2080.

b. Daily expenditures at Covelo per person would be $1.50. This figure excludes expenditures by residents of Covelo.

A-32. Dos Rios reservoir with full recreation development is expected to result ultimately in 40 small stores and 10 larger ones. The small stores would average about $100,000 each in annual retail sales; the large would average $350,000 each. At least one supermarket and a large variety store are anticipated.

A-33. Employment in stores directly attributable to the reservoir was used as a basis for determining total employment and population attributable to the reservoir. Results for 1990, 2030 and 2080 are shown in the following tabulation:

| | Direct Employment | Total Employment | Population |
|---|---|---|---|
| 1990 | 60 | 95 | 290 |
| 2030 | 190 | 350 | 1,150 |
| 2080 | 310 | 580 | 1,900 |

## A-34. IMPACT OF PROPOSED RECREATION DEVELOPMENT ON LOCAL AREA

This paragraph considers the impact upon relocated Covelo of presently proposed recreation development at Dos Rios Reservoir. Criteria adopted are:

a. Ultimate development would occur by 1990.

b. Annual attendance on Indian lands would ultimately equal 1.0 million.

c. Daily expenditures per visitor would be $1.50.

A-35. By 1990, Dos Rios Reservoir with the proposed recreation development would attract sufficient visitor expenditures to generate approximately 15 new small retail stores with average sales per store of $100,000 annually. Types of stores would include restaurants and cocktail lounges, motels, service stations, gift shops, drugstores, a boat repair shop, a moderate size grocery store and a liquor store.

A-36. Direct employment attributable to the reservoir would be approximately 60, indirect employment 95 and associated population about 290.

A-37. All of the above data on recreation impact are presented for informational purposes and to indicate the effect of recreation activity upon employment, population and basin economic environment. This impact effect is of the type falling within the definition of secondary benefits which is not included in project formulation or justification by the Corps of Engineers under present concepts of economic justification.

## TABLE A-1

## PERCENTAGE DISTRIBUTION OF TOTAL CIVILIAN LABOR FORCE AND EMPLOYMENT, BY INDUSTRY, HUMBOLDT COUNTY, 1959-65

| Distribution | 1959 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 |
|---|---|---|---|---|---|---|---|
| Labor force 1/ | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Unemployment | 5.0 | 8.4 | 10.4 | 8.3 | 8.5 | 7.5 | 8.5 |
| Employment | 95.0 | 91.6 | 89.6 | 91.7 | 91.5 | 92.5 | 91.5 |
| Total, employment* | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Agriculture | 5.0 | 5.1 | 5.3 | 5.2 | 5.2 | 5.1 | 5.0 |
| Construction | 4.8 | 4.3 | 5.3 | 4.9 | 4.1 | 4.8 | 6.6 |
| Manufacturing | 37.7 | 35.1 | 32.8 | 33.3 | 32.8 | 32.3 | 29.8 |
| Food | 2.4 | 2.7 | 2.2 | 2.5 | 2.2 | 2.1 | 2.1 |
| Lumber | 33.7 | 31.1 | 28.9 | 29.5 | 29.0 | 28.7 | 25.5 |
| All other | 1.6 | 1.6 | 1.4 | 1.4 | 1.6 | 1.6 | 2.1 |
| Transportation, communication and public utilities | 6.1 | 5.9 | 5.9 | 6.3 | 6.6 | 5.9 | 5.8 |
| Trade | 18.0 | 18.9 | 18.5 | 17.5 | 18.0 | 18.3 | 18.3 |
| Finance; insurance; real estate | 2.1 | 2.7 | 2.5 | 2.5 | 2.5 | 2.4 | 2.7 |
| Service | 13.3 | 14.3 | 14.6 | 14.7 | 15.3 | 15.6 | 15.7 |
| Government | 11.9 | 12.4 | 13.8 | 14.5 | 14.7 | 14.5 | 14.5 |
| All other 1/ | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 0.8 | 0.8 |

1/ Includes forestry, fisheries, miscellaneous agricultural workers and mining.

* Columns may not add to totals due to rounding.

Source: State of California, Department of Employment.

TABLE A-2

## CIVILIAN LABOR FORCE AND EMPLOYMENT, SELECTED INDUSTRIES
## HUMBOLDT COUNTY, 1959-65

(Thousands)

| Distribution | 1959 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | Net Change 1959-65 |
|---|---|---|---|---|---|---|---|---|
| Labor Force 1/ | 39.8 | 40.4 | 39.6 | 40.0 | 40.1 | 41.1 | 41.1 | +1.3 |
| Unemployment | 2.0 | 3.4 | 4.1 | 3.3 | 3.4 | 3.0 | 3.5 | +1.5 |
| Total, Employment * | 37.7 | 37.0 | 35.6 | 36.6 | 36.6 | 37.2 | 37.6 | - .1 |
| Agriculture | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 | 0 |
| Construction | 1.8 | 1.6 | 1.9 | 1.8 | 1.5 | 1.8 | 2.5 | + .7 |
| Manufacturing | 14.2 | 13.0 | 11.7 | 12.2 | 12.0 | 12.0 | 11.2 | -3.0 |
| Food | 0.9 | 1.0 | 0.8 | 0.9 | 0.8 | 0.8 | 0.8 | - .1 |
| Lumber | 12.7 | 11.5 | 10.3 | 10.8 | 10.6 | 10.7 | 9.6 | -3.1 |
| All other | 0.6 | 0.6 | 0.5 | 0.5 | 0.6 | 0.6 | 0.8 | + .2 |
| Trans;Comm; Public Utilities | 2.3 | 2.2 | 2.1 | 2.3 | 2.4 | 2.2 | 2.2 | - .1 |
| Trade | 6.8 | 7.0 | 6.6 | 6.4 | 6.6 | 6.8 | 6.9 | + .1 |
| Finance; Ins; Real Estate | 0.8 | 1.0 | 0.9 | 0.9 | 0.9 | 0.9 | 1.0 | + .2 |
| Service | 5.0 | 5.3 | 5.2 | 5.4 | 5.6 | 5.8 | 5.9 | + .9 |
| Government | 4.5 | 4.6 | 4.9 | 5.3 | 5.4 | 5.4 | 5.8 | +1.3 |
| All Other 1/ | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.3 | 0.3 | - .1 |

1/ Includes forestry, fisheries, miscellaneous agricultural workers and mining.

* Columns may not add to totals due to rounding.

Source: State of California, Department of Employment.

## TABLE A-3

## EMPLOYMENT BY INDUSTRY, MENDOCINO COUNTY
## 1940, 1950 and 1960

Percent change, 1940 to 1950, 1950 to 1960 and 1940 to 1960

| Industry | [1] 1940 | 1950 | Percent Change 1940-50 | 1960 | Percent Change 1950-60 | Percent Change 1940-60 |
|---|---|---|---|---|---|---|
| All Industries | 8,481 | 14,137 | 66.7 | 16,123 | 14.0 | 90.1 |
| Good Producing Industries | 4,464 | 7,941 | 44.1 | 6,717 | -15.4 | 50.5 |
| Agriculture | 2,082 | 2,147 | 3.1 | 1,110 | -48.3 | -46.7 |
| Logging & sawmills [2] | 1,578 | 4,176 | 164.6 | 4,229 | 1.3 | 168.0 |
| Construction | 595 | 1,115 | 87.4 | 702 | -37.0 | 18.0 |
| All other | 209 | 503 | 140.7 | 676 | 34.4 | 223.4 |
| Service Industries | 3,901 | 5,908 | 53.3 | 8,778 | 46.8 | 125.0 |
| Transportation, communications & utilities | 534 | 844 | 58.1 | 1,139 | 35.0 | 113.3 |
| Wholesale trade | 107 | 209 | 95.3 | 476 | 127.8 | 344.9 |
| Retail trade | 1,240 | 1,855 | 49.6 | 2,421 | 30.5 | 95.2 |
| Finance, insurance and Real Estate | 85 | 180 | 11.8 | 417 | 131.7 | 390.6 |
| Other business and personal services [3] | 835 | 1,221 | 46.2 | 1,267 | 3.8 | 51.7 |
| Hospital, schools, other professional services | 837 | 1,290 | 54.1 | 2,431 | 88.4 | 190.4 |
| Public administration | 263 | 381 | 44.6 | 627 | 64.6 | 138.4 |
| Not reported | 116 | 216 | 86.2 | 628 | 190.7 | 441.4 |

Source: U. S. Census.

[1] Emergency employment not included.

[2] Including "Industries not Specified." In 1960, most of the employment in this cagegory was employment in a new plant utilizing wood in its manufactured product.

[3] Including "Entertainment and Recreation."

## TABLE A-4

## VALUE OF PRINCIPAL AGRICULTURAL PRODUCTS HUMBOLDT AND MENDOCINO COUNTIES

### 1961-1965

### ($000)

| | 1961 Value | 1962 Value | 1963 Value | 1964 Value | 1965 Value |
|---|---|---|---|---|---|
| Humboldt County | $21,803 | $12,768 | $12,987 | $13,196 | $11,652 |
| Mendocino County | 8,277 | 10,315 | 9,258 | 12,193 | 12,465 |
| Total | $21,080 | $23,083 | $22,245 | $25,389 | $24,117 |

Source: Crop Reports - Humboldt County Department of Agriculture and Mendocino County Department of Agriculture.

## TABLE A-5

## TAXABLE SALES

## HUMBOLDT AND MENDOCINO COUNTIES

### 1950 - 1965

| Year | Humboldt County | Mendocino County |
|---|---|---|
| | (In Millions of Dollars) | |
| 1950 | 84 | 38 |
| 1960 | 139 | 54 |
| 1961 | 130 | 51 |
| 1962 | 131 | 56 |
| 1963 | 138 | 63 |
| 1964 | 156 | 68 |
| 1965 | 181 | 74 |

## TABLE A-6

## CALIFORNIA AND EEL RIVER BASIN POPULATION PROJECTION

Year 1960 to 2080

| Census Divisions[1][2] | 1960[3] | 1980[5] | 2000 | 2020 | 2040 | 2060 | 2080 |
|---|---|---|---|---|---|---|---|
| California (in 000's) | 15,717[4] | 28,000 | 42,000 | 59,000 | 66,000 | 77,000 | 82,000 |
| Eel River Basin Census Division | | | | | | | |
| Ferndale - Fortuna | 14,600 | 24,500 | 35,100 | 56,000 | 87,000 | 105,000 | 120,000 |
| Scotia | 6,700 | 8,000 | 11,000 | 14,000 | 18,000 | 20,000 | 21,000 |
| Garberville - Mad River | 7,500 | 14,000 | 18,000 | 26,000 | 26,000 | 42,000 | 47,000 |
| Covelo - Laytonville | 4,900 | 5,500 | 6,000 | 8,000 | 10,000 | 11,000 | 12,000 |
| Willits - Redwood - Lake | 6,800 | 11,000 | 16,000 | 24,000 | 31,000 | 36,000 | 40,000 |
| Basin Totals | 40,500 | 63,000 | 86,000 | 128,000 | 182,000 | 214,000 | 240,000 |

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[1] U.S. Census Bureau "Census Divisions" as shown in 1960 Census of Population.

[2] All or portions of Census Divisions lying within the Eel River Basin have been combined into the following five groupings:

| | |
|---|---|
| Ferndale - Fortuna: | Ferndale, Fortuna, Arcata and Eureka, S.E., all in Humboldt County. |
| Scotia: | Scotia in Humboldt County. |
| Garberville - Mad River: | Garberville in Humboldt County and Mad River in Trinity County. |
| Covelo - Laytonville: | Covelo and Laytonville - Legget in Mendocino County and Orland and Willows in Glenn County. |
| Willits - Redwood - Lake: | Willits and Redwood - Potter Valley in Mendocino County and Upper Lake - Clear Lake in Lake County. |

[3] Estimate based on 1960 Census of Population.

[4] 1960 census.

[5] Population projections 1980-2020 - Department of Water Resources, State of California.
Population projections 2020-2080 San Francisco District, Corps of Engineers.

## TABLE A-7

## RECREATION USE IN VISITOR DAYS
## EEL RIVER BASIN

### 1960 and 2080

| Recreation Use | 1960 | 2080 |
|---|---|---|
| Water based - Includes swimming, boating and fishing | 494,000 | 56,000,000 |
| Others - Includes camping, picnicking, riding, hiking, hunting and community | 374,000 | 42,000,000 |
| Total, visitor-days | 868,000 | 98,000,000 |
| Visitor origin | | |
| Outside basin | 738,000 | 95,300,000 |
| Residents | 130,000 | 2,700,000 |

TABLE A-8

## EEL RIVER BASIN
## LAND USE: 1960-2060

(Acres)

| | Residential and Commercial | Industrial | Agriculture | Commercial Timberland | Public and Reserved | Other Timberland, Grassland, Unused | Total |
|---|---|---|---|---|---|---|---|
| | | | 1960 | | | | |
| | 16,700 | 2,150 | 68,500 | 1,377,000 | 29,500 | 826,150 | 2,320,000 |
| Percent of total | NEG | NEG | 2.5 | 59.4 | 1.3 | 35.6 | 100.0 |
| | | | 1980 | | | | |
| | 26,000 | 3,000 | 64,000 | 1,375,000 | 31,000 | 821,000 | 2,320,000 |
| Percent of total | 1.12 | NEG | 2.7 | 59.3 | 1.34 | 35.0 | 100.0 |
| | | | 2000 | | | | |
| | 35,000 | 3,500 | 60,000 | 1,373,000 | 33,000 | 815,500 | 2,320,000 |
| Percent of total | 1.5 | NEG | 2.6 | 59.0 | 1.4 | 35.0 | 100.0 |
| | | | 2020 | | | | |
| | 53,000 | 4,500 | 48,000 | 1,368,000 | 39,500 | 807,000 | 2,320,000 |
| Percent of total | 2.28 | NEG | 2.1 | 58.0 | 1.70 | 34.8 | 100.0 |
| | | | 2040 | | | | |
| | 76,000 | 5,000 | 40,000 | 1,355,000 | 53,000 | 791,000 | 2,230,000 |
| Percent of total | 3.3 | NEG | 1.7 | 58.4 | 2.3 | 34.0 | 100.0 |
| | | | 2060 | | | | |
| | 89,000 | 5,500 | 33,000 | 1,344,000 | 64,000 | 784,500 | 2,320,000 |
| Percent of total | 3.84 | NEG | 1.4 | 57.9 | 2.8 | 33.8 | 100.0 |

# TABLE A-8a

## EMPLOYMENT - EEL RIVER BASIN [1/]
1960 - 2020 - 2080

| Type of Employment | Number Employed | 1960 Percent of Total Employment | Number Employed | 2020 Percent of Total Employment | Number Employed | 2080 Percent of Total Employment |
|---|---|---|---|---|---|---|
| Agricultural | 1,290 | 10.5 | 1,040 | 2.5 | 800 | 1.0 |
| Industrial | 6,065 | 49.2 | 12,600 | 29.9 | 19,000 | 27.0 |
| Other (Services) | 4,965 | 40.3 | 28,500 | 67.6 | 52,000 | 72.0 |
| Total, Employment | 12,320 | | 42,140 | | 71,800 | |
| Total, Population | 39,839 | 100.0 | 128,000 | 100.0 | 240,000 | 100.0 |

[1/] For population of basin, see Table A-6.

TABLE A-8b

## LAND-USE PROJECTION
## Year 1960 to 2080
(In Acres)

| 1/2/ Census Divisions | Residential and Commercial | Industrial | Agriculture | 4/ Commercial Timberland | Public and 5/ Reserved | Other Timber-land, Grass-land, Unused | Total |
|---|---|---|---|---|---|---|---|
| 1960 3/ | | | | | | | |
| Ferndale-Fortuna | 7,500 | 840 | 33,000 | 150,000 | 400 | 83,260 | 274,000 |
| Scotia | 3,600 | 500 | 10,500 | 51,000 | 1,000 | 6,400 | 73,000 |
| Garberville-Mad River | 1,500 | 300 | 2,000 | 465,000 | 27,000 | 199,200 | 695,000 |
| Covelo-Laytonville | 2,100 | 210 | 16,000 | 497,000 | 1,000 | 365,690 | 882,000 |
| Willits-Redwood-Lake | 2,000 | 300 | 7,000 | 214,000 | 100 | 172,000 | 396,000 |
| Basin totals | 16,700 | 2,150 | 68,500 | 1,377,000 | 29,500 | 826,150 | 2,320,000 |
| 1980 | | | | | | | |
| Ferndale-Fortuna | 13,000 | 1,400 | 29,500 | 148,000 | 1,000 | 81,100 | 274,000 |
| Scotia | 4,400 | 580 | 10,000 | 51,000 | 1,500 | 5,520 | 73,000 |
| Garberville-Mad River | 3,000 | 350 | 1,500 | 465,000 | 27,000 | 198,150 | 695,000 |
| Covelo-Laytonville | 2,500 | 220 | 16,000 | 497,000 | 1,000 | 365,280 | 882,000 |
| Willits-Redwood-Lake | 3,100 | 450 | 7,000 | 214,000 | 500 | 170,950 | 396,000 |
| Basin totals | 26,000 | 3,000 | 64,000 | 1,375,000 | 31,000 | 821,000 | 2,320,000 |
| 2000 | | | | | | | |
| Ferndale-Fortuna | 18,800 | 1,670 | 26,500 | 146,000 | 2,000 | 79,030 | 274,000 |
| Scotia | 5,500 | 630 | 10,000 | 51,000 | 1,500 | 4,370 | 73,000 |
| Garberville-Mad River | 3,500 | 420 | 1,000 | 465,000 | 27,000 | 198,080 | 695,000 |
| Covelo-Laytonville | 2,600 | 230 | 16,000 | 497,000 | 1,000 | 365,170 | 882,000 |
| Willits-Redwood-Lake | 4,600 | 550 | 6,500 | 214,000 | 1,500 | 168,850 | 396,000 |
| Basin totals | 35,000 | 3,500 | 60,000 | 1,373,000 | 33,000 | 815,500 | 2,320,000 |

### TABLE A-8b
(Cont'd)
### LAND-USE PROJECTION
### Year 1960 to 2080
(In Acres)

| Census Divisions 1/2/ | Residential and Commercial | Industrial | Agriculture | Commercial Timberland 4/ | Public and Reserved 5/ | Other Timberland, Grassland, Unused | Total |
|---|---|---|---|---|---|---|---|
| 2020 | | | | | | | |
| Ferndale-Fortuna | 31,200 | 2,280 | 16,000 | 143,000 | 4,000 | 77,520 | 274,000 |
| Scotia | 7,000 | 680 | 9,500 | 51,000 | 1,500 | 3,320 | 73,000 |
| Garberville-Mad River | 5,000 | 540 | 1,000 | 463,000 | 29,000 | 196,460 | 695,000 |
| Covelo-Laytonville | 3,000 | 250 | 16,000 | 497,000 | 1,000 | 364,750 | 882,000 |
| Willits-Redwood-Lake | 6,800 | 750 | 5,500 | 214,000 | 4,000 | 164,950 | 396,000 |
| Basin totals | 53,000 | 4,500 | 48,000 | 1,368,000 | 39,500 | 807,000 | 2,320,000 |
| 2040 | | | | | | | |
| Ferndale-Fortuna | 48,000 | 2,610 | 11,000 | 132,000 | 6,000 | 74,390 | 274,000 |
| Scotia | 9,000 | 700 | 8,500 | 50,000 | 1,500 | 3,300 | 73,000 |
| Garberville-Mad River | 6,500 | 620 | 500 | 463,000 | 34,000 | 191,380 | 695,000 |
| Covelo-Laytonville | 4,100 | 270 | 16,000 | 497,000 | 4,500 | 360,130 | 882,000 |
| Willits-Redwood-Lake | 8,400 | 800 | 4,000 | 214,000 | 7,000 | 161,600 | 396,000 |
| Basin totals | 76,000 | 5,000 | 40,000 | 1,355,000 | 53,000 | 791,000 | 2,320,000 |
| 2060 | | | | | | | |
| Ferndale-Fortuna | 58,000 | 2,900 | 6,000 | 126,000 | 7,500 | 73,600 | 274,000 |
| Scotia | 10,000 | 770 | 7,500 | 50,000 | 2,000 | 2,730 | 73,000 |
| Garberville-Mad River | 7,200 | 680 | 500 | 462,000 | 35,000 | 190,620 | 695,000 |
| Covelo-Laytonville | 4,300 | 280 | 16,000 | 497,000 | 8,500 | 355,920 | 882,000 |
| Willits-Redwood-Lake | 9,500 | 870 | 3,000 | 210,000 | 11,000 | 161,630 | 396,000 |
| Basin totals | 89,000 | 5,500 | 35,000 | 1,344,000 | 64,000 | 784,500 | 2,320,000 |

## TABLE A-8b
(Cont'd)
## LAND-USE PROJECTION
Year 1960 to 2080
(In Acres)

| 1/2/ Census Divisions | Residential and Commercial | Industrial | Agriculture | 4/ Commercial Timberland | Public and 5/ Reserved | Other Timberland, Grassland, Unused | Total |
|---|---|---|---|---|---|---|---|
| | | | 2080 | | | | |
| Ferndale-Fortuna | 65,000 | 3,100 | 3,000 | 120,000 | 9,000 | 73,900 | 274,000 |
| Scotia | 10,500 | 830 | 7,000 | 50,000 | 2,500 | 2,170 | 73,000 |
| Garberville-Mad River | 7,500 | 700 | 500 | 460,000 | 36,000 | 190,300 | 695,000 |
| Covelo-Laytonville | 4,500 | 290 | 16,000 | 497,000 | 12,500 | 351,710 | 882,000 |
| Willits-Redwood-Lake | 10,500 | 950 | 2,500 | 208,000 | 14,000 | 160,060 | 396,000 |
| Basin totals | 98,000 | 5,860 | 29,000 | 1,335,000 | 74,000 | 778,140 | 2,320,000 |

---

[1] U.S.Census Bureau "Census Divisions" as shown in 1960 Census of Population.

[2] All or a portion of the Divisions lying in the Eel River Basin have been grouped as follows:

<u>Ferndale-Fortuna</u>: Ferndale, Fortuna, Arcata and Eureka, S.E., Humboldt County, Scotia in Humboldt County.

<u>Garberville-Mad River</u>: Garberville in Humboldt County, Mad River in Trinity County.

<u>Covelo-Laytonville</u>: Covelo, Laytonville, Leggett in Mendocino County, Orland, Willows in Glenn County.

<u>Willits-Redwood-Lake</u>: Willits, Redwood, Potter Valley in Mendocino County, Clear Lake in Lake County.

[3] Estimate based on 1960 Census of Population.

[4] Includes U.S. Forest Service timberland.

[5] Includes park and recreation areas.

TABLE A-9

## EEL RIVER BASIN SERVICE AREA WATER REQUIREMENT - 1960 - 2080

| | 1960 | | 1980 | | 2000 | | 2020 | | 2040 | | 2060 | | 2080 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Normal | High | Normal | High | Normal | High | Normal | High | Normal | High | Normal | High | Normal | High |
| **M & I** 1/ | (Ac. ft.) | | (Ac. ft.) | | (Ac. ft.) | | (Ac. ft.) | | (Ac. ft.) | | (Ac. ft.) | | (Ac. ft.) | |
| Scotia | 1,500 | 2,200 | 2,600 | 3,900 | 4,200 | 6,300 | 6,400 | 9,600 | 9,300 | 14,000 | 12,000 | 18,000 | 19,000 | 22,000 |
| Fortuna | 2,700 | 4,000 | 5,900 | 8,800 | 10,800 | 16,200 | 21,400 | 32,100 | 39,700 | 59,500 | 53,600 | 80,400 | 72,000 | 78,000 |
| Ferndale | 500 | 700 | 800 | 1,100 | 1,000 | 1,500 | 1,400 | 2,200 | 1,900 | 2,900 | 2,400 | 3,600 | 2,900 | 4,300 |
| Subtotal | 4,700 | 6,900 | 9,300 | 13,800 | 16,000 | 24,000 | 29,200 | 43,900 | 50,900 | 76,400 | 68,000 | 102,000 | 94,700 | 104,300 |
| **IRRIGATION** 2/ | | | | | | | | | | | | | | |
| Scotia, Fortuna, Ferndale | 19,000 | — | 30,000 | — | 37,800 | — | 36,000 | — | 33,600 | — | 31,800 | — | 31,000 | — |
| Grand Total | 23,700 | 25,900 | 39,300 | 43,800 | 53,800 | 61,800 | 65,200 | 79,900 | 84,500 | 110,000 | 99,800 | 133,800 | 125,700 | 135,300 |
| **GROUND WATER SUPPLY** 3/ | 30,000 | | 30,000 | | 30,000 | | 30,000 | | 30,000 | | 30,000 | | 30,000 | |
| **SUPPLEMENTAL REQUIREMENT** | 4/ (6,300) | | 9,300 | | 23,800 | | 35,200 | | 54,500 | | 69,800 | | 95,700 | |

1/ USPHS Estimate 1960-2060; Corps of Engineers Estimate 2060-2080.

2/ DWR Bulletin No. 173, July 1967

3/ USBR Estimate.

4/ Surplus.

## TABLE A-10 [1]

## ROUND VALLEY
## PRESENT AND PROJECTED CROP PATTERNS [2]
(Acres)

| Crops | 1960 | 1980 | 2000 | 2020 |
|---|---|---|---|---|
| **Irrigated** | | | | |
| Improved pasture | 600 | 3,200 | 5,600 | 5,400 |
| Orchards [3] | 450 | 2,300 | 3,900 | 3,900 |
| Silage crops [4] | - | 900 | 1,600 | 1,500 |
| Alfalfa | - | 1,100 | 1,900 | 1,900 |
| Miscellaneous truck | - | 100 | 300 | 400 |
| Subtotal | 1,050 | 7,600 | 13,300 | 13,100 |
| **Non-Irrigated** | | | | |
| Improved pasture | 3,500 | 1,100 | - | - |
| Orchards [3] | 180 | 300 | - | - |
| Small grain [5] | 1,700 | 700 | - | - |
| Alfalfa | 240 | - | - | - |
| Mature meadow [6] | 265 | 300 | 300 | 300 |
| Urban and industrial | 700 | 900 | 1,200 | 1,400 |
| Open range | 9,585 | 6,400 | 2,500 | 2,500 |
| Subtotal | 16,250 | 9,700 | 4,000 | 4,200 |
| Total [7] | 17,300 | 17,300 | 17,300 | 17,300 |

[1] Source: Memorandum Report, Present and Projected Land Values, Round Valley, Mendocino County, California. Department of Water Resources, State of California, July 1964

[2] Projections assume that economically efficient supplies of water will be developed. The validity of this assumption is discussed in the text.

[3] Primarily, pears, some walnuts and prunes.

[4] Corn, corn silage, milo, sudan.

[5] Barley, oats, wheat and mixed of miscellaneous hay and grain.

[6] Lowlands with drainage problem.

[7] Composed of areas below 1,470 feet in Round Valley.

## TABLE A-11

## TOTAL EXPENDITURES AND DIRECT EMPLOYMENT ATTRIBUTABLE TO DOS RIOS RESERVOIR [1]

| Year | Attendance (000) | Daily Expenditure | Total Expenditure (000) | Employment |
|---|---|---|---|---|
| 1990 | 2,000 | $3.00 | $ 6,000 | 240 |
| 2000 | 3,000 | 3.00 | 9,000 | 360 |
| 2010 | 3,800 | 3.00 | 11,500 | 460 |
| 2020 | 4,500 | 3.00 | 13,500 | 540 |
| 2030 | 5,000 | 3.00 | 15,000 | 600 |
| 2040 | 5,500 | 3.00 | 16,500 | 660 |
| 2050 | 6,000 | 3.00 | 18,000 | 720 |
| 2060 | 6,400 | 3.00 | 19,000 | 760 |
| 2070 | 6,700 | 3.00 | 20,000 | 800 |
| 2080 | 7,000 | 3.00 | 21,000 | 840 |

---

[1] Dos Rios Reservoir with recreation facilities fully developed.

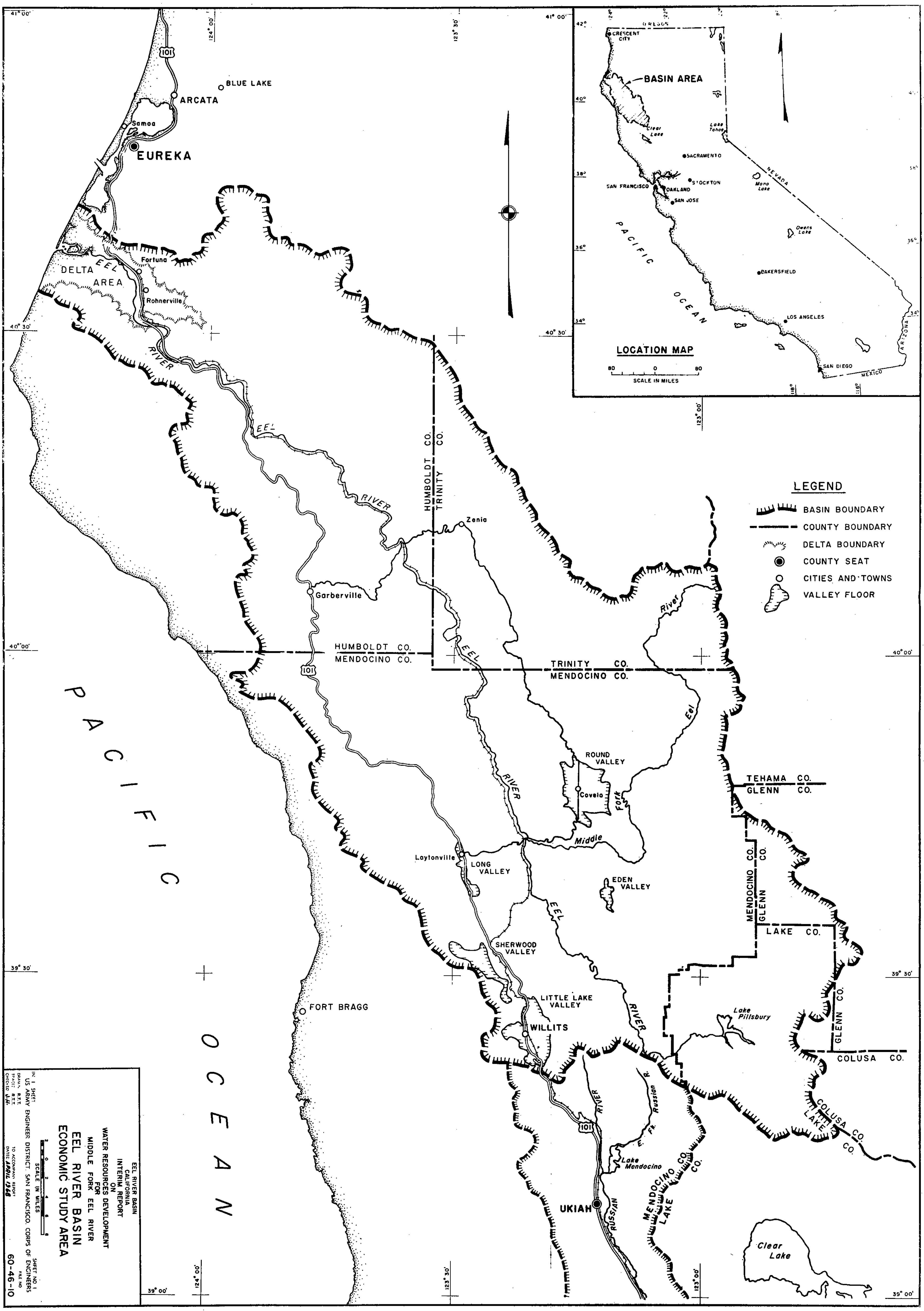
## TABLE A-12

## EXPENDITURES AND DIRECT EMPLOYMENT BY CATEGORY
## DOS RIOS RESERVOIR 1/

| Category | 10th Year |  |  |  | 50th Year |  |  |  | 100th Year |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | Expenditure (000) |  | Employment |  | Expenditure (000) |  | Employment |  | Expenditure (000) |  | Employment |  |
|  |  | Total |  | Total |  | Total |  | Total |  | Total |  | Total |
| Restaurants | $1,600 |  | 60 |  | $4,400 |  | 180 |  | $6,100 |  | 240 |  |
| Grocery | 400 |  | 20 |  | 1,100 |  | 40 |  | 1,500 |  | 60 |  |
| Total, food |  | $2,000 |  | 80 |  | $5,500 |  | 220 |  | $ 7,600 |  | 300 |
| Service station | 800 |  | 30 |  | 2,000 |  | 80 |  | 2,900 |  | 120 |  |
| Other transportation | 200 |  | 10 |  | 700 |  | 30 |  | 900 |  | 40 |  |
| Total, transportation |  | $1,000 |  | 40 |  | $2,700 |  | 110 |  | $ 3,800 |  | 160 |
| Lodging |  | 1,300 |  | 50 |  | 3,600 |  | 140 |  | 4,000 |  | 200 |
| Drugstore items |  | 600 |  | 25 |  | 1,600 |  | 65 |  | 2,300 |  | 90 |
| Miscellaneous |  | 600 |  | 25 |  | 1,600 |  | 65 |  | 2,300 |  | 90 |
| Total, expenditures |  | $5,500 |  | 220 |  | $15,000 |  | 600 |  | $21,000 |  | 840 |

---

1/ Dos Rios Reservoir with recreation facilities fully developed and ultimate annual attendance of 7 million persons.



EEL RIVER BASIN
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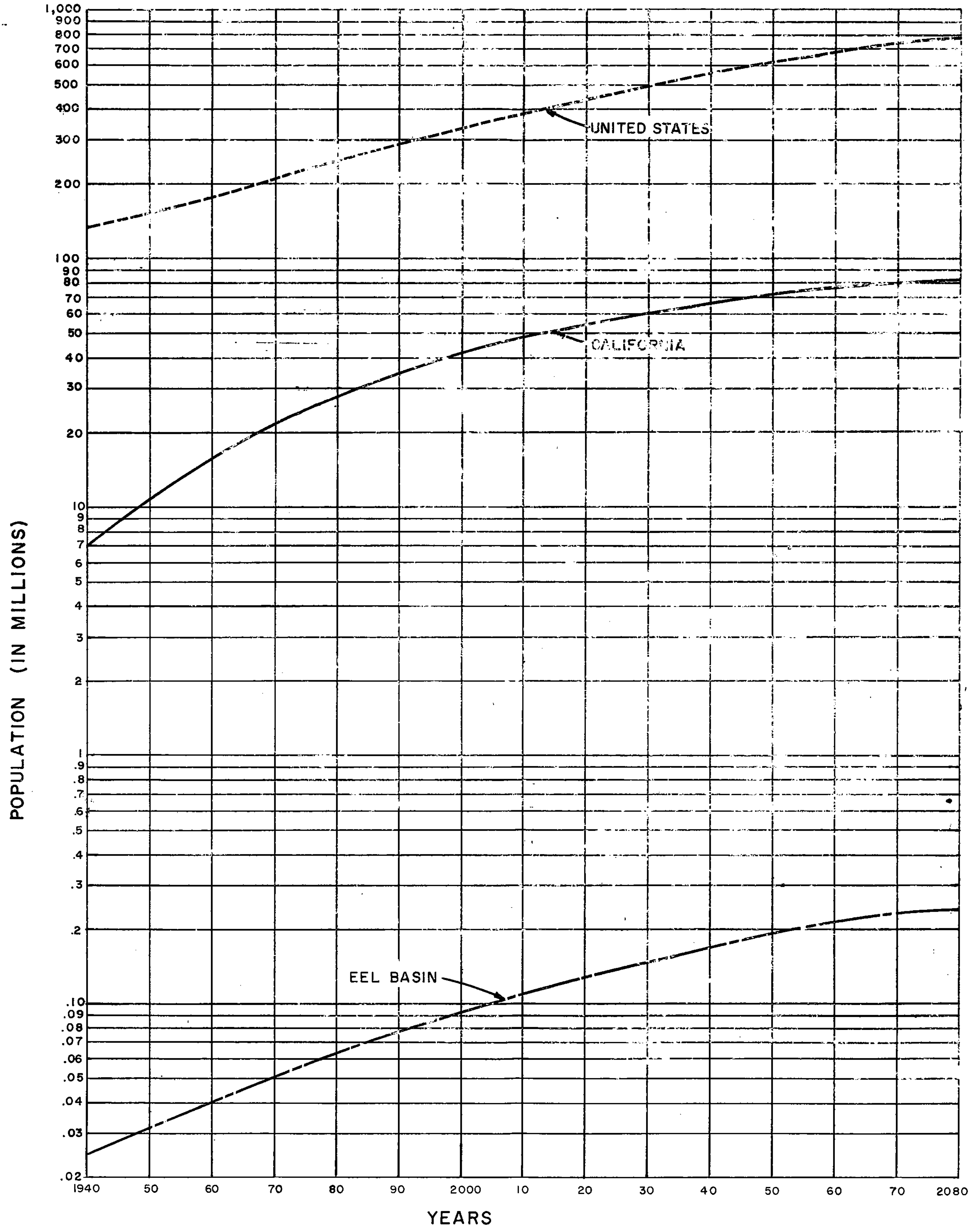
WATER RESOURCES DEVELOPMENT
FOR
MIDDLE FORK EEL RIVER

**EEL RIVER BASIN**
**ECONOMIC STUDY AREA**

SCALE IN MILES
2 0 2 4 6 8

IN 1 SHEET
SHEET NO 1
US ARMY ENGINEER DISTRICT. SAN FRANCISCO. CORPS OF ENGINEERS
DRAWN R.T.T.
TRACED R.T.T.
CHECKED J.H.
TO ACCOMPANY REPORT
DATED APRIL 1968
FILE NO
60-46-10

FIGURE A-I



EEL RIVER BASIN
CALIFORNIA
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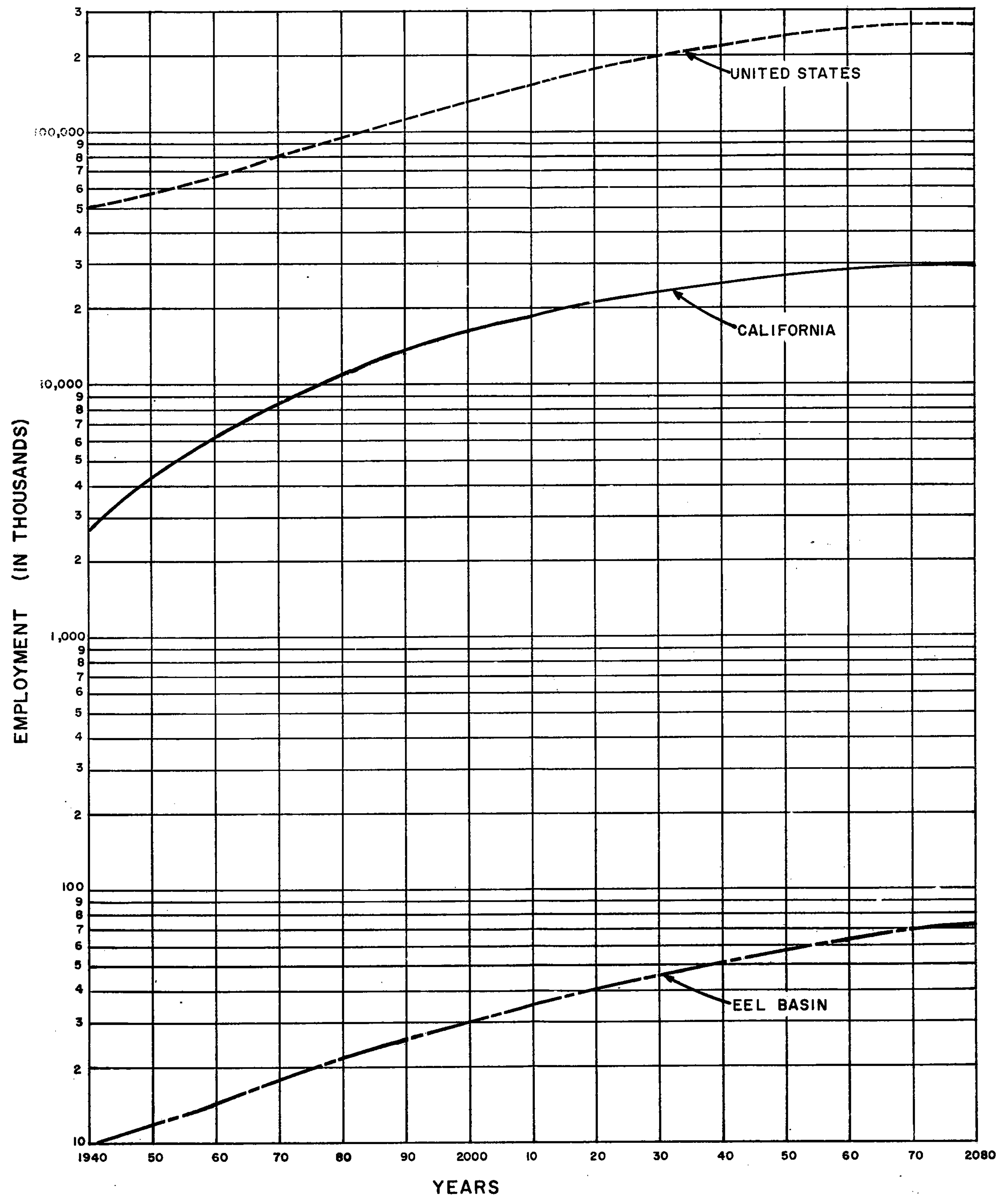
WATER RESOURCES DEVELOPMENT
FOR
MIDDLE FORK EEL RIVER

## POPULATION PROJECTIONS
## 1940-2080

IN 4 SHEETS — SHEET NO. 1
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E
DRAWN: E.C. — FILE NO.
TRACED: R.R.K. — TO ACCOMPANY REPORT 60-34-10
CHECKED: E.C. — DATED APRIL 1968

FIG. A-2



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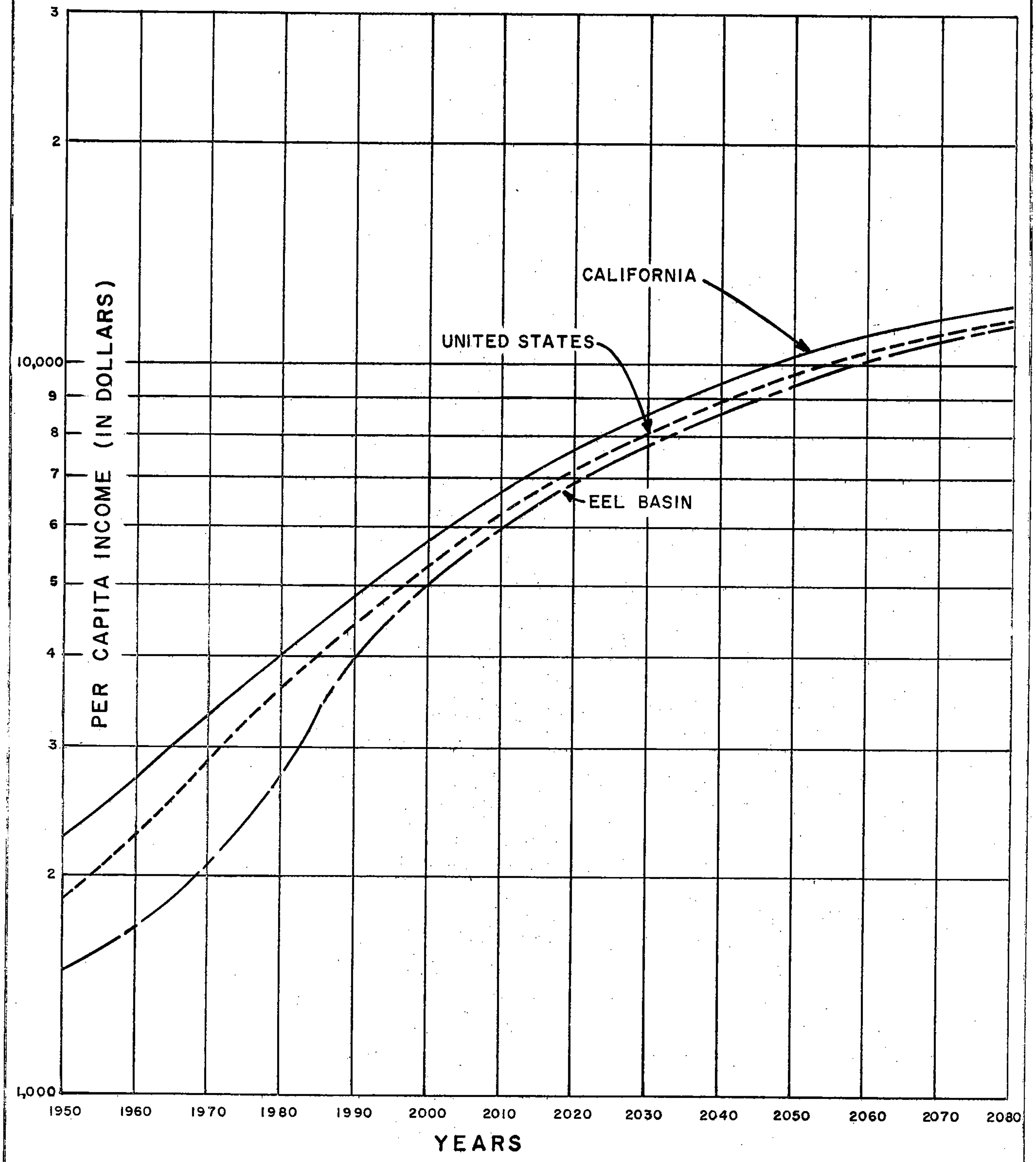
# EMPLOYMENT PROJECTIONS
# 1940-2080

IN 4 SHEETS SHEET NO.2
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E
DRAWN: E.C. FILE NO.
TRACED: P.L.H. TO ACCOMPANY REPORT 60-34-10
CHECKED: E.C. DATED APRIL 1968

FIG. A-3



EEL RIVER BASIN
CALIFORNIA
INTERIM REPORT
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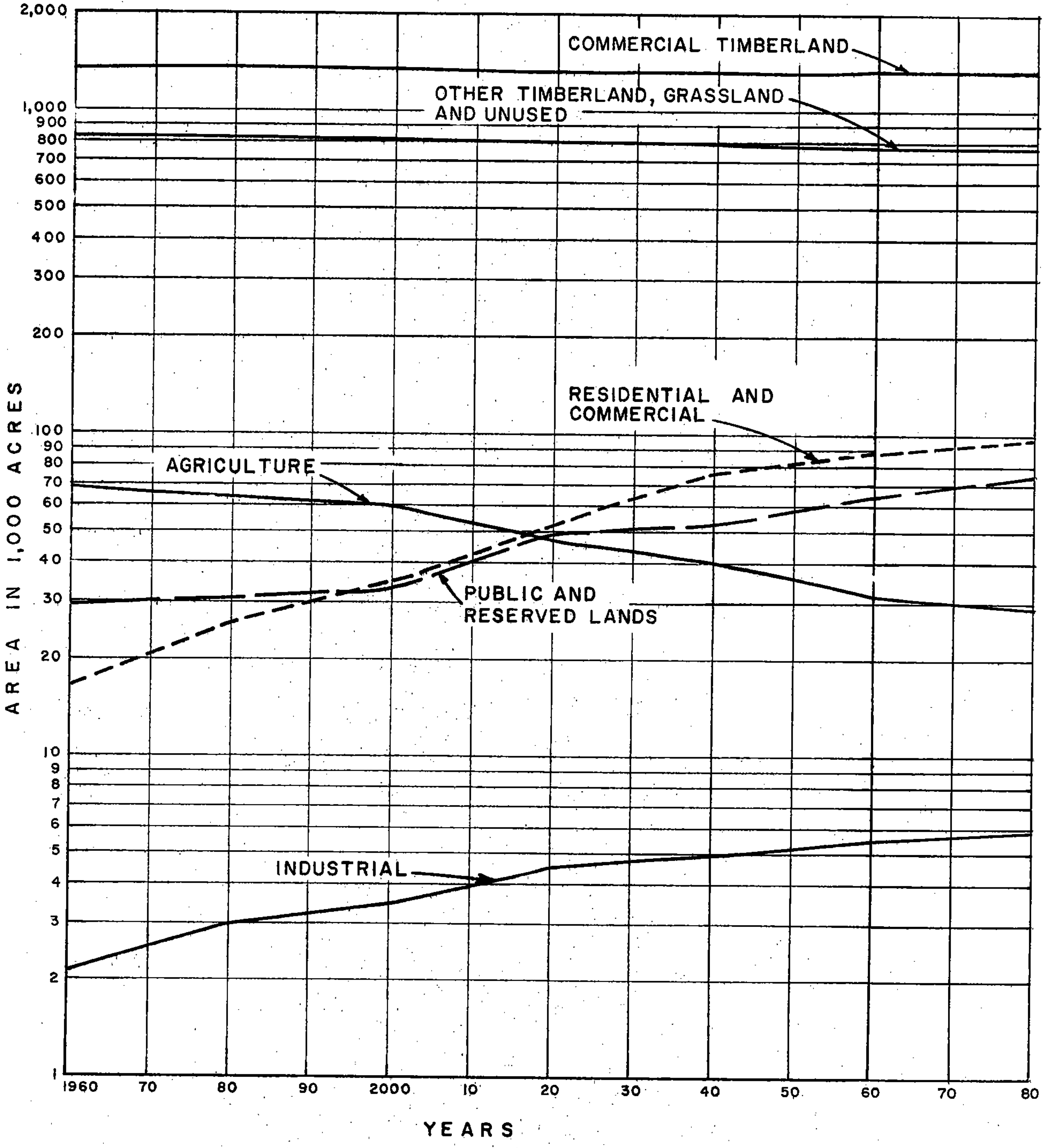
WATER RESOURCES DEVELOPMENT
FOR
MIDDLE FORK EEL RIVER

PROJECTIONS OF PER CAPITA INCOME EEL RIVER BASIN CALIFORNIA & UNITED STATES 1950-2080 (1960 PRICE LEVEL)

IN 4 SHEETS SHEET NO. 3
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E
DRAWN: E.C. FILE NO.
TRACED: P.L.H. TO ACCOMPANY REPORT 60-34-10
CHECKED: E.C. DATED APRIL 1968

FIG. A-4



EEL RIVER BASIN
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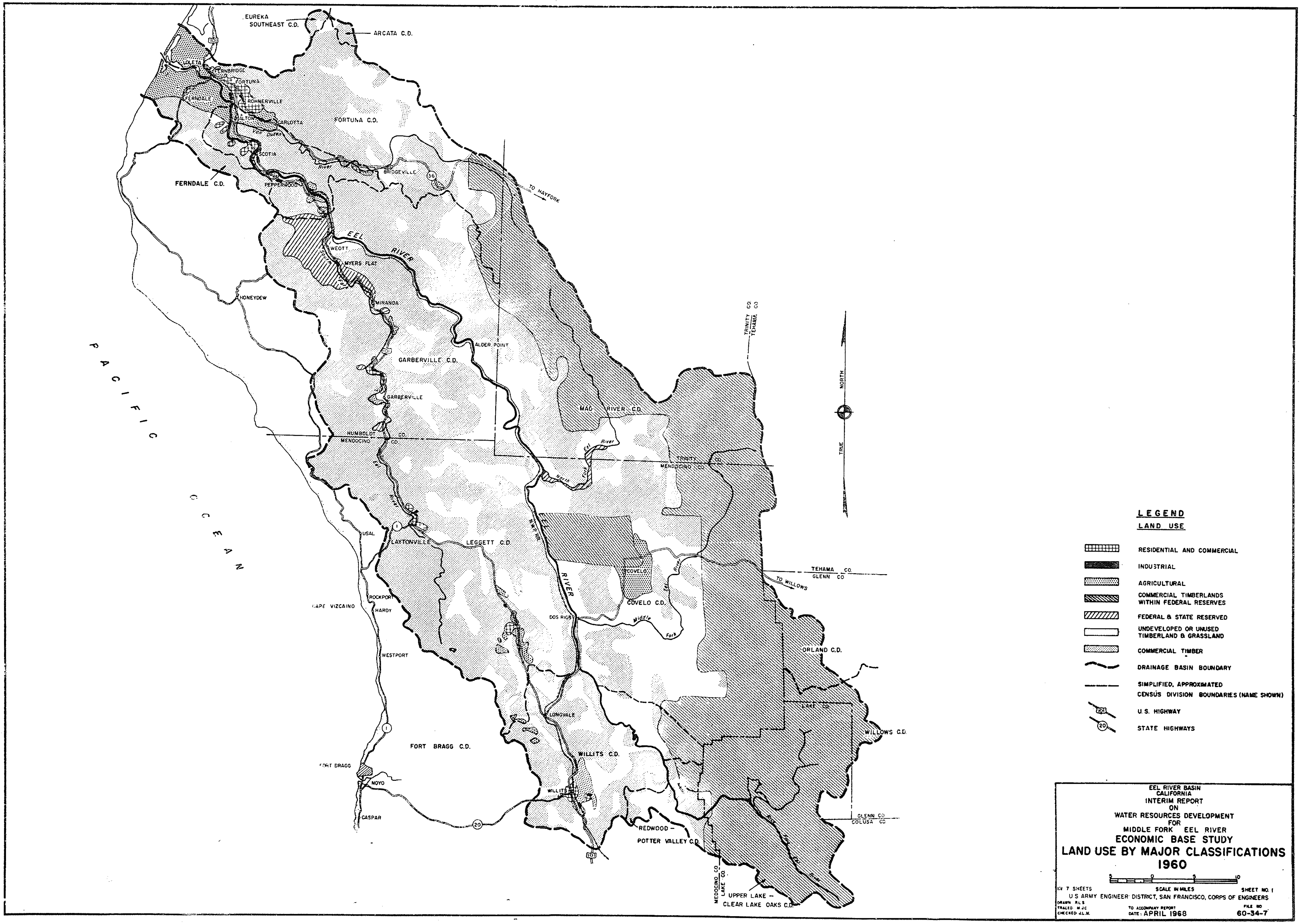
MIDDLE FORK EEL RIVER

## CHANGES IN LAND USE BY MAJOR CLASSIFICATION-1960-2080

IN 4 SHEETS SHEET NO.4

U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C. OF E.
DRAWN: E.C. FILE NO.
TRACED: P.L.H. TO ACCOMPANY REPORT 60-34-10
CHECKED: E.C. DATED: APRIL 1968

FIG. A-5



EEL RIVER BASIN
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FOR
MIDDLE FORK EEL RIVER

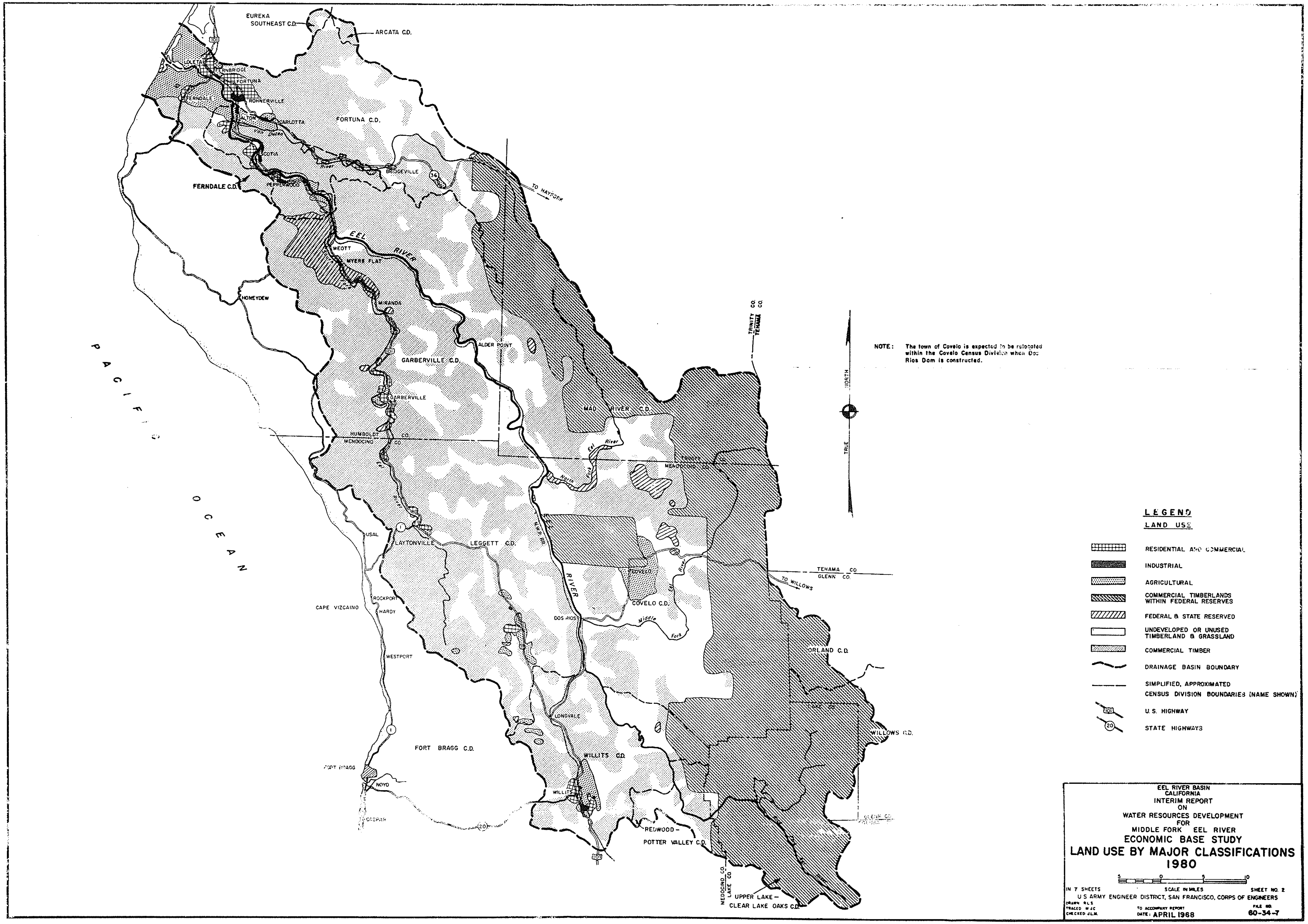
## ECONOMIC BASE STUDY

## LAND USE BY MAJOR CLASSIFICATIONS
## 1960

5 0 5 10
SCALE IN MILES

IN 7 SHEETS
SHEET NO. 1
U S ARMY ENGINEER DISTRICT, SAN FRANCISCO, CORPS OF ENGINEERS
DRAWN R.L.S.
TRACED M.J.C.
CHECKED J.L.M.
TO ACCOMPANY REPORT
DATE: APRIL 1968
FILE NO
60-34-7

FIG. A-6



NOTE: The town of Covelo is expected to be relocated within the Covelo Census Division when Dos Rios Dam is constructed.

EEL RIVER BASIN
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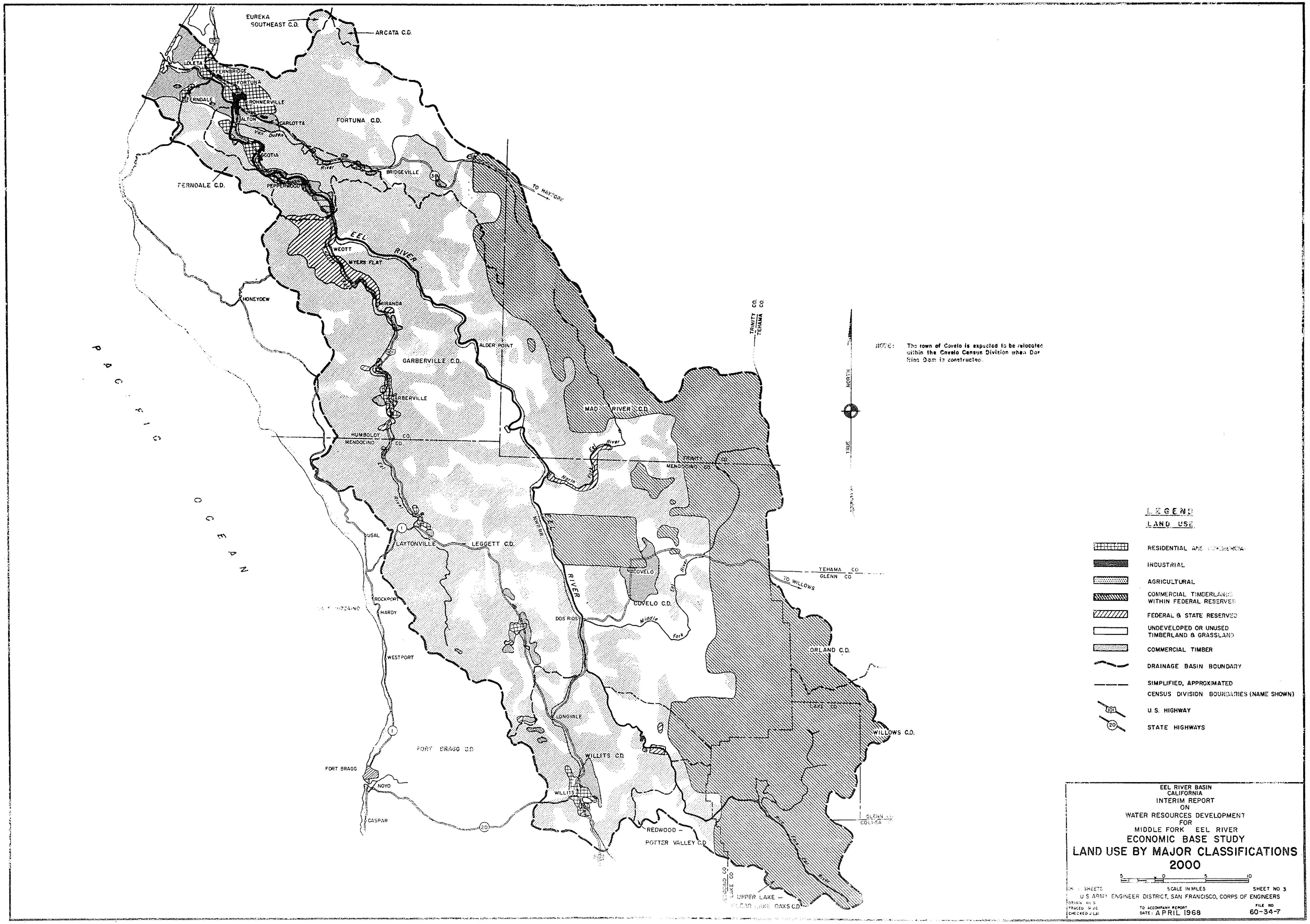
MIDDLE FORK EEL RIVER
ECONOMIC BASE STUDY

## LAND USE BY MAJOR CLASSIFICATIONS
## 1980

IN 7 SHEETS
SHEET NO. 2
U S ARMY ENGINEER DISTRICT, SAN FRANCISCO, CORPS OF ENGINEERS
DRAWN R.L.S.
TRACED M.J.C.
CHECKED J.L.M.
TO ACCOMPANY REPORT
DATE: APRIL 1968
FILE NO.
60-34-7

FIG. A-7



NOTE: The town of Covelo is expected to be relocated within the Covelo Census Division when Dos Rios Dam is constructed.

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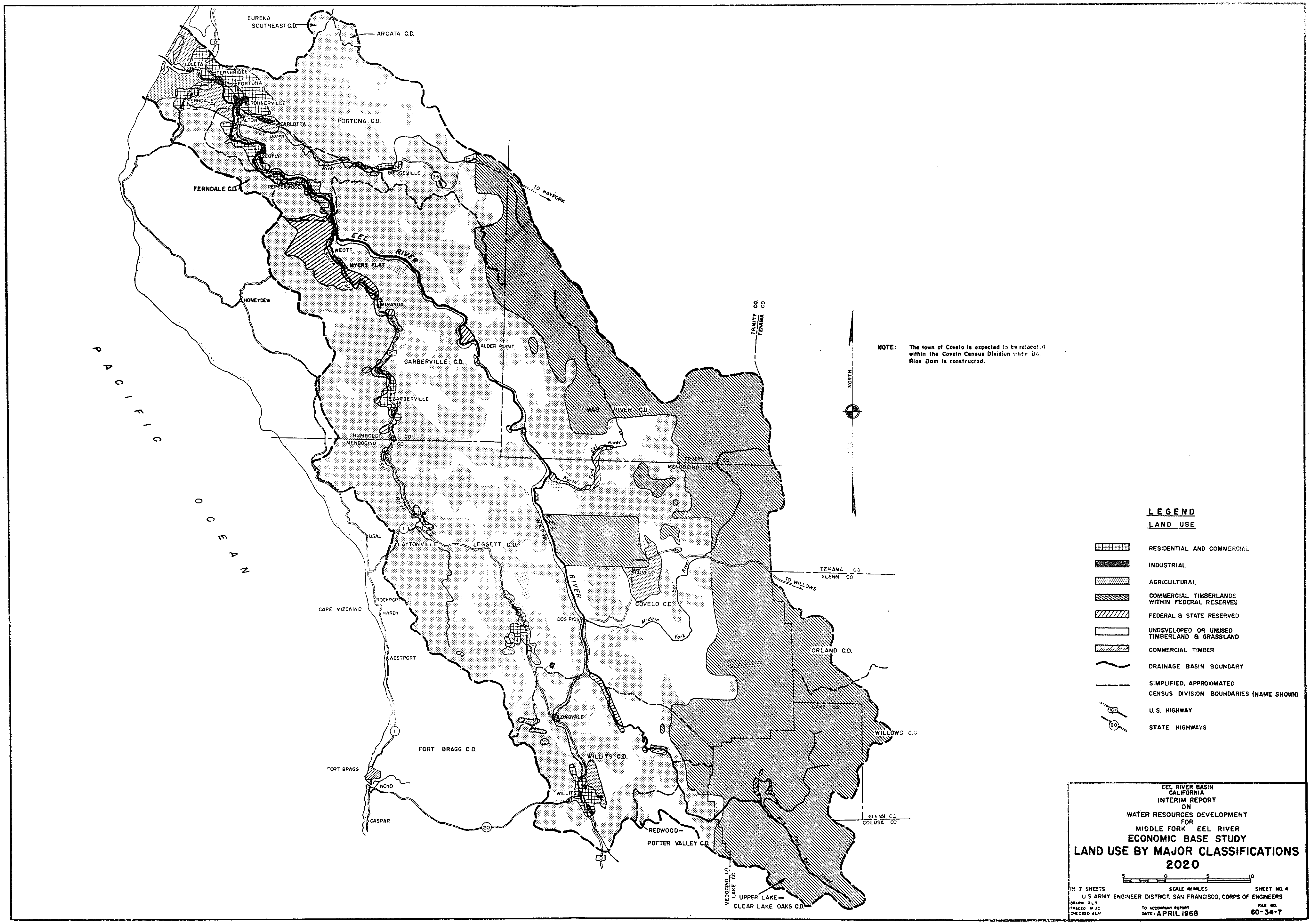
# LAND USE BY MAJOR CLASSIFICATIONS
# 2000

IN SHEETS SHEET NO. 3
U.S. ARMY ENGINEER DISTRICT, SAN FRANCISCO, CORPS OF ENGINEERS
DRAWN R.L.S.
TRACED M.J.C.
CHECKED J.L.M.
TO ACCOMPANY REPORT
DATE: APRIL 1968
FILE NO.
60-34-7

FIG. A-8



NOTE: The town of Covelo is expected to be relocated within the Covelo Census Division when Dos Rios Dam is constructed.

**LEGEND**

**LAND USE**

- ▦ RESIDENTIAL AND COMMERCIAL
- ■ INDUSTRIAL
- ▒ AGRICULTURAL
- ▨ COMMERCIAL TIMBERLANDS WITHIN FEDERAL RESERVES
- ▨ FEDERAL & STATE RESERVED
- ☐ UNDEVELOPED OR UNUSED TIMBERLAND & GRASSLAND
- ▒ COMMERCIAL TIMBER
- DRAINAGE BASIN BOUNDARY
- SIMPLIFIED, APPROXIMATED CENSUS DIVISION BOUNDARIES (NAME SHOWN)
- U. S. HIGHWAY
- STATE HIGHWAYS

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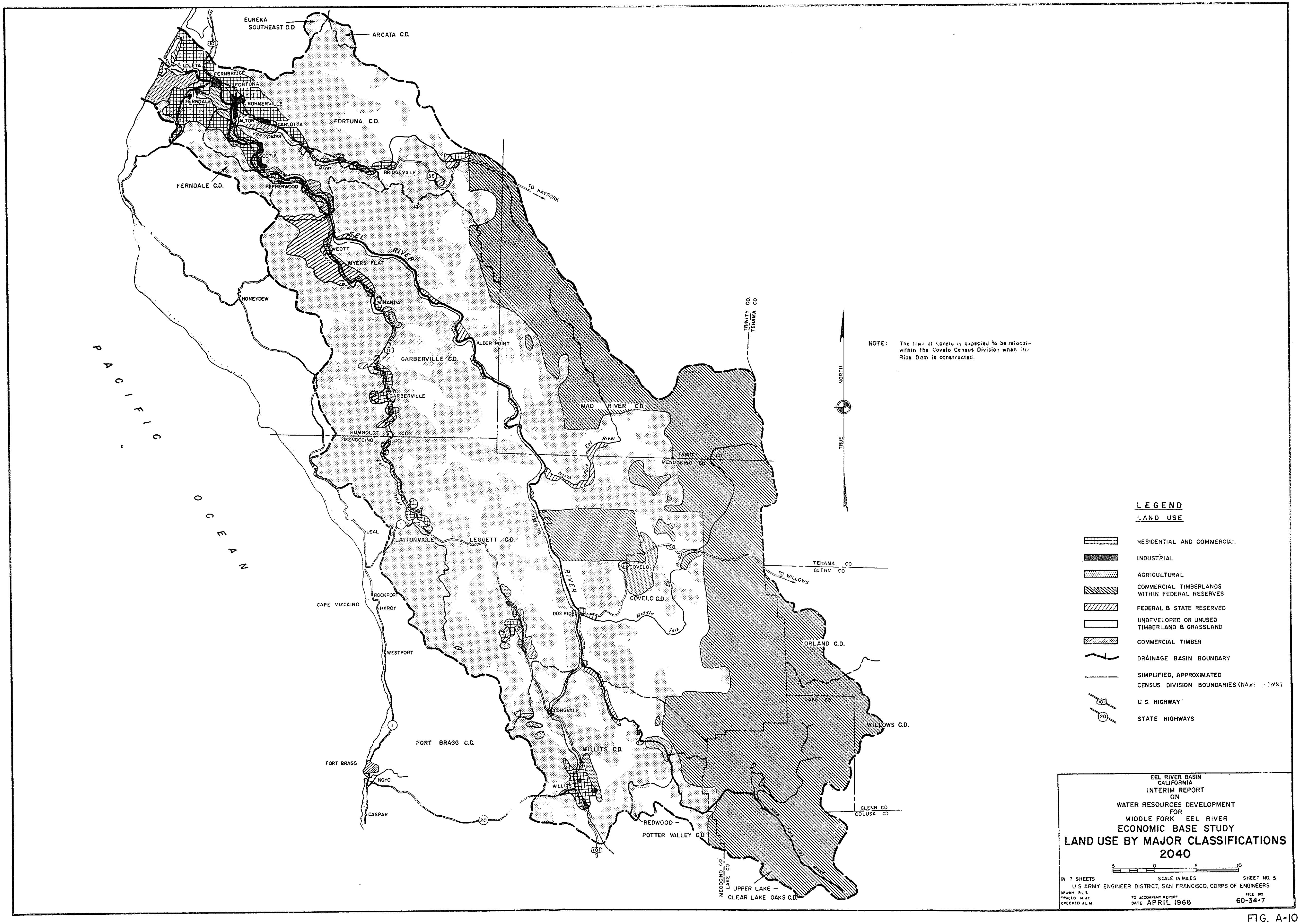
## LAND USE BY MAJOR CLASSIFICATIONS 2020

5 0 5 10
IN 7 SHEETS SCALE IN MILES SHEET NO. 4
U S ARMY ENGINEER DISTRICT, SAN FRANCISCO, CORPS OF ENGINEERS
DRAWN R.L.S.
TRACED M.J.C.
CHECKED 4.L.M.
TO ACCOMPANY REPORT
DATE: APRIL 1968
FILE NO.
60-34-7

FIG. A-9



NOTE: The town of Covelo is expected to be relocate within the Covelo Census Division when Dos Rios Dam is constructed.

EEL RIVER BASIN
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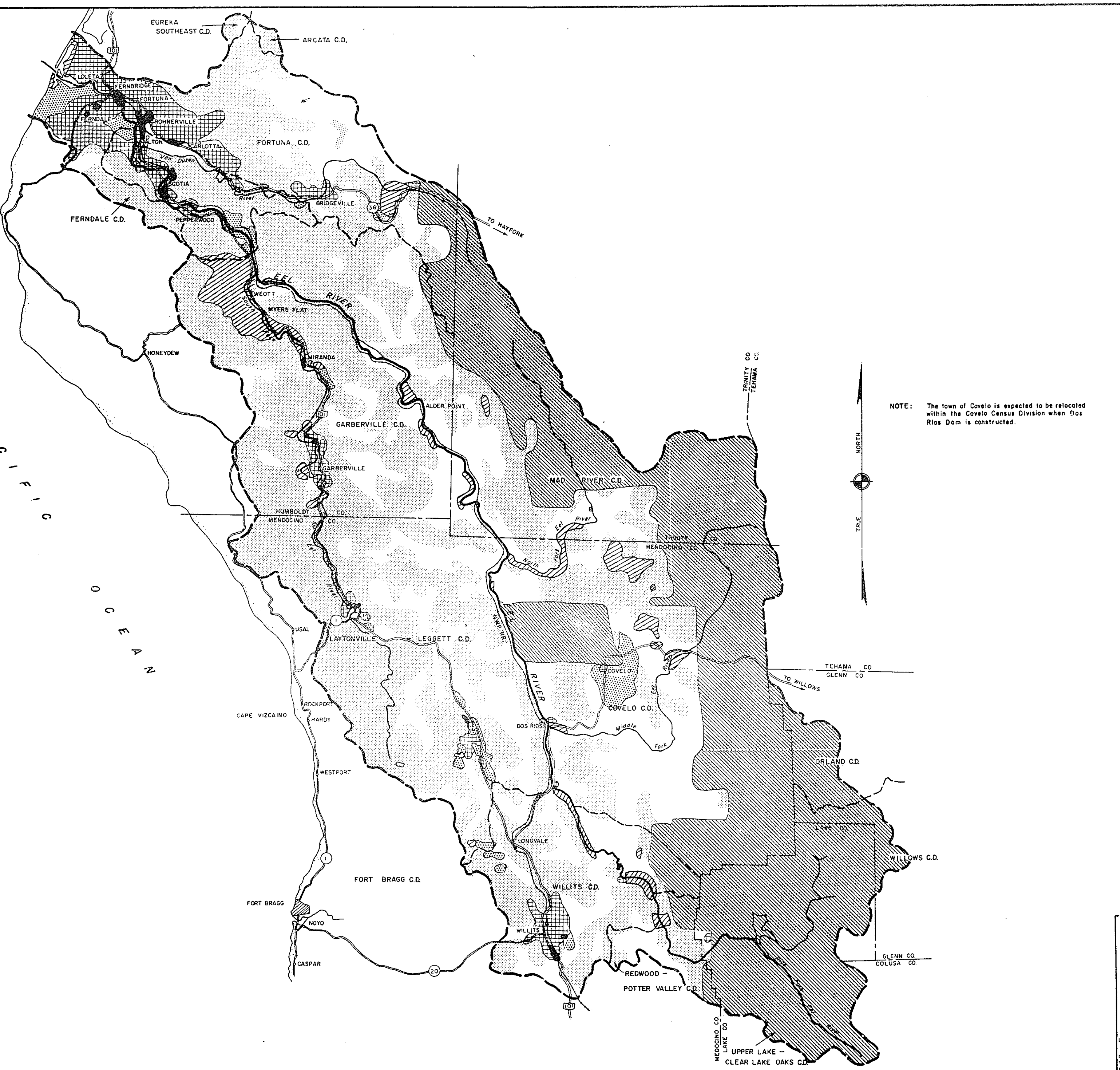
## LAND USE BY MAJOR CLASSIFICATIONS
## 2040

IN 7 SHEETS
SHEET NO. 5
U S ARMY ENGINEER DISTRICT, SAN FRANCISCO, CORPS OF ENGINEERS
DRAWN R.L.S.
TRACED M.J.C.
CHECKED J.L.M.
TO ACCOMPANY REPORT
DATE: APRIL 1968
FILE NO
60-34-7

FIG. A-10



NOTE: The town of Covelo is expected to be relocated within the Covelo Census Division when Dos Rios Dam is constructed.

LEGEND

LAND USE

- ▦ RESIDENTIAL AND COMMERCIAL
- ▩ INDUSTRIAL
- ░ AGRICULTURAL
- ▧ COMMERCIAL TIMBERLANDS WITHIN FEDERAL RESERVES
- ▨ FEDERAL & STATE RESERVED
- ☐ UNDEVELOPED OR UNUSED TIMBERLAND & GRASSLAND
- ▒ COMMERCIAL TIMBER
- DRAINAGE BASIN BOUNDARY
- SIMPLIFIED, APPROXIMATED CENSUS DIVISION BOUNDARIES (NAME SHOWN)
- U.S. HIGHWAY
- STATE HIGHWAYS

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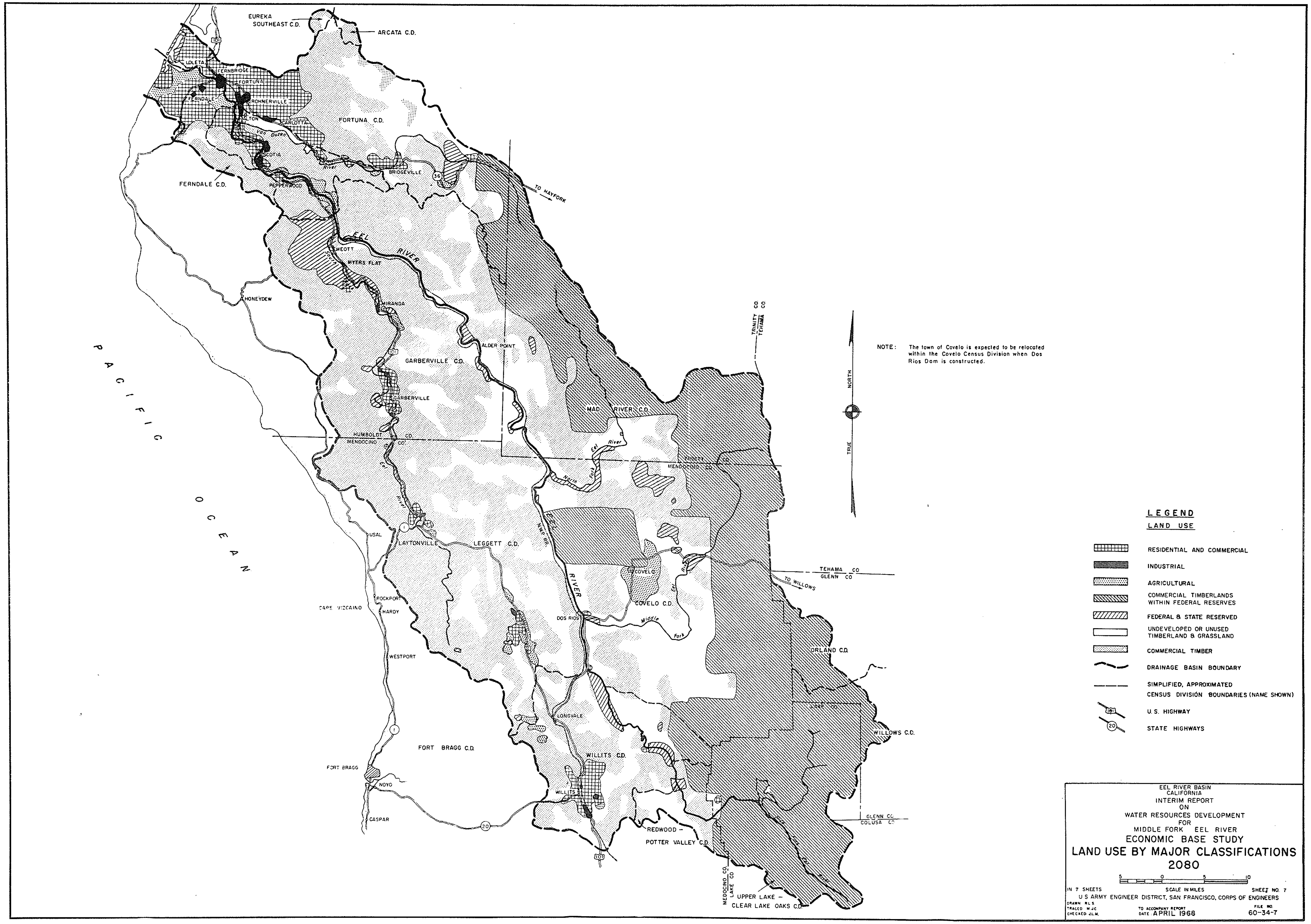
# LAND USE BY MAJOR CLASSIFICATIONS
# 2060

5 0 5 10

IN 7 SHEETS SCALE IN MILES SHEET NO. 6
U S ARMY ENGINEER DISTRICT, SAN FRANCISCO, CORPS OF ENGINEERS
DRAWN R.L.S.
TRACED M.J.C.
CHECKED J.L.M.
TO ACCOMPANY REPORT
DATE: APRIL 1968
FILE NO.
60-34-7

FIG. A-11



NOTE: The town of Covelo is expected to be relocated within the Covelo Census Division when Dos Rios Dam is constructed.

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## LAND USE BY MAJOR CLASSIFICATIONS
## 2080

5 0 5 10
SCALE IN MILES

IN 7 SHEETS
SHEET NO. 7
U S ARMY ENGINEER DISTRICT, SAN FRANCISCO, CORPS OF ENGINEERS
DRAWN R.L.S.
TRACED M.J.C.
CHECKED J.L.M.
TO ACCOMPANY REPORT
DATE: APRIL 1968
FILE NO.
60-34-7

FIG. A-12

# EEL RIVER BASIN, CALIFORNIA

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# FOR
# MIDDLE FORK EEL RIVER

APRIL 1968

## APPENDIX B

## HYDROLOGY AND HYDRAULIC DESIGN

## TABLE OF CONTENTS

## TABLE OF CONTENTS (Continued)

## TABLE OF CONTENTS (Continued)

## TABLES

## TABLE OF CONTENTS (Continued)

## PLATES

# EEL RIVER BASIN, CALIFORNIA

# INTERIM REPORT
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# WATER RESOURCES DEVELOPMENT
# FOR
# MIDDLE FORK EEL RIVER

APRIL 1968

## APPENDIX B

## HYDROLOGY AND HYDRAULIC DESIGN

## GENERAL

### B-1. PURPOSE

**The purpose of this appendix is to present data, assumptions and conclusions concerning the hydrology, hydraulic design and water supply potential of the proposed plan of improvement on the Middle Fork Eel River and certain related general aspects of the Eel River Basin.**

### B-2. SCOPE

This appendix presents hydrologic data and discusses derivation of the standard project flood, spillway design flood, discharge-frequency relations and historical flood analyses in considerable detail. Discussion of reductions in downstream flood peaks obtainable from the adopted flood control storage and regulation procedures is presented. Results of studies of other amounts of flood control storage are not presented in this appendix but are discussed in the main report. Water resources analyses are restricted to developing storage-yield relations. Project formulation studies leading to the adopted project are discussed in the main report and other appendices.

### B-3. PLAN OF IMPROVEMENT

The proposed plan of improvement, formulated elsewhere in this report, consists of a rock and earthfill dam impounding runoff from 745 square miles, located at river mile 3 on the Middle Fork of the Eel River. The dam would be 730 feet high, with a side channel leading to a tunnel-type spillway on the left abutment. Gross storage would be about 7.6 million acre-feet of which 2 million acre-feet would be inactive, 5 million acre-feet would be for water supply and fishery releases and 0.6 million acre-feet for flood control. An additional 0.3 million acre-feet of storage would be induced during the occurrence of the standard project flood by the spillway gate regulation procedure. A 17-foot diameter tunnel, about 21 miles in length, with upstream portal invert elevation at 1,405 feet, mean sea level, would be constructed for diversion of water from the reservoir to the Sacramento River Basin with subsequent delivery to other areas of the State of California.

## B-4. PRIOR REPORTS

An Interim Report for Water Resources Development, Eel River, California, was published as House Document 234, July 1965. As a result, the Flood Control Act of 1965 authorized flood control by levees along the lower 15 miles of the Eel River and lower reaches of Salt River, a tributary of the Eel River. The report also presents a plan of possible development of upstream multipurpose reservoirs for long-range water resource needs. An office report on Standard Project Flood Determination, South Fork Eel River, California, was approved on 30 March 1961, by the Office, Chief of Engineers. Review and further studies following the occurrence of the December 1964 flood resulted in significant revisions in standard project flood estimates and these were presented in an office report dated June 1967 and approved, in part, 30 August 1967.

## B-5. DESCRIPTION OF BASIN

a. Location. The Eel River Basin is located between 39°15' and 40°45' latitude, paralleling the coast of California. It drains an area of about 3,600 square miles which is approximately 140 miles long by 40 miles wide. The river flows in a northwesterly direction and enters the Pacific Ocean at a point 15 miles south of the City of Eureka, California. Its drainage originates in the five counties of Mendocino, Trinity, Humboldt, Lake and Glenn. Plate 1 of the main report shows the location and orientation of the basin.

b. Major tributaries. Major tributaries to the Eel River and to the Middle Fork Eel River are tabulated below, starting with the most downstream tributary:

| Tributary Name or Reference Point | Drainage Area (Square Miles) | | |
|---|---|---|---|
| Eel River at mouth | | | 3,620 |
| Eel River below mouth of Van Duzen River | | | 3,580 |
| Van Duzen River | | 429 | |
| Eel River below mouth of South Fork Eel River | | | 2,950 |
| South Fork Eel River | | 689 | |
| Eel River below mouth of North Fork Eel River | | | 1,910 |
| North Fork Eel River | | 282 | |
| Eel River below mouth of Middle Fork Eel River | | | 1,460 |
| Middle Fork Eel River | | 753 | |
| Elk Creek | 115 | | |
| Mill Creek | 100 | | |
| Williams Creek | 31 | | |
| Black Butte River | 162 | | |
| Eel River below mouth of Outlet Creek | | | 690 |
| Outlet Creek | | 162 | |

c. <u>Elevation distribution</u>. The Middle Fork Eel River, where improvement is proposed, enters the Eel River at river mile 115 and has a greater percentage of its drainage area at elevations above 5,000 feet, the average winter freezing level, than any other major tributary. The table below presents the elevation-area percentage distribution for the Middle Fork Eel River Basin:

| Elevation (feet M.S.L.) | Percentage of basin area |
|---|---|
| Above 6,000 | 5 |
| " 5,000 | 22 |
| " 4,000 | 40 |
| " 3,000 | 60 |
| " 900 | 100 |

d. <u>Existing water developments</u>. Most of the existing water resource development within the Eel River Basin consists of ground water development in the Delta region and in the Round and Little Lake Valleys. The largest surface water development is Scott Dam (Lake Pillsbury) constructed in 1921 by Pacific Gas and Electric Company. Storage in this reservoir (87,000 acre-feet) is exported south into the East Fork of the Russian River Basin at Van Arsdale Diversion Dam via the Potter Valley Tunnel for generation of power. The diverted flow has proved to be a valuable water resource to the Russian River Basin. Average annual diversion amounts to about 180,000 acre-feet. The small Benbow Dam and Reservoir on South Fork Eel River is owned by Division of Beaches and Parks, State of California. It was constructed in 1913 to impound 1,060 acre-feet of storage for recreation purposes. Morris Dam and Reservoir on Davis Creek, a small tributary to Outlet Creek near Willits, is operated by the Pacific Gas and Electric Company for delivery of municipal water supply to the town of Willits. It was constructed in 1927 with a storage capacity of 800 acre-feet. There are no surface water developments on the Middle Fork Eel River.

## HYDROLOGY

### B-6. CLIMATE

The climate of the Eel River Basin is typical of California coastal basins. Temperatures near the coast are tempered by ocean surface temperatures, while inland, behind the coastal mountain barriers, temperature extremes are greater. The growing season varies from about 150 days in the inland valleys to over 300 days along the coast. The Middle Fork Eel River drainage lies entirely within the inland region. The following data for a coastal weather station (Eureka) and an inland weather station (Covelo) near the proposed reservoir demonstrate the marked variations in temperatures:

| Station | Elev. | Average Annual | Average Max.Month | Average Min.Month | Highest Recorded | Lowest Recorded |
|---|---|---|---|---|---|---|
| Eureka | 43' | 52° | Aug 57° | Jan 47° | Sep 85° | Dec 22° |
| Covelo | 1385' | 56° | Jul 74° | Jan 40° | Sep 114° | Jan 7° |

Normal annual precipitation over the Eel River Basin varies from about 40 inches near the coast to over 100 inches near the crest of the westerly ridge of the South Fork Eel River. The average for the entire basin is about 57 inches and is about 56 inches for the Middle Fork Eel River Basin. Ninety-five percent of the precipitation falls during the months of October through April. The following rainfall data illustrate the range of rainfall intensity at two typical locations:

| Station | Elev. | Average Annual (inches) | Average for Jan (inches) | Highest of Record Monthly (inches and date of occurrence) | Highest of Record Daily (inches and date of occurrence) |
|---|---|---|---|---|---|
| Eureka | 43' | 38 | 6.7 | 18.3(Jan 1890) | 5.0(29 Oct 1950) |
| Mad River R.S. | 2800' | 59 | 11.5 | 36.7(Dec 1964) | 7.9(22 Dec 1964) |

The extreme monthly variation in rainfall in the Middle Fork Eel River Basin is shown in the following tabulation of monthly rainfall expressed as a percent of the annual mean:

Rainfall - Percent of Annual Mean

| Station | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Covelo | 0.1 | 0.3 | 1.6 | 6.2 | 12.1 | 18.5 | 20.5 | 17.3 | 12.8 | 5.9 | 3.3 | 1.4 | 100% |
| Dos Rios | 0.1 | 0.2 | 1.1 | 6.2 | 10.6 | 20.3 | 21.1 | 17.2 | 12.6 | 5.9 | 3.4 | 1.3 | 100% |

Precipitation in the form of snow occurs occasionally at elevations above 2,500 feet, but seldom accumulates to significant depths at elevations below 5,000 feet. Snowmelt is a minor factor in flood runoff.

The Middle Fork Eel River Basin is the only tributary with a significant amount of runoff from snowmelt. About 25 percent of the annual runoff occurs during the months of April, May and June. Detailed data on climate are presented in the "Climate of Humboldt and Del Norte Counties," prepared by the State Climatologist, U.S. Weather Bureau, and published by the Agricultural Extension Service, University of California.

## B-7. PRECIPITATION

a. Precipitation records. Precipitation records are available from about 40 rain gages in or adjacent to the Eel River Basin of which four are located in the Middle Fork Eel River Basin. Ten of these gages are the recording type. Data from 28 stations are published in the monthly publication "Climatological Data, California" by the U.S. Weather Bureau. Available data from these gages, adjusted to the base period 1906-56, were used in preparing the Normal Annual Isohyetal Map shown on Plate B-1.

b. Precipitation distribution. The areal distribution of normal annual precipitation is closely related to the topographic features of the basin. Areas of high seasonal rainfall occur over mountain ridges. There is a marked division of the year into wet and dry seasons. July and August are months of consistently low rainfall. For this reason the U.S. Weather Bureau has adopted the period 1 July to the following 30 June as the official rainfall season. The monthly distribution of precipitation is shown in the tabulation in the previous paragraph. Over 80 percent of the seasonal rainfall occurs between 1 November and 1 April.

c. Major storms of record. Major flood-producing storms occurred during January 1914, February 1915, December 1937, February 1940, January 1943, December 1955, February 1960, and December 1964. The three greatest storms during the past 100 years were probably those of January 1862, December 1955 and December 1964. Little information is available on the 1862 storm. Comparison of three-day rainfall from major storms recorded at five long-term U.S. Weather Bureau stations follows:

| Date | Eureka | Upper Mattole | Willits | Dos Rios | Covelo |
|---|---|---|---|---|---|
| | | (Rainfall in inches) | | | |
| 20-22 Jan 1914 | 2.70 | 10.76 | 7.32 | - | 7.26 |
| 31 Jan - 2 Feb 1915 | 6.53 | 17.24 | 9.21 | - | 7.85 |
| 10-12 Dec 1937 | 2.76 | 8.67 | 13.10 | 9.81 | 11.39 |
| 27-29 Feb 1940 | 1.16 | 11.28 | 10.41 | 9.11 | 5.78 |
| 20-22 Jan 1943 | 2.87 | 5.62 | 11.03 | - | 7.71 |
| 21-23 Dec 1955 | 2.73 | 10.59 | 9.99 | 13.42 | 7.33 |
| 7-9 Feb 1960 | 2.83 | 7.73 | 11.69 | 10.85 | 9.16 |
| 21-23 Dec 1964 | 3.27 | 12.49 | 13.58 | 18.65 | 13.10 |

d. Standard project storm. The standard project storm represents the most severe flood-producing rainfall depth-area-duration relationship reasonably characteristic of the region in which the drainage basin is located. The storms of 19-24 January 1943, 21-24 December 1955, 20-23 December 1964, and the Sacramento criteria [1] were analyzed in standard project storm studies. The December 1955 and December 1964 storms had isopercentual centers (storm rainfall expressed as a percent of normal annual) in some part of the Eel River Basin. The 20-23 December 1964 storm, with center near Laytonville, California, was found to be the most critical and was adopted as the standard project storm. Since the storm center occurred over the upper portion of the South Fork Eel River and Eel River Basins, only minor transposition is required for maximization. The basin outline, storm isopercentual lines and transposition curve are shown on Plate B-2. The 20-23 December 1964 storm was transposed over the basins above each damsite considered on the Middle Fork Eel River and over the basin above Eel River at Scotia. The 96-hour rainfall depth resulting from this transposition procedure averaged 25.5 inches for the basin upstream of the proposed Dos Rios damsite on Middle Fork Eel River and 22.7 inches for the basin upstream of Scotia. Values for other sub-basins are presented in the paragraph on standard project flood derivation. About 3 percent of the total rainfall of the transposed storm occurred during the maximum hour, 9 percent during the maximum 3 hours, 17 percent during the maximum 6 hours and 51 percent during the maximum 24 hours.

e. Probable maximum storm. The probable maximum storm is a storm synthesized by maximization of meteorological characteristics, such as wind speed, wind direction, dew point, etc. It represents the most severe storm reasonably possible in the region. Standard procedures for derivation of this storm in California are contained in Hydrometeorological Report No. 36, U.S. Weather Bureau, October 1961. These procedures were derived from data prior to the occurrence of the December 1964 storm and may require significant modification for coastal basins of northern California. Values obtained from the curves and tables contained in Hydrometeorological Report No. 36 resulted in a three-day storm total of 25 inches as compared with 23 inches during an equal period for the standard project storm for the basin upstream of the Dos Rios Damsite. Probable maximum storm values were tentatively increased for this report by about 45 percent, for a three-day rainfall amount of 35.5 inches, in order to obtain rainfall values consistent with the storm of record and the adopted standard project storm. During advance engineering studies the Hydrometeorological Section of the U.S. Weather Bureau would be requested to review the probable maximum precipitation for this basin.

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[1] "Standard Project Rain-Flood Criteria, Sacramento-San Joaquin Valley, California," Sept. 1958, U.S. Army Engineer District, Corps of Engineers, Sacramento, California.

## B-8. RUNOFF

a. Streamflow records. Twenty-six stream gaging stations are currently in operation within the Eel River Basin. Of these, five are on the main stem of the Eel River and seven are on the Middle Fork Eel River. The long-term stream gage records for Eel River at Scotia and Eel River at Van Arsdale Diversion Dam were used to adjust mean annual runoff at other points within the basin to a common base period of 50 years (1911-60). Monthly runoff estimates at numerous damsites and gaging sites were made by the U.S. Geological Survey and the California Department of Water Resources. These estimates were adopted for use by all agencies by the Hydrology Subgroup, Work Group No. 2, Northwestern California Planning Coordination, of the California State-Federal Interagency Group, a committee of Federal and state agencies concerned with coordinated planning of water resources development in the region. Mean annual runoff for the entire Eel River Basin is estimated at 6.3 million acre-feet with about one million acre-feet contributed by the Middle Fork Eel River. The year of greatest runoff occurred during October 1957 - September 1958 (water year 1958) when the runoff was about 225 percent of normal. The year of least runoff was water year 1924, with runoff of about 17 percent of normal. About 90 percent of the annual runoff occurs during the months November through April, with about 25 to 30 percent normally occurring in February. The Middle Fork Eel River is the only tributary with appreciable area above 5,000 feet in elevation (about 22 percent) and consequently is the only tributary that has appreciable late season runoff. The tabulation which follows illustrates the seasonal characteristic of runoff and the prolonged April-June runoff from the Middle Fork Eel as compared with the South Fork Eel and Eel River at Scotia.

Middle Fork Eel River at Dos Rios Damsite
(745 square-mile drainage area)

| Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.9 | 4.9 | 13.6 | 18.0 | 21.0 | 15.8 | 14.8 | 7.7 | 2.4 | 0.5 | 0.2 | 0.2 | 100 % |

South Fork Eel near Miranda
(537 square-mile drainage area)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.9 | 5.6 | 15.9 | 23.8 | 22.8 | 15.2 | 9.6 | 3.9 | 1.4 | 0.5 | 0.2 | 0.2 | 100 % |

Eel River at Scotia
(3,113 square-mile drainage area)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.8 | 5.1 | 15.1 | 22.3 | 22.8 | 15.6 | 10.9 | 4.9 | 1.6 | 0.5 | 0.2 | 0.2 | 100 % |

Data on selected gaging stations follow:

| Location | Drainage area (sq.mile) | Period of Record | Maximum (c.f.s.) | Discharge3/ (c.s.m.) | 50-year Mean Natural Runoff 1/ (acre-feet) |
|---|---|---|---|---|---|
| Eel River at Scotia | 3,113 | 1910-66 | 752,000 | 240 | 5,200,000 |
| Eel River at Alderpoint | 2,079 | 1955-65 | 561,000 | 270 | 2,800,000 |
| Eel River below Dos Rios | 1,484 | (1911-13<br>1951-66) | 460,0002/ | 310 | 2,050,000 |
| Middle Fork Eel River below Black Butte River near Covelo | 367 | 1951-66 | 133,000 | 360 | 630,000 |
| Eel River above Dos Rios | 705 | 1950-65 | 184,000 | 260 | 1,000,000 |
| South Fork Eel near Miranda | 537 | 1939-66 | 199,0002/ | 370 | 1,200,000 |

1/ Adjusted to 1911-60 natural unregulated conditions.

2/ Gaged trace incomplete due to destruction or malfunction; this estimate by the U.S.G.S. appears too large when compared with other basin data: value of 400,000 c.f.s. at Dos Rios and 186,000 c.f.s. at Miranda were estimated by this office.

3/ c.s.m. represents c.f.s. per square mile of drainage area; maximum of all locations occurred on 22 December 1964.

b. Flood problem. U.S. Highway 101 follows along the South Fork Eel River from Laytonville to Dyerville and on the Eel River from Dyerville to Fernbridge. State Highway 36 follows the Van Duzen River from Bridgeville to Alton. The Northwestern Pacific Railroad parallels the main Eel River from Outlet Creek to Fernbridge. Flooding on the main stem between Scotia and the mouth of the Middle Fork is largely confined to railroad property and related industry in the few small communities located on the alluvial terraces along the stream. Other flood damages which could be prevented by the plan of improvement occur on the Eel River below the mouth of the Van Duzen River.

c. Flood characteristics. Flood inundation begins in the Eel River Delta agricultural lands at a discharge of about 120,000 c.f.s. and significant bank erosion occurs in the canyon reaches when the discharge past Scotia exceeds about 150,000 c.f.s. Peak discharges occur at Fernbridge, in the Delta, about 18 hours after the occurrence of the highest rainfall intensity during the storm. Duration of overbank flow may last from four to five days during the occurrence of severe floods such as December 1955 and December 1964. Peak discharges on the Middle Fork Eel River occur about 8 hours after the most intense rainfall occurrence.

d. Major floods of record. The flood of December 1964 was the most destructive flood of record in the Eel River Basin. It is estimated that the peak discharge at Scotia was 752,000 c.f.s., about 40 percent greater than the second highest of record. All historical evidence indicates that this flood was probably the largest during the past 100 years. Flood runoff from the Eel River at Scotia for the period 20-28 December 1964 was about 4,500,000 acre-feet, the equivalent of almost 27 inches of runoff from the 3,113 square-mile basin. Runoff during the maximum four or five days approached the average annual runoff. Runoff from the Middle Fork Eel River during this same period was about 980,000 acre-feet, almost equal to the average annual runoff from this tributary, and equivalent to about 25 inches of runoff from the basin. Prior to 1964, the flood of 18-24 December 1955 was the maximum flood of record since the Scotia gaging station was installed in 1910, and exceeds the next highest flood (February 1915) by about 50 percent. Data during the ten largest events recorded for the Eel River at Scotia follow:

| Date | Duration (days) | Peak Discharge (c.f.s.) | Runoff (acre-feet) |
|---|---|---|---|
| Dec 1964 | 9 | 752,000 | 4,470,000 |
| Dec 1955 | 6 | 541,000 | 2,490,000 |
| Dec 1915 | 4 | 351,000 | 1,380,000 |
| Dec 1937 | 4 | 345,000 | 591,000 |
| Feb 1960 | 3 | 343,000 | 1,140,000 |
| Jan 1943 | 3 | 315,000 | 1,040,000 |
| Jan 1914 | 5 | 309,000 | 1,470,000 |
| Feb 1940 | 3 | 305,000 | 1,160,000 |
| Feb 1917 | 3 | 292,000 | 854,000 |
| Feb 1963 | 4 | 252,000 | 840,000 |

## B-9. UNIT HYDROGRAPH DERIVATION

Unit hydrographs were derived by reproduction of gaged hydrographs recorded on gages throughout the Eel River Basin as well as at gages on other coastal streams of northern California. A lag versus basin characteristic curve was developed from these unit hydrographs and data extracted from topographic maps of the basins. A dimensionless S-curve hydrograph was adopted from the unit hydrographs that were derived from gaged hydrograph analysis and utilized to shape unit hydrographs required for ungaged areas. These were tested indirectly by trial reproduction of gaged hydrographs at some of the most downstream gaging points of the river, using a system of channel routing and sub-basin combining. Ordinates of the adopted unit hydrographs used to derive standard project flood hydrographs are tabulated in Table B-1.

## B-10. FLOOD ROUTING THROUGH RIVER CHANNELS

Channel routing coefficients were derived by adopting routing values obtained from trial routing and combining of local hydrographs and from storage-loop curve studies. The discharge hydrographs of 18-21 December 1955, 21-25 December 1955, and 12-15 January 1956 were the principal hydrographs that were used to establish routing coefficients for the three major routing reaches: Dos Rios to Alderpoint, Alderpoint to Scotia and Miranda to Scotia. There is only minor storage in the steep narrow canyon reaches of this stream, thus the value of "x", weighted outflow constant, is very close to 0.5 which would reflect virtually no storage attenuation. The following values of "x", weighted outflow constant; "k", slope of the discharge storage curve in hours; and "t", routing time interval in hours; were used for each of the routing reaches:

| | "x" | "k" | "t" | Number of |
|---|---|---|---|---|
| | | (for each sub-reach) | | Sub-reaches |
| | (coef.) | (hours) | (hours) | |
| Scott Dam to English Ridge Damsite | 0.4 | 3 | 3 | 1 |
| English Ridge Damsite to Dos Rios | 0.4 | 1 | 3 | 1 |
| Spencer-Franciscan Damsite to Dos Rios | 0.4 | 1 | 3 | 1 |
| Dos Rios to Alderpoint | 0.4 | 3 | 3 | 1 |
| Alderpoint to Scotia | 0.4 | 3 | 3 | 3 |
| Alderpoint to Sequoia Damsite | 0.4 | 4 | 3 | 1 |
| Sequoia Damsite to Scotia | 0.4 | 2.5 | 3 | 2 |
| Miranda to Scotia | 0.4 | 3 | 3 | 3 |
| Scotia to confluence with Van Duzen River | 0.3 | 2.4 | 3 | 1 |

## B-11. STANDARD PROJECT FLOOD

a. Definition. The standard project flood is defined as a discharge hydrograph representing flood discharges that may be expected from the most severe combination of meteorologic and hydrologic conditions that are considered reasonably characteristic of the geographical region involved, excluding extremely rare combinations. Previous reports on Eel River have adopted the January 1943 storm transposition and then later the December 1955 storm transposition. However, since the occurrence of the December 1964 storm flood, these earlier derivations required revision. The storm transposition, discussed in an earlier paragraph on standard project storm, results in 96-hour storm rainfall about 15 percent greater than that which is estimated to have occurred over the basin upstream of Scotia during the December 1964 storm. This nominal increase results from the fact that the storm center actually occurred over the headwaters of the South Fork Eel River and upper main stem of Eel River.

b. Loss rates. Loss rates associated with the derivation of the standard project flood were based on reproduction studies of the 13-16 January 1956 flood hydrographs which followed a major storm-flood event. Loss rate values starting at 0.25 inch per hour and reducing to a minimum rate of 0.02 inch per hour were adopted. The river basin was saturated prior to the occurrence of the January 1956 storm since it followed the December 1955 storm which resulted in the greatest flood of record, prior to the December 1964 event.

c. Base flow. Base flow was added to estimated surface runoff to account for water in storage in the river system from a previous storm and shallow ground water and sub-surface interflow. A value of about 10 c.f.s. per square mile was adopted which is equivalent to about 1.8 inches of runoff from the basin during a five-day period.

d. Snowmelt. Runoff from snowmelt was estimated by the criteria presented in "Standard Project Rain-Flood Criteria," September 1958, U.S. Army Engineer District, Sacramento, California. Snowmelt by these criteria adds some runoff from most of the sub-basins, for example: 1.5 inches from the area above the English Ridge damsite on upper Eel River, 3.4 inches and 2.4 inches respectively from the area upstream of the Spencer-Franciscan and Dos Rios damsites on Middle Fork Eel River and zero from the South Fork Eel River and lower Eel River Basin. The weighted average is 0.9 inches for the area upstream of Fernbridge in the Eel River Delta.

e. Summary of results. Discharge hydrographs at selected index points are presented on Plates B-3 and B-4. Standard project storm data and adopted peak discharge values are presented in the tabulation which follows:

| Location | Drainage Area (sq.mi.) | Basin Average Precipitation (inches) | Total 1/ Runoff (inches) | Peak Discharge 2/ (c.f.s.) |
|---|---|---|---|---|
| Middle Fork Eel River at Spencer-Franciscan Damsite | 425 | 29.7 | 31.7 | 190,000 3/ |
| Middle Fork Eel River at Dos Rios Damsite | 745 | 25.5 | 26.0 | 275,000 3/ |
| Eel River at Scott Dam (Lake Pillsbury) | 288 | 27.4 | 27.8 | 115,000 (inflow)<br>80,000 (outflow) |
| Eel River at English Ridge Damsite | 488 | 24.9 | 24.2 | 160,000 |
| Eel River below Dos Rios | 1,484 | 23.2 | 22.1 | 450,000 4/ |
| Eel River at Alderpoint | 2,079 | 22.5 | 20.6 | 580,000 4/ |
| South Fork Eel near Miranda | 537 | 34.6 | 33.0 | 224,000 |
| South Fork Eel at Weott | 643 | 34.0 | 31.6 | 265,000 |
| Eel River at Scotia | 3,113 | 22.7 | 20.2 | 820,000 4/ |
| Eel River below confluence with Van Duzen River | 3,583 | 22.7 | 20.2 | 920,000 4/ |

1/ Includes base flow and snowmelt.
2/ Storm centered over each drainage area.
3/ Would be controlled by proposed project.
4/ Would be reduced by proposed project.

### B-12. SPILLWAY DESIGN FLOOD

The spillway design flood hydrograph was developed for the proposed Dos Rios Dam on Middle Fork Eel River using unit hydrographs, loss rates and base flows similar to those used in the standard project flood but incorporating the adopted probable maximum precipitation values. The resulting peak inflow to the reservoir from the 72-hour precipitation of 35.5 inches is 470,000 c.f.s. This is a 70 percent greater peak inflow and 50 percent greater rainfall than the adopted standard project flood. After adjustment for loss rates, snowmelt and base flow, the total runoff is equal to 32.6 inches or 1.3 million acre-feet. The reservoir area at full flood control pool would be about 40,000 acres (62.5 square miles). The unit hydrograph and inflow were adjusted to account for rainfall on the large surface area. This adjustment resulted in only a minor change in the shape of the inflow hydrograph. Hydrograph and runoff data are presented on Plate B-5.

## B-13. DISCHARGE FREQUENCY

Records of discharge for the gaging station Eel River below Dos Rios for the period 1911-13, 1951-65 and for the gaging station Eel River at Alderpoint for the period 1956-65 were correlated with the corresponding period for the Scotia gage and adjusted to the 1911-65 period of record for Scotia. The coefficient of correlation is 0.89 for the gage below Dos Rios and the adjusted mean discharge is 68,000 c.f.s. with an adjusted standard deviation of 0.29; for the gage at Alderpoint, the coefficient of correlation is 0.97 with an adjusted mean discharge of 93,000 c.f.s. and standard deviation of 0.29. The equivalent length of record of the adjusted statistics is about 48 years. The Alderpoint gage was destroyed during the December 1964 flood and has since been replaced by the gage at Ft. Seward (approximately 7 miles downstream). Curves for gaged and long-term periods at all selected damage index points are presented on Plate B-6. The discharge-frequency analysis indicates that the December 1955 flood on the main stem is probably exceeded on the average of two to three times in 100 years and that on the average, the December 1964 flood probably will be exceeded less frequently than once in 100 years. The adopted curve for Eel River at Scotia indicates that, without the plan of improvement, a discharge of 680,000 c.f.s. has about a 1 percent chance of being exceeded during any year. This magnitude is about 80 percent of that of the standard project flood. Good correlation exists between peak discharges recorded at the gaging station at Scotia and the stages observed downstream at Fernbridge in the Eel River Delta. The stage-frequency curve for Eel River at Fernbridge was developed from this correlation. The adopted frequency curves were approved for planning use by Office, Chief of Engineers by 2nd Indorsement, dated 30 August 1967. Annual maxima discharges at Scotia and stage at Fernbridge are listed in Table B-2.

## B-14. FLOOD CONTROL STORAGE

a. Storage required for flood control. Since bank erosion in the canyon areas starts at discharges corresponding to approximately 150,000 c.f.s. at Scotia, it would be desirable to make no releases from upstream flood control reservoirs during periods when the flow exceeds this amount. The levee project, as authorized for the Eel River Delta, would provide protection from about a one percent chance flood initially and would eventually provide protection from the standard project flood by virtue of incidental flood control storage effect of future upstream reservoirs. Therefore the Delta area is assumed to place no restriction on reservoir releases. Following these general criteria, the five most severe flood events since 1911 which would require storage for the proposed Dos Rios Reservoir on Middle Fork Eel River are as follows:

| Flood Event | Runoff at Dos Rios Damsite (acre-feet) |
|---|---|
| Feb 1915 | 400,000 |
| Feb 1940 | 350,000 |
| Dec 1955 | 650,000 |
| Feb 1960 | 280,000 |
| Dec 1964 | 800,000 |
| S.P.F. (3100 sq. mi. storm center) | 950,000 |
| S.P.F. (745 sq. mi. storm center) | 1,030,000 |

b. Flood control storage frequency analysis. An analysis was made of the frequency that various amounts of flood control storage would be utilized. The storage-frequency relation would be used as a guide in locating certain recreation facilities. Since the schedule of water supply demands from the reservoir is still uncertain and under any schedule, the initial period of build-up in water supply demand would probably assure a nearly full water supply pool during most winters of early project life, the estimates presented in the tabulation which follows are based on the assumption of a full water supply pool during the onset of major flood events.

| Exceedence Frequency Years per 100 Years | Flood Control Storage Utilized (acre-feet) |
|---|---|
| Standard Project Flood | 900,000 (including surcharge) |
| 1 | 650,000 ( " " ) |
| 2 | 600,000 |
| 5 | 450,000 |
| 10 | 350,000 |
| 20 | 250,000 |

c. Recommended flood control storage capacity. Conclusions from economic studies discussed in the main report resulted in the recommendation that 600,000 acre-feet or primary flood control storage be provided in the proposed Dos Rios Reservoir with an additional 300,000 acre-feet developed by surcharge operation procedures during the occurrence of the standard project flood.

## B-15. RESERVOIR REGULATION FOR FLOOD CONTROL

a. Primary flood control pool. The time of travel between the proposed Dos Rios Dam and Scotia is about 12 hours. Minor bank erosion and flood damage begin when discharge at Scotia exceeds about 150,000 c.f.s. With these restraints as guides, the normal flood regulation and operation plan would consist of restricting releases from the proposed reservoir to that required for fisheries whenever the Eel River at Scotia is forecast to exceed 150,000 c.f.s. within the next 12 hours. These minimum releases would be maintained until discharges at Scotia have peaked and receded to about 200,000 c.f.s. and forecasted to continue receding. Any water stored in the flood control pool as a result of this operation would then be released at a rate such that discharges at Scotia will not exceed 150,000 c.f.s.

b. Induced surcharge operation. If accumulated flood waters fill the allocated flood control storage, the spillway tainter gates would be operated in a manner which would duplicate the discharge characteristics of an ungated spillway with a 100-foot crest length and with crest elevation at the top of the flood control pool. In this report, an ungated ogee section having a length of 100 feet and crest elevation of 1,602 feet was adopted as giving a reasonable surcharge operation. This procedure would be followed until 10 feet of surcharge (approximately 400,000 acre-feet of storage) has accumulated. If the reservoir continued to rise, the gates would be opened at a rate not to exceed 10,000 c.f.s. per hour until the gates would be fully open. This rate of opening was selected on the basis of the rate of change of the rising limb of the inflow hydrograph of the standard project flood. As the reservoir stage recedes, the gates would remain fully open until the pool level recedes to the top of the flood control pool, after which time they would be set to release the inflow or follow the criteria for emptying the flood control pool, whichever gives the maximum release.

c. Dual-use of flood control pool. Utilization of the flood control pool during the season of low flood probability would be acceptable if it were of any value to the water supply needs of the project. With 600,000 acre-feet of capacity allocated to flood control, some of this space could be released during early April and as much as one-half to three-fourths by the end of May. However, owing to the long carryover period of the water supply, this operation would be of little value in increasing the firm yield which could be obtained from the project.

d. Discharge reductions. Studies of historical floods indicate that maximum reductions in downstream peak discharges obtainable from complete control of Middle Fork Eel River runoff would be obtained by the proposed plan of flood control operation.

Control of Middle Fork Eel River at Dos Rios damsite would accomplish about a 25 percent reduction in peak discharges in the Eel River Delta. The proposed storage would be capable of reducing the standard project flood peak in the Delta from a discharge of 920,000 c.f.s. to about 710,000 c.f.s. or a stage reduction of 1.4 feet at Fernbridge with existing flood plain characteristics. The project would be capable of reducing the record flood peak (December 1964), from 840,000 c.f.s. to 650,000 c.f.s. A one percent chance flood at Fernbridge would be reduced from a discharge of 750,000 c.f.s. to a discharge of 580,000 c.f.s., representing a stage reduction of 1.4 feet. Reductions in discharge in other historical floods are presented in Table B-2. Reduction curves are plotted on Plate B-7.

## B-16. ENGLISH RIDGE PROJECT

The Bureau of Reclamation, U.S. Department of the Interior, is investigating a water resources development of the upper main stem of Eel River (English Ridge Project). Water developed by the English Ridge project would be utilized to meet certain in-basin needs as well as future water needs of areas located south and east of the Eel River Basin. Planning studies, to date, indicate that about 140,000 acre-feet of flood control storage and about 140,000 acre-feet of induced surcharge during the occurrence of the standard project flood are being considered. These concepts would provide containment of a flood having an exceedence frequency of about 2 to 5 percent. During the occurrence of the standard project flood with an assumed full water supply pool, the English Ridge project would be capable of reducing the peak discharge in the Eel River Delta, at Fernbridge, by about 90,000 c.f.s. The combined Dos Rios Dam and English Ridge Dam projects would be capable of reducing the standard project flood peak to 620,000 c.f.s. compared to 920,000 c.f.s. under present conditions. Similarly, the December 1964 event would be reduced from a peak discharge of 840,000 c.f.s under present basin development to about 580,000 c.f.s. with operation of both projects. Comparable data for six major historical flood events are presented in Table D-3. Discharge hydrograph data are presented on Plates B-8 through B-11 for the operation during a post-project occurrence of the December 1964 flood and the standard project flood.

## B-17. SEDIMENT RESERVATION

Suspended sediment load data have been collected on Eel River and tributaries since October 1957. Runoff during water years 1958 and 1964 exceeded that of any other year. During the recession and following the flood of December 1964, the Middle Fork Eel River below Black Butte Creek aggraded approximately 7 feet. A watershed management and sediment yield study is being completed by the U.S. Soil Conservation Service and a report of findings will be published early in 1968. Data on the depletion of storage from deposition of sediment in Lake Pillsbury located in the upper reaches of the main stem Eel River are presented in a publication by the U.S. Geological Survey

"Sedimentation of Lake Pillsbury, Lake County, California," Water-Supply Paper 1619-EE, which finds that the average rate of depletion during the 1921-59 period was about 0.7 acre-foot per year. Data collected since 1957 and particularly during the December 1964 flood indicate that this may be below normal. Preliminary estimates for the Middle Fork Eel River indicate that the average annual loss of storage resulting from deposition of sediment would be about 2 acre-feet per square mile. Storage depletion during an assumed 100 year economic life would amount to about 150,000 acre-feet, or about 2 percent of the initial gross storage. The data collection program will be continued in order to assure that this estimate is significantly accurate. In addition to the storage reserved for suspended sediment, consideration must be given to the loss of storage due to movement of material from landslides. The Department of Water Resources, State of California, has estimated the volume of material from this source to be about 500,000 acre-feet, of which about 50 percent would occur at elevations within the inactive pool. The combination of possible deposition from these two sources is small compared to the gross reservoir storage and, for purposes of this report, it is assumed to be deposited within the inactive pool (below elevation 1425 feet m.s.l.).

## B-18. HYDROLOGIC NETWORK

The U.S. Weather Bureau and the State of California presently operate a system of radio interrogated precipitation and stream gaging stations within the Eel River Basin. This system is part of the data collection program and river forecasting responsibility of the U.S. Weather Bureau. Regulation of proposed Dos Rios Reservoir would necessitate collection of additional hydrologic data on a timely basis in order to operate the facility. It is expected that a minimum network would consist of the following:

a. Two inflow gages.

b. Two reservoir stage recorders.

c. Reservoir water temperature sensors at approximately 25-foot vertical intervals.

d. Class A weather station at the dam or near the Round Valley arm of the reservoir.

e. Several radio reporting precipitation stations and snow depth (water equivalent) stations within the basin.

f. Continuation and supplementation of the existing stream gage network.

Specific locations and instrumentation would be developed during project design studies.

## SUPPLEMENTAL WATER SUPPLY

### B-19. NEED FOR WATER SUPPLY

Several alternative plans for developing the water resources of the Middle Fork Eel River were studied. These plans, discussed in the main report, considered damsites which proved less favorable than the proposed Dos Rios site. Analyses were made to determine the amount of supplementary water which could be developed by proposed Dos Rios Dam and Reservoir, the estimated cost, economic feasibility and methods of repayment of cost allocated to water supply. Discussion in this appendix is limited to the subject of expected yields under various assumptions and the storage required to effect such yields. Phases of the study pertaining to costs, allocations, benefits, et cetera, are contained in the main report and other appendices.

### B-20. PERIOD ANALYZED

The period analyzed, 1911 through 1960, includes critically dry periods as well as seasons of high runoff. It is considered that results obtained from other studies, therefore, represent conservative estimates of water supply yields. The years subsequent to 1960, a period of higher than average runoff, would not affect water supply yields.

a. Availability of stream flow records. Estimated unimpaired flows at the proposed site for the 50-year period of study have been computed and published in Bulletin 136, "Office Report, North Coastal Area Investigations, Project Hydrology," October 1964, by the Department of Water Resources, State of California. The estimated monthly inflows available for development for water years 1911 through 1960 are shown in Table B-4 and Plate B-12.

### B-21. FACTORS CONSIDERED IN WATER DEVELOPMENT

Prior to initiating detailed computations to determine the amount of water which could be developed at the Dos Rios site, it was necessary to give consideration to factors which could have a marked effect on results and conclusions reached. The following factors were considered:

a. Evaporation. An annual net water loss by evaporation from the reservoir surface was estimated at 2.5 acre-feet per acre with the following average monthly distribution:

| Month | Net Loss (acre-feet/acre) | Month | Net Loss (acre-feet/acre) |
|---|---|---|---|
| January | 0 | July | 0.50 |
| February | 0 | August | 0.45 |
| March | 0 | September | 0.30 |
| April | 0.25 | October | 0.20 |
| May | 0.35 | November | 0 |
| June | 0.45 | December | 0 |

Adjustment for rainfall on reservoir surface in excess of evaporation during winter months was not considered significant in the light of inherent error in runoff estimates. Monthly losses in acre-feet were computed from the surface area corresponding to the average reservoir water surface during the month. The relations between elevation and area and between elevation and storage are shown in Plate B-13.

b. Required releases for fishery mitigation. The U.S. Fish and Wildlife Service and the California Department of Fish and Game have requested mitigative measures including minimum releases from the reservoir to compensate for the blocking of the anadromous fishery spawning grounds. The Service requested the following releases which are equivalent to about 217,000 acre-feet per year:

1 October to 31 May -------- 350 c.f.s.

1 June to 30 September ----- 200 c.f.s.

c. Water quality control. Storage of water for releases pertinent to water quality of streams within the basin was considered. Fishery releases are more than sufficient to meet the criteria established in a preliminary report on the Eel River basin, dated November 1962, prepared by the Public Health Service, Department of Health, Education and Welfare (this function has since been transferred to the Federal Water Pollution Control Administration). The report indicated about 50 c.f.s. would be required on the Eel River upstream of the Eel River Delta and about 200 c.f.s. in the Delta to meet demands over the next 100 years. The Delta demand would be met not only by the proposed project but also by runoff from 2,400 square miles of the Eel River basin. The Federal Water Control Administration advised that it is studying water quality aspects of the Eel River basin and potential export service areas. No date of completion was indicated. Based on these factors, no additional releases for the specific purpose of water quality need to be provided.

d. Minimum pool. Formulation studies discussed elsewhere in this report resulted in an adopted minimum pool of 2 million acre-feet for the proposed, among others, of providing a desirable elevation for the invert of Grindstone Tunnel. Grindstone Tunnel would be provided for the diversion of water to the Sacramento River basin to the east.

e. Export water supply yield. Water supply releases from the proposed Dos Rios Project would be used in combination with excess unregulated flows to develop a firm yield at the Sacramento-San Joaquin Delta Pool, the concept of which is explained in the main report. Demand on the proposed reservoir would vary with the amount of regulated water available at the Delta Pool from the California State Water Project or from surplus unregulated flows from the Sacramento-San Joaquin Basin. In order to insure a reasonable estimate of possible yield from the proposed project, alternative routings were made to develop storage-yield relations using the following assumptions:

(1) Firm average annual yield as measured at the Dos Rios Reservoir.

(2) Yield, as measured at the Delta Pool, assuming 25 percent of the demand during normal years would be met from surplus unregulated water in the Delta but full demand would be met from the Dos Rios Project during the critically dry period (1928-34).

(3) Similar to (2) except assuming 50 percent of the demand during normal years could be met from surplus unregulated water.

Under assumptions (2) and (3) the yield at the Delta Pool credited to the Dos Rios Project would be the average annual diversion during the critical period. Storage-yield relations for assumptions (1) and (3) are shown on Plate B-14. Independent analysis by the Department of Water Resources, State of California, using system-wide routings resulted in a storage yield relation in agreement with the relation developed using assumption (3).

f. Yield from adopted storage. Project formulation studies presented in other portions of this report resulted in selection of the Dos Rios site with a gross storage of 7,600,000 acre-feet. Of this storage 2,000,000 acre-feet would be inactive and 5,000,000 acre-feet would be provided for the water supply fishery mitigative releases pool. The reservoir would have an annual loss by evaporation of about 80,000 acre-feet per year. It would supply firm fishery mitigation releases of about 213,000 acre-feet per year and using the storage-yield relation under assumption (3) would develop a firm annual water supply yield at the Sacramento-San Joaquin Delta Pool of about 900,000 acre-feet. Under assumption (1) this amount of water supply storage would be capable of developing a firm annual yield at the site of about 660,000 acre-feet. Under assumption (3), the critical drawdown period would be about seven years (1928-34) and the full-to-full period would be about 28 years (1928-56). Under assumption (1) the critical drawdown period would be about 18 years (1916-34) and the full-to full period would be about 40 years (1916-56). A reservoir stage hydrograph under assumption (1) for the period 1910-60 is shown on Plate B-15. Reservoir stage-frequency curves were developed and the following values are for the first of month elevations for the months of May and October and for annual minimum elevations:

| Years per 100 that reservoir water stage falls below a given level 1/ | 1 May | 1 October | Annual Minimum |
|---|---|---|---|
| | (Stage in feet, mean sea level) | | |
| 2 | 1455 | 1425 | 1424 |
| 10 | 1480 | 1450 | 1447 |
| 50 | 1540 | 1519 | 1517 |
| 90 | 1584 | 1565 | 1563 |
| 95 | 1587 | 1570 | 1569 |

1/ Top of water supply pool is at elevation 1587.

## HYDRAULIC DESIGN

### B-22. GENERAL

The analyses contained in this appendix are the basis for determining the spillway crest elevation, height of dam above the maximum water surface, hydraulic dimensions of the spillway, outlet works, water supply diversion tunnel (Grindstone Tunnel) and the diversion tunnel required during construction. The site plan of the dam, spillway, outlet works and Grindstone Tunnel are shown on Plates 3 and 4 of the main report.

### B-23. AREA AND CAPACITY CURVES

The elevation-area and elevation-capacity curves shown on Plate B-13 were developed from data prepared by the State of California, Department of Water Resources. Data between elevations 920 and 1280 were obtained from 1:4800 scale maps and data for elevations above 1280 were obtained from 1:62,500 scale maps. The proposed location of the dam and reservoir is shown on Plate 3 of the main report.

### B-24. DESIGN CRITERIA

For this survey report, the applicable portions of the Engineering Manual for Civil Works, Hydraulic Design Criteria Charts, Engineer Circulars and Engineer Technical Letters were used as guides. The most recent criteria are presented in Engineer Technical Letter No. 1110-2-17, "Freeboard Allowance for Earthquake Shock," dated 28 February 1967, Engineer Technical Letter No. 110-2-8, "Computations of Freeboard Allowance for Waves in Reservoirs," dated 1 August 1966, and Engineer Circular No. 1110-2-27, "Policies and Procedures Pertaining to Determination of Spillway Capacities and Freeboard Allowance for Dams," dated 1 August 1966. Other references used in this design are: "Hydroelectric Handbook," by Creager and Justin, June 1955; "American Civil Engineering Practice," Volume II, by Robert W. Abett, 1956; "Hydraulic Transients," by George R. Rich, 1951; "Engineering Hydraulics," by Hunter Rouse, 1950; "Handbook of Applied Hydraulics," by Calvin V. Davis, 1942; and an article entitled "Penstocks Sized Quickly," by G.S. Sarkaria, in "Engineering News Record," August 1957.

## B-25. STORAGES AND CONTROLLING ELEVATIONS

Project formulation established 2.0 million acre-feet of inactive storage, 5.0 million acre-feet of water supply storage and 600,000 acre-feet of primary flood control for a total capacity of 7.6 million acre-feet. The controlling elevations are:

| | |
|---|---|
| Streambed | 920 feet |
| Bottom of water supply pool | 1,425 feet |
| Top of water supply pool | 1,587 feet |
| Top of flood control pool | 1,602 feet |
| Maximum water level, spillway design flood | 1,626 feet |
| Crest of dam | 1,650 feet |

## B-26. DIVERSION AND CARE OF WATER

Provisions would be made during construction to divert or store streamflow up to and including the standard project flood. It was estimated that 300 feet would be about the maximum height to which the dam could be built in one construction season. Rating curves were computed for 33-, 40- and 50-foot diameter tunnels using a Manning's "n" value of 0.011 and the standard project flood hydrograph routed through each tunnel. The following table summarizes the results:

| Tunnel dia. ft. | Maximum Pool Elevation | Bottom Reservoir Elevation | Water Depth | Freeboard Allowance | Dam Height |
|---|---|---|---|---|---|
| 33 | 1,317 | 920 | 397 | 5 | 402 |
| 40 | 1,282 | 920 | 362 | 5 | 367 |
| 50 | 1,223 | 920 | 303 | 5 | 308 |

The 50-foot diameter diversion tunnel was selected to provide adequate capacity during construction to pass the standard project flood without overtopping the embankment of the dam. A floating log boom would be installed upstream from the inlet to minimize the potential of debris plugging the entrance. A diversion dam would be required during the first construction season in which the river is diverted through the tunnel. The diversion would be made after the end of the flood season which is considered to be about the 15th of April. A review of past streamflow records indicates that after this date a peak flow of 25,000 c.f.s. may be expected with a frequency of about once in 10 years. An outflow of 25,000 c.f.s. would raise the water level behind the diversion dam about 60 feet to elevation 983 feet and store about 2,500 acre-feet of runoff. Five feet of freeboard added to the water level establishes the crest elevation of the diversion dam at 988 feet.

## SPILLWAY

### B-27. DESCRIPTION OF SPILLWAY

A gated side-channel spillway would be provided for regulation of flood control releases and for passing the spillway design flood. The spillway crest (elevation 1,581 feet) would be 6 feet below the bottom of the flood control pool. Three tainter gates, each 30 feet wide by 44 feet high, would be provided. With the three gates operating according to planned regulation procedures, the maximum water level of the reservoir would rise to elevation 1,626 feet during the spillway design flood. The peak inflow of the spillway design flood, 470,000 c.f.s., would be reduced to an outflow peak of 109,000 c.f.s. Releases would flow to the 50-foot diameter diversion tunnel through a 50-foot diameter inclined tunnel. A stilling basin to dissipate energy would be provided at the downstream end of the diversion tunnel. The estimated minimum freeboard required for wave ride-up plus wind set-up, with an overland wind velocity of 40 miles per hour would be 5 feet. However, the freeboard allowance was increased to 9 feet, giving due consideration to the great height of the dam, the large storage capacity of the reservoir, the probable error in the elevation-storage curve and preliminary nature of the probable maximum flood estimate. The required allowance for settlement due to earthquake is 15 feet (2 percent of the dam height). Adding freeboard plus the allowance for settlement due to earthquakes to the maximum water level in the reservoir establishes the crest of dam at elevation 1,650 feet. The details of the spillway are presented on Plate B-19.

### B-28. DERIVATION OF THE SPILLWAY RATING CURVE

The basic equation for discharge over a weir is:

$$Q = CLH3/2$$

Q = Total discharge

C = Discharge coefficient

L = Crest length of weir

H = Energy head on weir

The theoretical value of C with an approach depth of one-half the design head varies from 3.1 to 4.0 as the depth of water over the weir increases. The gate rating curves are shown on Plate B-16. The spillway profile and embankment section are shown on Plate B-17.

### B-29. SPILLWAY TUNNEL

There would be a transition from the 100-foot wide rectangular section of the trough of the side-channel spillway to a 50-foot wide section. The 50-foot section would transition to a 50-foot diameter tunnel which would connect to the 50-foot diameter diversion tunnel shown on Plate 4 of the main report. The spillway flows would pass through critical depth at the downstream end of the 100-foot wide trough of the spillway. The critical depth would be 33 feet with a velocity of 33 feet per second for the spillway design flood. Table B-5 presents the flow characteristics of the tunnel. The estimated maximum velocity in the tunnel for the design discharge of 109,000 c.f.s. would be 184 feet per second at the junction with the diversion tunnel and 140 feet per second at the exit portal. The depth of flow in the 50-foot diameter tunnel would vary from about 26 to 17 feet without air entrainment and 29 to 24 feet with air entrainment. Details of the side-channel and spillway tunnel are shown on Plates B-18 and B-19.

## B-30. SPILLWAY STILLING BASIN

A conventional stilling basin with energy dissipation by a hydraulic jump was adopted for this design. The downstream end of the combined diversion and spillway tunnel would transition to a 50-foot wide by 39 feet high rectangular section. From this portal, the section would flare to a 140-foot wide stilling basin. The length of the transition would be 650 feet. The flare ratio of the side walls would be 1:14 which is 2.5 times the Froude number at the tunnel portal. The sequent depth for the design flow of 109,000 c.f.s. is 85 feet. Baffle blocks would reduce the required depth after jump to 76 feet for the spillway design flood. Adding 5 feet of freeboard to the required depth established the wall height of 81 feet. The length of the basin was set at 250 feet, or about 3 times the sequent depth. One row of 7 baffle blocks, 10 feet wide, 10 feet high by 20 feet long, would be placed at the downstream one-third point of the basin. No tailwater rating curve was developed. However, for this stage of design, the tailwater was assumed to be at elevation 940 feet. This elevation establishes the bottom of the basin at elevation 864 feet. Details of the stilling basin are presented on Plate 4 of the main report and in greater detail on Plate B-20 of this appendix.

## B-31. FLOOD CONTROL AND EMERGENCY OUTLET WORKS

Flood control releases would be made through the gated spillway. However, a low level outlet system with high pressure gates would be required to permit draining the reservoir in event of an emergency. Conduits for the system would be placed in the concrete plug in the diversion tunnel, as shown on Plate B-19. The releases would flow through the tunnel to the stilling basin. The capacity of the emergency system, in conjunction with the other outlets, would be sufficient to drain the reservoir in a reasonable length of time, about one to one and one-half months.

## OUTLET WORKS

### B-32. GENERAL

Facilities would be provided for quality controlled releases of water from the reservoir for fish mitigation and other downstream water demands. The outlet works were designed for a discharge of 400 c.f.s. with either all of the discharge going to the river below the dam or up to one-half of the discharge going to the fish hatchery. Plate 4 of the main report and Plate B-21 of this appendix presents the plan, profile and details of the facilities.

### B-33. INTAKE STRUCTURE

The intake would consist of a concrete structure built on the steep slope (about one vertical on one horizontal) of the left abutment of the dam at a point near the entrance to the proposed spillway. Inlets would be placed at four different elevations to permit temperature and turbidity control of the releases. The bottom inlet would be at elevation 1,364 feet which is 61 feet below the minimum water supply pool level. The top inlet would be at elevation 1,565 or 22 feet below the maximum conservation pool. The two intermediate inlets would be at elevation 1,440 and 1,510 feet. Each inlet would be connected to an independent cell of the tower where gates would control the selection of water for releases.

### B-34. OPERATION

Outflow from the inlets would be carried in 6.5-foot diameter conduits to a valve chamber for control of the releases from the reservoir. The chamber would be under the left abutment of the dam and have a sloping access shaft. The top of the shaft would be close to the top of the inlet structure. Flows from alternative inlets are combined into two conduits prior to entering the valve chamber. A single 6.5-foot diameter conduit would lead from the chamber to the downstream side of the dam where the flow would be split into two 4-foot diameter conduits for delivery to the Eel River and the fish hatchery.

## GRINDSTONE TUNNEL

### B-35. GENERAL

Water supply studies indicate that the minimum capacity of the conveyance facility at elevation 1,425 m.s.l. should be about 3,000 c.f.s. It would flow near full at maximum discharge based on an "n" value of 0.012 in Manning's formula. A 17-foot diameter concrete tunnel would be required. A control tower equipped with gates for flow regulation at the entrance to the tunnel and a stilling basin near the exit portal would be necessary. The delivery tunnel would be approximately 21 miles in length. The discharge rating curve for the tunnel is shown on Plate B-22 and the physical details are shown on Plate B-23 and Plate 4 of the main report.

## B-36. INTAKE TOWER

The intake tower would be a vertical structure set in the reservoir near the shoreline. The invert of the control gates would be at elevation 1,405 feet, 20 feet below the bottom of the water supply pool. The floor of the operating house on top of the tower would be at elevation 1,635 feet, 9 feet above the maximum reservoir level for spillway design flood. The tower would contain 8.5 feet by 15.5 feet regulation slide gates and two emergency slide gates of the same dimensions. Bulkhead recesses would be provided upstream from the slide gates for the closure of the conduit for inspection or repair of the emergency slide gates.

## B-37. TUNNEL PORTAL TRANSITION

The downstream 40 feet of the tunnel would transition from the 17-foot diameter to a rectangular section 17 feet wide by 13.4 feet high to improve the flow characteristics as the water enters the stilling basin.

## B-38. STILLING BASIN

The stilling basin was designed for a maximum discharge of 4,900 c.f.s. which occur with the gates fully opened, the reservoir at the top of the water supply pool and with a low "n" value of 0.010 in the tunnel. The basin would be 38 feet wide and 60 feet long with a 70-foot transition between the tunnel portal and the basin. The sequent depth for a hydraulic jump would be 19 feet. Baffle piers would reduce the required depth after jump to 17 feet and adding 3 feet of freeboard establishes the top of the wall at 20 feet above the bottom of the basin.

# HYDROELECTRIC POWER

## B-39. GENERAL

Hydroelectric power generation facilities were investigated which would utilize the available energy in the 200 c.f.s. minimum fishery release through the outlet works. The available net head would be from 285 feet to 447 feet, depending on the water level in the reservoir. The location for the plant would be between the dam and the fish hatchery. The design capacity, and also the firm capacity, would be 4,800 kilowatts. A bypass around the powerhouse would sustain the flow to the fish hatchery when the turbines would be operating at a lower discharge than needed for the hatchery. A small afterbay storage basin would be provided with an overflow weir to return any excess flow to the river.

## B-40. DESIGN CRITERIA

The design of a possible plant was based on criteria presented in EM 1110-2-3001, "Planning and Design of Hydroelectric Power Plant

Structures;" Hydroelectric Handbook" by Creager and Justin; "American Civil Engineering Practice, Vol. II," by Robert W. Abbott; and Design Standards No. 6, Turbines and Pumps" by the U.S.B.R.

## B-41. PLANT DIMENSIONS

The 4,800 KW plant capacity was based on 200 c.f.s. discharging under a net head of 285 feet with the reservoir level at the bottom of the water supply pool, elevation 1,425, and combined turbine generator efficiency of 86%. Water hammer could produce about 800 feet of extra head at the turbine if no provisions are made for pressure relief. Therefore, an automatic surge suppressor would be installed in the penstock just upstream from the power plant. The hydraulic dimensions of the draft tube and plant are listed below:

| Item | Dimensions |
|---|---|
| Runner discharge diameter | 3.0' |
| Inlet diameter to scroll case | 3.2' |
| Depth of draft tube below centerline distributor | 8.2' |
| Length of draft tube from centerline distributor | 11.5' |
| Width of draft tube | 9.1' |
| Power plant dimensions | 23'x41' |

TABLE B-1

EEL RIVER BASIN

UNIT HYDROGRAPHS

| Time (In increments of Unit time Periods) | 3 Hour Unit Period Subarea No. 1 | 3 Hour Unit Period Subarea No. 2 | 3 Hour Unit Period Subarea No. 3 | 3 Hour Unit Period Subarea No. 4 | 3 Hour Unit Period Subarea No. 5 | 3 Hour Unit Period Subarea No. 6 | 3 Hour Unit Period Subarea No. 7 | 3 Hour Unit Period Subarea No. 8 | 3 Hour Unit Period Subarea No. 9 | 3 Hour Unit Period Subarea No. 10 | 1 Hour Unit Period Subarea No. 11 | 2 Hour Unit Period Subarea No. 12 | 3 Hour Unit Period Subarea No. 13 | 3 Hour Unit Period Subarea No. 14 | 3 Hour Unit Period Subarea No. 15 | 6 Hour Unit Period Subarea No. 16 | 3 Hour Unit Period Subarea No. 17 | 3 Hour Unit Period Subarea No. 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 4,600 | 3,000 | 2,200 | 4,100 | 3,900 | 8,100 | 1,100 | 2,400 | 3,500 | 2,100 | 350 | 2,000 | 1,100 | 1,300 | 2,300 | 3,300 | 3,300 | 2,800 |
| 2 | 20,300 | 14,000 | 10,000 | 9,800 | 19,500 | 29,300 | 4,200 | 12,100 | 13,500 | 10,400 | 1,250 | 5,000 | 2,700 | 5,800 | 8,700 | 13,200 | 2,800 | 11,700 |
| 3 | 11,900 | 7,900 | 13,000 | 28,100 | 14,000 | 42,100 | 10,600 | 25,100 | 29,600 | 6,500 | 2,500 | 14,000 | 10,100 | 20,000 | 11,400 | 46,200 | 1,200 | 21,000 |
| 4 | 7,400 | 5,200 | 7,400 | 15,900 | 8,900 | 24,800 | 7,300 | 9,200 | 19,000 | 4,300 | 3,110 | 22,600 | 5,200 | 25,100 | 5,800 | 84,800 | 700 | 13,000 |
| 5 | 4,800 | 3,400 | 4,600 | 10,000 | 5,700 | 15,700 | 5,200 | 6,000 | 13,300 | 2,800 | 3,070 | 19,400 | 2,000 | 19,000 | 3,400 | 71,500 | 400 | 8,800 |
| 6 | 3,600 | 2,500 | 3,500 | 6,400 | 4,100 | 10,500 | 4,100 | 4,200 | 9,500 | 1,900 | 2,770 | 17,200 | 1,000 | 13,200 | 2,500 | 34,500 | 300 | 6,500 |
| 7 | 2,700 | 2,000 | 2,700 | 4,800 | 3,300 | 8,100 | 3,000 | 3,000 | 7,400 | 1,600 | 2,130 | 13,000 | 500 | 9,500 | 2,100 | 22,000 | 100 | 5,100 |
| 8 | 2,100 | 1,500 | 2,200 | 3,600 | 2,600 | 6,200 | 2,300 | 2,700 | 5,700 | 1,300 | 1,640 | 10,200 | 200 | 7,500 | 1,900 | 15,200 | 0 | 4,100 |
| 9 | 1,600 | 1,200 | 1,800 | 2,700 | 2,100 | 4,800 | 1,800 | 2,300 | 4,600 | 900 | 1,340 | 8,400 | 0 | 6,100 | 1,700 | 11,000 |  | 3,400 |
| 10 | 1,100 | 900 | 1,500 | 2,100 | 1,700 | 3,800 | 1,400 | 2,000 | 3,800 | 700 | 1,150 | 7,000 |  | 5,200 | 1,000 | 8,200 |  | 2,900 |
| 11 | 800 | 600 | 1,200 | 1,600 | 1,300 | 2,900 | 1,200 | 1,900 | 3,300 | 600 | 1,030 | 6,000 |  | 4,400 | 1,500 | 6,200 |  | 2,500 |
| 12 | 600 | 400 | 1,000 | 1,200 | 900 | 2,100 | 1,100 | 1,700 | 2,900 | 400 | 940 | 5,200 |  | 3,800 | 1,300 | 4,500 |  | 2,200 |
| 13 | 300 | 300 | 800 | 700 | 600 | 1,300 | 1,000 | 1,500 | 2,600 | 200 | 840 | 4,600 |  | 3,300 | 1,200 | 3,000 |  | 1,900 |
| 14 | 200 | 100 | 600 | 400 | 300 | 700 | 900 | 1,300 | 2,300 | 100 | 760 | 4,200 |  | 2,800 | 1,100 | 1,800 |  | 1,700 |
| 15 | 0 | 0 | 400 | 100 | 0 | 0 | 800 | 1,100 | 2,000 | 0 | 680 | 3,700 |  | 2,400 | 1,000 | 900 |  | 1,400 |
| 16 |  |  | 300 | 0 |  |  | 700 | 900 | 1,700 |  | 600 | 3,400 |  | 2,000 | 900 | 0 |  | 1,100 |
| 17 |  |  | 200 |  |  |  | 600 | 700 | 1,400 |  | 530 | 3,100 |  | 1,700 | 800 |  |  | 900 |
| 18 |  |  | 0 |  |  |  | 500 | 500 | 1,100 |  | 460 | 2,800 |  | 1,400 | 600 |  |  | 700 |
| 19 |  |  |  |  |  |  | 300 | 200 | 800 |  | 430 | 2,500 |  | 1,200 | 300 |  |  | 400 |
| 20 |  |  |  |  |  |  | 100 | 200 | 500 |  | 370 | 2,300 |  | 1,000 | 200 |  |  | 200 |
| 21 |  |  |  |  |  |  | 0 | 100 | 200 |  | 330 | 2,000 |  | 700 | 100 |  |  | 0 |
| 22 |  |  |  |  |  |  |  | 0 | 0 |  | 290 | 1,800 |  | 500 | 0 |  |  |  |
| 23 |  |  |  |  |  |  |  |  |  |  | 260 | 1,600 |  | 300 |  |  |  |  |
| 24 |  |  |  |  |  |  |  |  |  |  | 230 | 1,500 |  | 100 |  |  |  |  |
| 25 |  |  |  |  |  |  |  |  |  |  | 210 | 1,300 |  | 0 |  |  |  |  |
| 26 |  |  |  |  |  |  |  |  |  |  | 200 | 1,200 |  |  |  |  |  |  |
| 27 |  |  |  |  |  |  |  |  |  |  | 180 | 1,000 |  |  |  |  |  |  |
| 28 |  |  |  |  |  |  |  |  |  |  | 160 | 900 |  |  |  |  |  |  |
| 29 |  |  |  |  |  |  |  |  |  |  | 140 | 800 |  |  |  |  |  |  |
| 30 |  |  |  |  |  |  |  |  |  |  | 110 | 700 |  |  |  |  |  |  |
| 31 |  |  |  |  |  |  |  |  |  |  | 100 | 600 |  |  |  |  |  |  |
| 32 |  |  |  |  |  |  |  |  |  |  | 80 | 400 |  |  |  |  |  |  |
| 33 |  |  |  |  |  |  |  |  |  |  | 50 | 200 |  |  |  |  |  |  |
| 34 |  |  |  |  |  |  |  |  |  |  | 30 | 100 |  |  |  |  |  |  |
| 35 |  |  |  |  |  |  |  |  |  |  | 10 | 0 |  |  |  |  |  |  |
| 36 |  |  |  |  |  |  |  |  |  |  | 0 |  |  |  |  |  |  |  |
| D.A. (Sq. mi) | 288 | 200 | 248 | 425 | 320 | 745 | 224 | 374 | 598 | 157 | 42 | 537 | 106 | 643 | 234 | 3,113 | 41 | 429 |
| N.A.P (in ) | 56 | 48 | 54 | 63 | 47 | 56 | 62 | 54 | 57 | 55 | 75 | 74 | 74 | 74 | 57 | 58 | 40 | 57 |

SUBAREA INDEX:

1) Eel River at Scott Dam.
2) Eel River from Scott Dam to English Ridge.
3) Eel River from English Ridge Damsite, Dos Rios Damsite, to Dos Rios below.
4) Middle Fork Eel River at Spencer-Francisco Damsite.
5) Middle Fork Eel River from Spencer-Francisco Damsite to Dos Rios Damsite.
6) Middle Fork Eel River at Dos Rios Damsite.
7) Nosk Fork Eel River at Minor Damsite.
8) Eel River from Mina Damsite to Alderpoint.
9) Eel River from Dos Rios below Alderpoint.
10) Eel River from Alderpoint to Sequoia Damsite.
11) South Fork Eel River at Branscomb gage.
12) South Fork Eel River at Miranda gage.
13) South Fork Eel River from Miranda to West.
14) South Fork Eel River at Weott.
15) Eel River from Sequoia Damsite, and Weott, to Scotia.
16) Eel River basin at Scotia.
17) Eel River from Scotia to mouth of Van Duzen River.
18) Van Duzen River at Mouth.

Note: All unit graph ordinate values are in cubic feet per second.

## TABLE B-2

### Eel River
### Seasonal Maximum Discharges at Scotia and Estimated Seasonal Maximum Stages at Fernbridge

| Season | Date | Discharge @ Scotia c.f.s. | Fernbridge Stage * Ft. m.s.l. |
|---|---|---|---|
| 1910-11 | 20 Jan | 136,000 | 21.8 |
| 12 | 26 Jan | 170,000 | 23.4 |
| 13 | 18 Jan | 150,000 | 22.5 |
| 14 | 22 Jan | 309,000 | 28.1 |
| 1914-15 | 2 Feb | 351,000 | 29.1 |
| 16 | 7 Feb | 142,000 | 22.1 |
| 17 | 25 Feb | 292,000 | 27.7 |
| 18 | 7 Feb | 78,600 | 18.9 |
| 19 | 17 Jan | 149,000 | 22.5 |
| 1919-20 | 16 Apr | 62,000 | 17.9 |
| 21 | 19 Nov | 148,000 | 22.4 |
| 22 | 19 Feb | 123,000 | 21.2 |
| 23 | 28 Dec | 73,400 | 18.5 |
| 24 | 8 Feb | 73,400 | 18.5 |
| 1924-25 | 6 Feb | 127,000 | 21.4 |
| 26 | 4 Feb | 176,000 | 23.7 |
| 27 | 21 Feb | 221,000 | 25.6 |
| 28 | 27 Mar | 233,000 | 26.0 |
| 29 | 4 Feb | 41,000 | 16.6 |
| 1929-30 | 15 Dec | 120,000 | 21.1 |
| 31 | 23 Jan | 87,000 | 19.3 |
| 32 | 27 Dec | 127,000 | 21.4 |
| 33 | 17 Mar | 58,100 | 17.7 |
| 34 | 29 Mar | 50,900 | 17.3 |
| 1934-35 | 8 Apr | 79,900 | 19.4 |
| 36 | 16 Jan | 216,000 | 25.4 |
| 1936-37 | 5 Feb | 134,000 | 21.8 |
| 38 | 11 Dec | 345,000 | 28.8 |
| 39 | 3 Dec | 133,000 | 21.7 |
| 1939-40 | 28 Feb | 305,000 | 28.0 |
| 41 | 24 Dec | 150,000 | 22.5 |
| 42 | 6 Feb | 209,000 | 25.1 |
| 43 | 21 Jan | 315,000 | 28.2 |
| 44 | 4 Mar | 57,800 | 17.7 |
| 1944-45 | 3 Feb | 99,100 | 20.0 |
| 46 | 27 Dec | 239,000 | 26.2 |
| 47 | 12 Feb | 86,100 | 19.2 |
| 48 | 8 Jan | 114,000 | 20.8 |
| 49 | 18 Mar | 140,000 | 22.0 |
| 1949-50 | 18 Jan | 117,000 | 20.9 |
| 51 | 22 Jan | 249,000 | 26.5 |
| 52 | 27 Dec | 262,000 | 26.9 |
| 53 | 9 Jan | 215,000 | 25.4 |
| 54 | 17 Jan | 245,000 | 26.4 |
| 1954-55 | 31 Dec | 52,400 | 17.4 |
| 56 | 22 Dec | 541,000 | ** 31.1 |
| 57 | 25 Feb | 153,000 | 22.7 |
| 58 | 25 Feb | 202,000 | 24.8 |
| 59 | 12 Jan | 145,000 | 22.3 |
| 1959-60 | 8 Feb | 343,000 | 28.7<br>** (28.3) |
| 61 | 11 Feb | 113,000 | 20.7 |
| 62 | 14 Feb | 107,000 | 20.4 |
| 63 | 1 Feb | 252,000 | 26.6 |
| 64 | 21 Jan | 178,000 | 23.7 |
| 65 | 23 Dec | 752,000 | 33.0<br>** (32.9) |
| 66 | 5 Jan | 245,000 | ** 27.6 |

* From correlation relation; subtract 3.4 feet to obtain approximate gage stage.

** Observed data.

TABLE B-3

## Effect Of Dos Rios Dam, Alone And In Conjunction With A Potential English Ridge Project, On Historical And Hypothetical Flood Peak Discharges 1/

| | LOCATION | | | | |
|---|---|---|---|---|---|
| | | | | Fernbridge | |
| | Near Dos Rios, 2/ x 1000 c.f.s. | Near Alderpoint, x 1000 c.f.s. | Scotia, x 1000 c.f.s. | Discharge, x 1000 c.f.s. | River Stage, Ft. (m.s.l.) |
| Standard Project Flood | | | | | |
| Natural Conditions | 450 | 580 | 820 | 920 | 33.5 |
| with Dos Rios Dam | 210 | 340 | 610 | 710 | 32.1 |
| with Dos Rios and English Ridge Dams | 155 | 265 | 530 | 620 | 31.3 |
| December 1964 | | | | | |
| Natural Conditions | 400 | 561 | 752 | 840 | 33.0 |
| with Dos Rios Dam | 190 | 346 | 545 | 650 | 31.5 |
| with Dos Rios and English Ridge Dams | 90 | 230 | 470 | 580 | 31.0 |
| February 1960 | | | | | |
| Natural Conditions | 185 | 220 | 343 | 384 | 28.7 |
| with Dos Rios Dam | 80 | 120 | 260 | 300 | 27.2 |
| with Dos Rios and English Ridge Dams | 34 | 88 | 227 | 270 | 26.4 |
| February 1958 | | | | | |
| Natural Conditions | 119 | 134 | 202 | 226 | 24.8 |
| with Dos Rios Dam | 53 | 68 | 139 | 160 | 22.2 |
| with Dos Rios and English Ridge Dams | 20 | 37 | 128 | 155 | 21.9 |
| January 1956 | | | | | |
| Natural Conditions | 118 | 132 | 205 | 230 | 25.1 |
| with Dos Rios Dam | 50 | 65 | 147 | 175 | 22.8 |
| with Dos Rios and English Ridge Dams | 23 | 40 | 122 | 150 | 21.7 |
| December 1955 | | | | | |
| Natural Conditions | 283 | 376 | 541 | 606 | 31.4 |
| with Dos Rios Dam | 125 | 223 | 391 | 450 | 29.7 |
| with Dos Rios and English Ridge Dams | 57 | 156 | 342 | 400 | 29.0 |

1/ Discharges are based on 600,000 acre-feet of primary flood control storage plus secondary (surcharge) flood control storage (an amount equal to 300,000 acre-feet of storage during the occurrence of the standard project flood) for the Dos Rios damsite, and on 140,000 acre-feet of primary flood control storage plus secondary (surcharge) flood control storage (an amount equal to 140,000 acre-feet of storage during the occurrence of the standard project flood) for the English Ridge damsite.

2/ Discharge near Dos Rios has been recorded on the Eel River downstream of the confluence of the Middle Fork Eel River.

TABLE B-4

## Middle Fork Eel River at Dos Rios Site - Unimpaired Flows

(Thousands of Acre-Feet)

| | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1910-11 | 2.3 | 9.1 | 20.3 | 151.3 | 119.2 | 181.2 | 160.2 | 77.6 | 36.6 | 5.6 | 1.6 | 2.0 | 767.0 |
| 12 | 1.0 | 2.6 | 3.2 | 138.1 | 98.9 | 110.1 | 102.1 | 182.2 | 36.1 | 5.1 | 1.5 | 8.1 | 689.0 |
| 13 | 4.3 | 163.2 | 135.0 | 276.2 | 87.6 | 86.1 | 156.2 | 100.8 | 27.8 | 4.0 | 2.1 | 0.7 | 1,044.0 |
| 14 | 1.6 | 18.4 | 191.0 | 658.4 | 238.2 | 214.3 | 288.6 | 107.1 | 33.6 | 7.4 | 2.2 | 2.2 | 1,763.0 |
| 15 | 7.8 | 58.4 | 153.1 | 267.9 | 405.1 | 296.2 | 256.1 | 208.8 | 60.8 | 9.8 | 3.3 | 2.7 | 1,730.0 |
| 16 | 4.0 | 53.3 | 253.0 | 262.3 | 382.2 | 268.3 | 169.2 | 81.3 | 28.0 | 8.0 | 2.2 | 2.2 | 1,514.0 |
| 17 | 0.8 | 9.8 | 46.2 | 66.5 | 191.2 | 110.9 | 235.9 | 110.8 | 29.9 | 4.6 | 1.5 | 0.9 | 809.0 |
| 18 | 0.8 | 4.0 | 22.4 | 29.3 | 67.8 | 127.5 | 80.3 | 24.0 | 5.9 | 1.8 | 1.0 | 2.2 | 367.0 |
| 19 | 3.3 | 18.1 | 24.7 | 184.6 | 331.5 | 255.9 | 147.6 | 65.6 | 14.8 | 3.6 | 0.9 | 2.4 | 1,053.0 |
| 20 | 1.3 | 2.0 | 17.8 | 4.5 | 2.9 | 35.0 | 133.2 | 24.4 | 4.7 | 1.4 | 0.3 | 0.5 | 228.0 |
| 1920-21 | 6.8 | 317.6 | 379.3 | 288.9 | 237.4 | 176.5 | 96.4 | 90.1 | 26.1 | 4.9 | 1.6 | 1.4 | 1,627.0 |
| 22 | 0.8 | 8.8 | 45.9 | 29.7 | 192.2 | 125.5 | 159.6 | 92.3 | 26.3 | 6.2 | 1.9 | 1.8 | 691.0 |
| 23 | 9.1 | 22.6 | 104.9 | 75.1 | 49.1 | 24.8 | 123.1 | 25.5 | 12.2 | 3.3 | 1.0 | 1.3 | 452.0 |
| 24 | 5.4 | 8.0 | 13.4 | 22.6 | 70.2 | 10.6 | 11.0 | 8.8 | 3.3 | 1.1 | 1.0 | 0.6 | 156.0 |
| 25 | 21.3 | 95.9 | 156.9 | 80.4 | 511.9 | 106.7 | 297.4 | 180.3 | 47.0 | 8.5 | 2.7 | 3.0 | 1,512.0 |
| 26 | 5.5 | 12.0 | 24.7 | 47.0 | 263.3 | 48.3 | 138.6 | 29.3 | 7.6 | 2.5 | 0.7 | 1.5 | 581.0 |
| 27 | 4.8 | 191.8 | 177.1 | 227.5 | 517.7 | 167.5 | 228.1 | 67.1 | 19.8 | 5.6 | 1.6 | 2.4 | 1,611.0 |
| 28 | 3.1 | 61.4 | 46.1 | 109.1 | 119.3 | 268.9 | 207.7 | 44.2 | 11.0 | 3.8 | 2.0 | 1.4 | 878.0 |
| 29 | 1.8 | 23.3 | 47.5 | 26.5 | 66.3 | 35.6 | 54.2 | 31.5 | 15.9 | 4.0 | 1.2 | 1.2 | 309.0 |
| 30 | 0.6 | 1.6 | 151.6 | 111.8 | 108.0 | 120.8 | 74.2 | 37.1 | 9.5 | 2.9 | 0.7 | 12. | 620.0 |
| 1930-31 | 1.1 | 7.3 | 5.3 | 81.5 | 34.9 | 85.7 | 28.5 | 10.9 | 6.0 | 2.2 | 0.8 | 0.8 | 265.0 |
| 32 | 4.4 | 22.2 | 205.2 | 122.4 | 63.9 | 75.7 | 69.3 | 76.9 | 14.8 | 3.3 | 0.8 | 1.1 | 660.0 |
| 33 | 0.6 | 6.2 | 29.1 | 60.8 | 72.7 | 233.5 | 108.1 | 120.3 | 38.8 | 8.5 | 2.0 | 2.4 | 683.0 |
| 34 | 5.6 | 5.6 | 113.0 | 73.2 | 68.8 | 65.0 | 44.7 | 24.9 | 6.4 | 2.1 | 0.9 | 0.8 | 411.0 |
| 35 | 3.9 | 92.0 | 51.1 | 171.4 | 87.3 | 168.8 | 338.5 | 69.9 | 13.4 | 4.4 | 1.7 | 1.6 | 1,004.0 |
| 36 | 3.9 | 4.4 | 31.5 | 418.0 | 361.2 | 113.5 | 132.1 | 41.4 | 34.4 | 8.5 | 2.2 | 1.9 | 1,153.0 |
| 37 | 0.7 | 2.1 | 4.3 | 8.4 | 130.3 | 191.7 | 205.8 | 74.2 | 25.3 | 6.6 | 1.9 | 1.7 | 653.0 |
| 38 | 6.0 | 290.6 | 372.2 | 148.3 | 496.6 | 559.1 | 249.2 | 118.9 | 34.4 | 7.4 | 2.1 | 3.2 | 2,288.0 |
| 39 | 11.1 | 25.2 | 81.7 | 51.1 | 74.7 | 126.4 | 44.8 | 30.5 | 9.2 | 3.0 | 1.0 | 1.3 | 460.0 |

TABLE B-4
(Cont'd)

Middle Fork Eel River at Dos Rios Site - Unimpaired Flows
(Thousands of Acre-Feet)

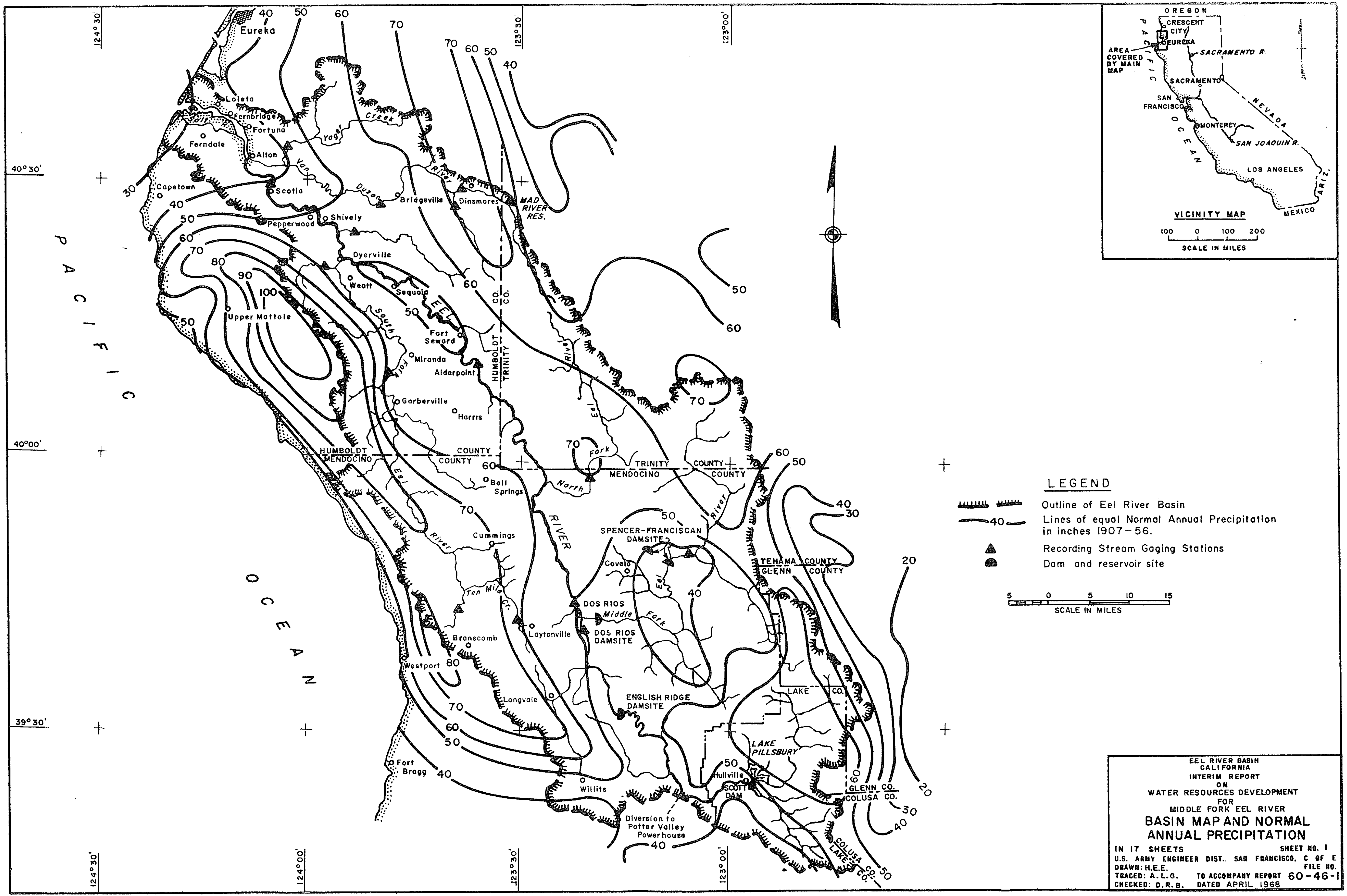
| | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1939-40 | 1.3 | 3.2 | 84.7 | 299.7 | 521.7 | 336.7 | 173.6 | 51.0 | 14.0 | 3.2 | 1.5 | 2.4 | 1,493.0 |
| 41 | 2.4 | 12.0 | 312.1 | 350.3 | 276.3 | 252.5 | 325.8 | 112.5 | 33.5 | 9.2 | 2.4 | 3.0 | 1,692.0 |
| 42 | 4.8 | 15.0 | 396.9 | 267.3 | 390.3 | 64.2 | 191.5 | 130.1 | 51.6 | 9.3 | 2.4 | 2.5 | 1,526.0 |
| 43 | 1.4 | 70.1 | 191.8 | 380.4 | 132.3 | 144.1 | 118.2 | 62.9 | 26.0 | 6.2 | 1.6 | 2.0 | 1,137.0 |
| 44 | 2.0 | 5.5 | 8.9 | 41.7 | 56.9 | 121.7 | 60.4 | 48.3 | 16.0 | 4.3 | 1.2 | 1.1 | 368.0 |
| 45 | 3.1 | 115.0 | 144.5 | 63.5 | 244.3 | 146.8 | 131.3 | 65.5 | 21.6 | 5.9 | 1.8 | 1.7 | 945.0 |
| 46 | 18.5 | 161.5 | 534.5 | 194.2 | 89.1 | 98.9 | 86.3 | 35.2 | 9.7 | 2.6 | 1.5 | 2.0 | 1,234.0 |
| 47 | 0.6 | 46.2 | 41.9 | 7.4 | 79.3 | 153.4 | 67.3 | 15.2 | 15.8 | 4.3 | 1.4 | 1.2 | 434.0 |
| 48 | 33.8 | 18.4 | 13.3 | 149.5 | 45.3 | 112.9 | 361.2 | 139.3 | 43.8 | 7.9 | 2.5 | 3.1 | 931.0 |
| 49 | 5.5 | 19.3 | 61.0 | 37.9 | 124.3 | 327.0 | 141.6 | 58.9 | 12.9 | 4.2 | 1.0 | 1.4 | 795.0 |
| 1949-50 | 1.0 | 8.6 | 8.7 | 166.3 | 174.3 | 181.1 | 155.7 | 66.1 | 17.6 | 5.0 | 1.1 | 1.5 | 787.0 |
| 51 | 109.1 | 150.9 | 349.6 | 339.0 | 264.8 | 117.2 | 54.2 | 73.4 | 14.8 | 5.0 | 1.5 | 2.5 | 1,482.0 |
| 52 | 3.3 | 48.5 | 366.3 | 255.3 | 386.7 | 204.6 | 230.2 | 139.5 | 40.0 | 9.2 | 2.3 | 1.1 | 1,687.0 |
| 53 | 1.1 | 4.6 | 226.0 | 623.1 | 94.6 | 136.8 | 155.9 | 116.4 | 74.4 | 16.9 | 3.4 | 1.8 | 1,455.0 |
| 54 | 3.0 | 58.3 | 60.3 | 386.5 | 253.7 | 204.2 | 220.1 | 48.8 | 17.2 | 4.7 | 1.8 | 1.4 | 1,260.0 |
| 55 | 2.2 | 50.7 | 116.1 | 95.0 | 61.0 | 74.2 | 75.7 | 102.9 | 14.1 | 3.6 | 0.9 | 0.6 | 597.0 |
| 56 | 0.9 | 33.9 | 889.4 | 640.7 | 366.1 | 174.8 | 144.7 | 136.8 | 35.7 | 6.5 | 1.9 | 1.6 | 2,433.0 |
| 57 | 14.8 | 12.7 | 11.2 | 56.6 | 258.9 | 242.6 | 102.0 | 139.2 | 28.9 | 5.7 | 1.9 | 7.5 | 822.0 |
| 58 | 97.5 | 120.5 | 225.4 | 350.9 | 873.8 | 244.0 | 298.2 | 142.7 | 44.6 | 9.6 | 3.2 | 1.6 | 2,412.0 |
| 59 | 1.3 | 9.0 | 15.6 | 257.2 | 194.1 | 124.7 | 82.1 | 26.2 | 7.4 | 1.6 | 0.6 | 2.2 | 722.0 |
| 1959-60 | 1.9 | 1.3 | 3.7 | 42.9 | 434.9 | 220.2 | 69.6 | 59.3 | 23.4 | 4.0 | 1.1 | 0.7 | 863.0 |
| Total | 433.2 | 2,502.8 | 6,969.4 | 9,198.2 | 10,773.1 | 8,072.7 | 7,586.3 | 3,926.9 | 1,202.6 | 269.0 | 81.4 | 97.4 | 51,113.0 |
| Mean | 8.7 | 50.1 | 139.4 | 184.0 | 215.4 | 161.5 | 151.7 | 78.5 | 24.1 | 5.4 | 1.6 | 1.9 | 1,022.3 |

## TABLE B-5

## Spillway Tunnel Hydraulics

(109,000 c.f.s., Spillway Design Flood)

| Location | Section (Feet) | Depth Without Air | Depth With Air | Velocity (f.p.s.) |
|---|---|---|---|---|
| Control sill | 100 Rectangular | 33.4 | 33.5 | 33 |
| Downstream end of transition | 50 Rectangular | 25.0 | 26.2 | 87 |
| Upstream end of 50-foot diameter tunnel | 50 Diameter | 26.0 | 28.8 | 106 |
| Junction with diversion tunnel | 50 Diameter | 17.1 | 23.8 | 184 |
| Station 33+00 | " | 19.1 | 24.3 | 159 |
| Station 45+50 | " | 21.1 | 25.3 | 139 |
| Tunnel portal | 50 Rectangular | 15.7 | 18.8 | 140 |

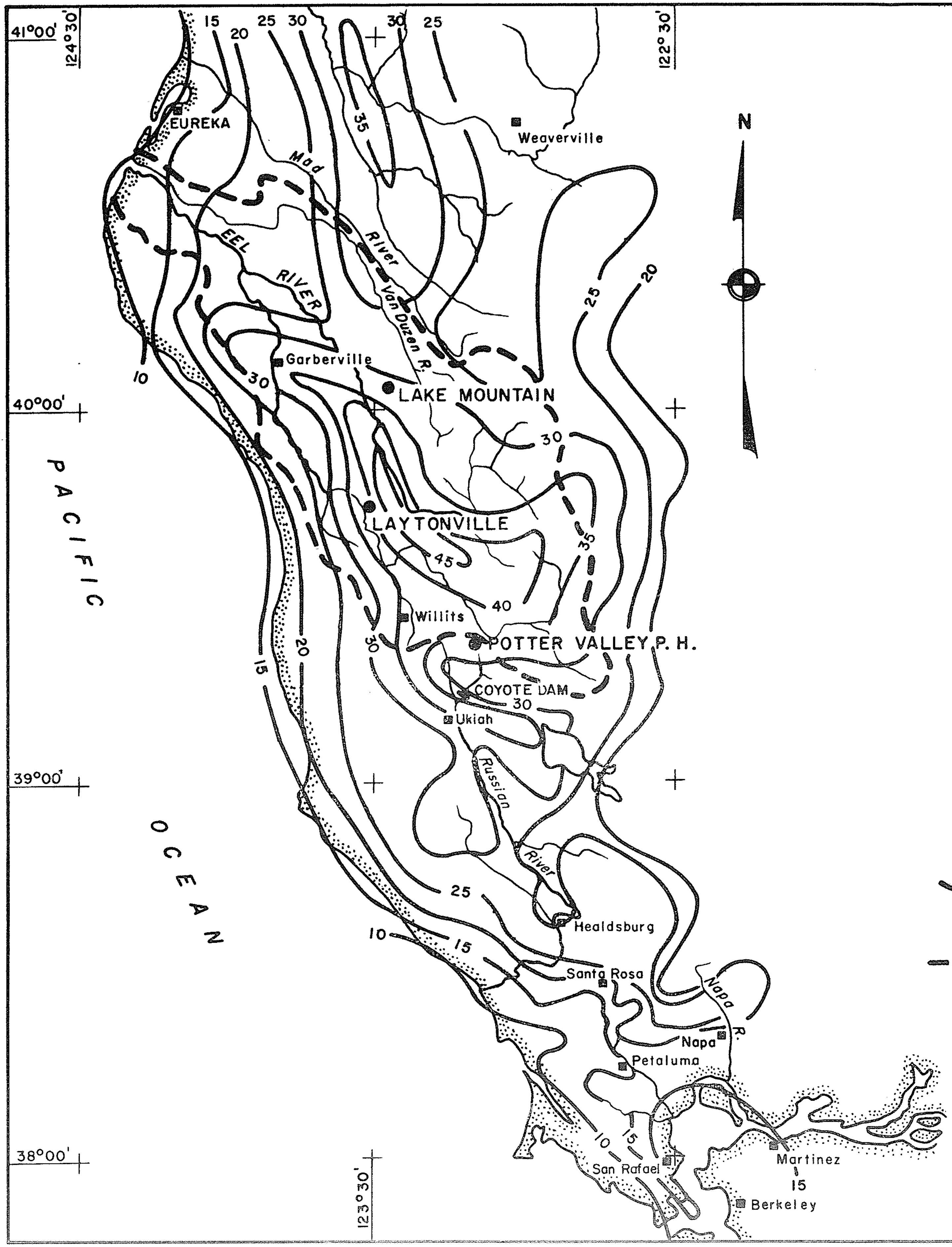


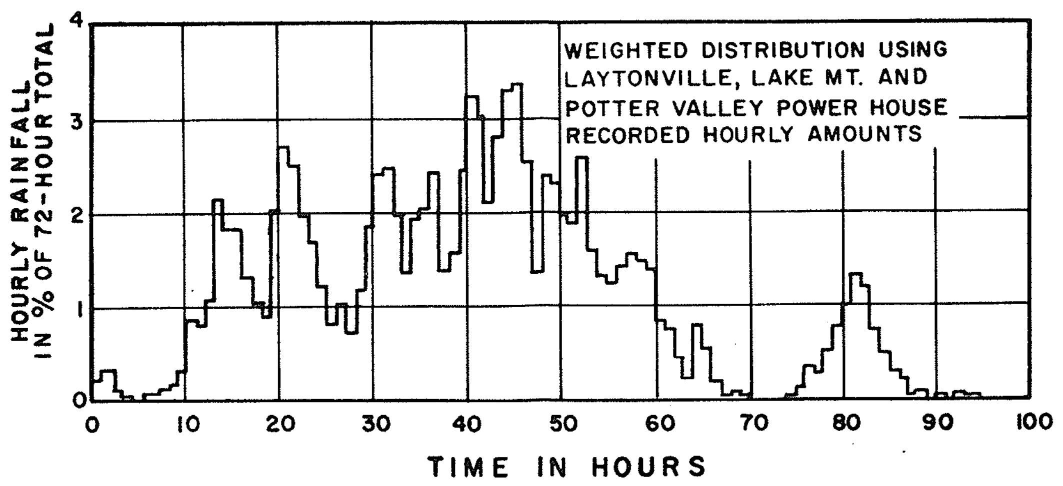
EEL RIVER BASIN
CALIFORNIA
INTERIM REPORT
ON
WATER RESOURCES DEVELOPMENT
FOR
MIDDLE FORK EEL RIVER

# BASIN MAP AND NORMAL ANNUAL PRECIPITATION

IN 17 SHEETS SHEET NO. 1
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E
DRAWN: H.E.E. FILE NO.
TRACED: A.L.G. TO ACCOMPANY REPORT 60-46-1
CHECKED: D.R.B. DATED APRIL 1968

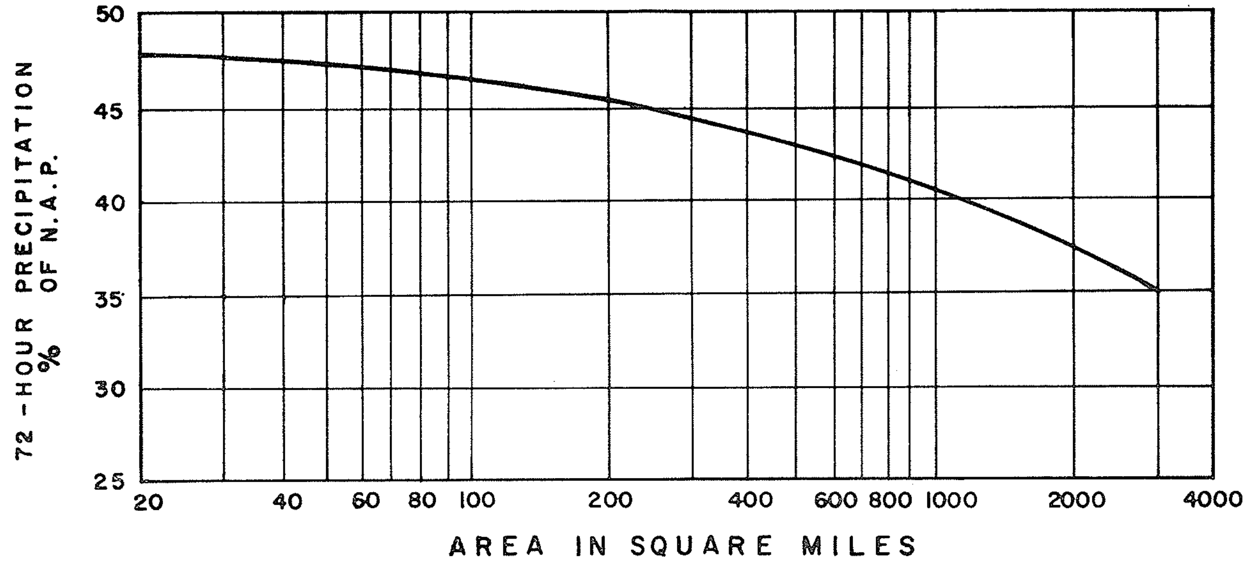
PLATE B-1





RAINFALL DISTRIBUTION

(TIME ZERO = 1200 HOURS 20 DEC 1964)



AREA-DEPTH CURVE

**LEGEND**

- 20 Isopercentual Line, in percent of normal annual precipitation
- ● Recording Precipitation Station used to distribute total storm precipitation
- ━ ━ ━ Basin Boundary

10 0 10 20 30

SCALE IN MILES

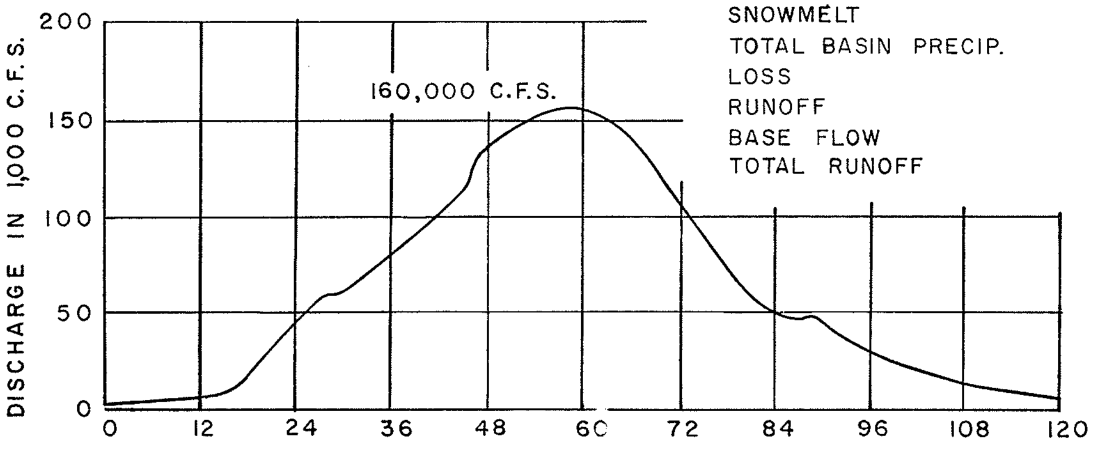
EEL RIVER BASIN
CALIFORNIA
INTERIM REPORT
ON
WATER RESOURCES DEVELOPMENT
FOR
MIDDLE FORK EEL RIVER

## ISOPERCENTUAL LINES

STORM OF 20-23 DECEMBER 1964

IN 17 SHEETS SHEET NO. 2
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C. OF E.
DRAWN: A.B.W. FILE NO.
TRACED: M.S. TO ACCOMPANY REPORT 60-46-1
CHECKED: M.H.B. DATED: APRIL 1968

PLATE B-2

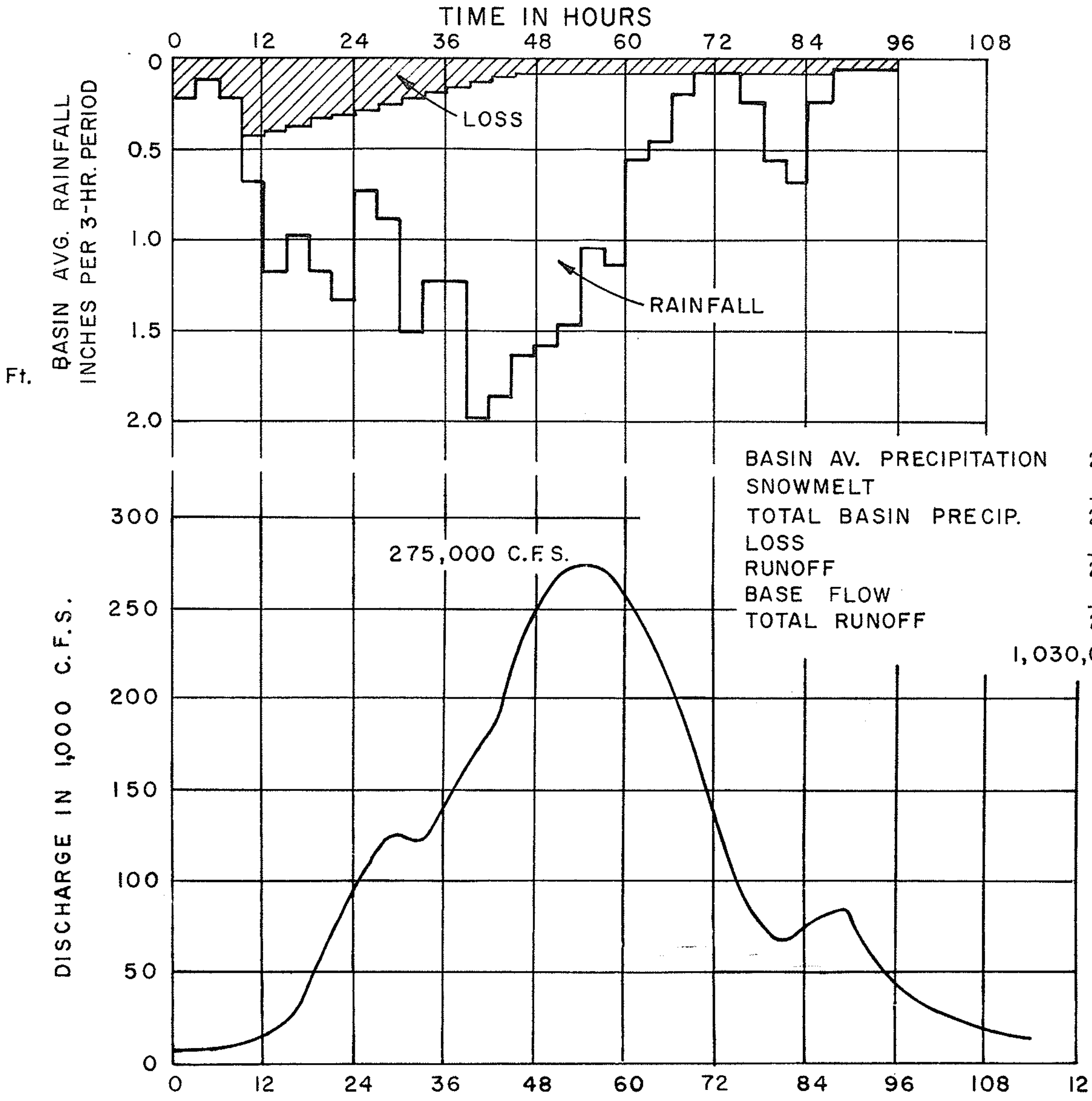


| | |
|---|---|
| BASIN AV. PRECIPITATION | 24.9" |
| SNOWMELT | 1.5" |
| TOTAL BASIN PRECIP. | 26.4" |
| LOSS | 4.5" |
| RUNOFF | 21.9" |
| BASE FLOW | 2.3" |
| TOTAL RUNOFF | 24.2" = 630,000 Ac. Ft. |

TIME IN HOURS

ENGLISH RIDGE DAMSITE

D.A. = 488 SQ.MI.

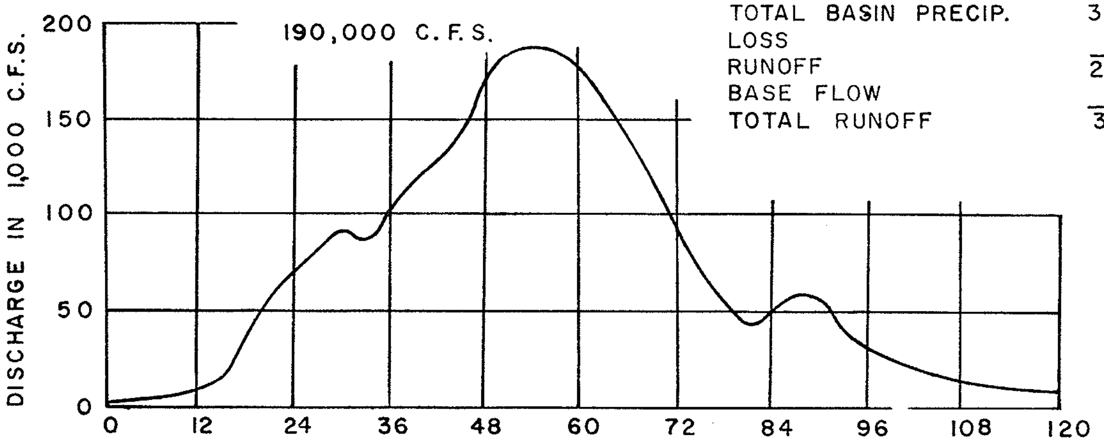


| | |
|---|---|
| BASIN AV. PRECIPITATION | 25.5" |
| SNOWMELT | 2.4" |
| TOTAL BASIN PRECIP. | 27.9" |
| LOSS | 4.5" |
| RUNOFF | 23.4" |
| BASE FLOW | 2.6" |
| TOTAL RUNOFF | 26.0" |
| | 1,030,000 Ac. Ft. |

TIME IN HOURS

DOS RIOS DAMSITE

D.A. = 745 SQ. MI.



| | |
|---|---|
| BASIN AV. PRECIPITATION | 29.7" |
| SNOWMELT | 3.4" |
| TOTAL BASIN PRECIP. | 33.1" |
| LOSS | 4.7" |
| RUNOFF | 28.4" |
| BASE FLOW | 3.3" |
| TOTAL RUNOFF | 31.7" = 720,000 Ac.Ft. |

TIME IN HOURS

SPENCER–FRANCISCAN DAMSITE

D.A. = 425 SQ.MI.

NOTE:

STORM TRANSPOSITION CENTERED ABOVE EACH INDIVIDUAL DAMSITE.

MULTIPLIER FOR OBTAINING HYDROGRAPHS WHEN STORM IS CENTERED OVER 3113 SQ. MI. AT SCOTIA:

| | |
|---|---|
| ENGLISH RIDGE DAM | .73 |
| SPENCER–FRANCISCAN DAM | .80 |
| DOS RIOS DAM | .78 |

EEL RIVER BASIN
CALIFORNIA
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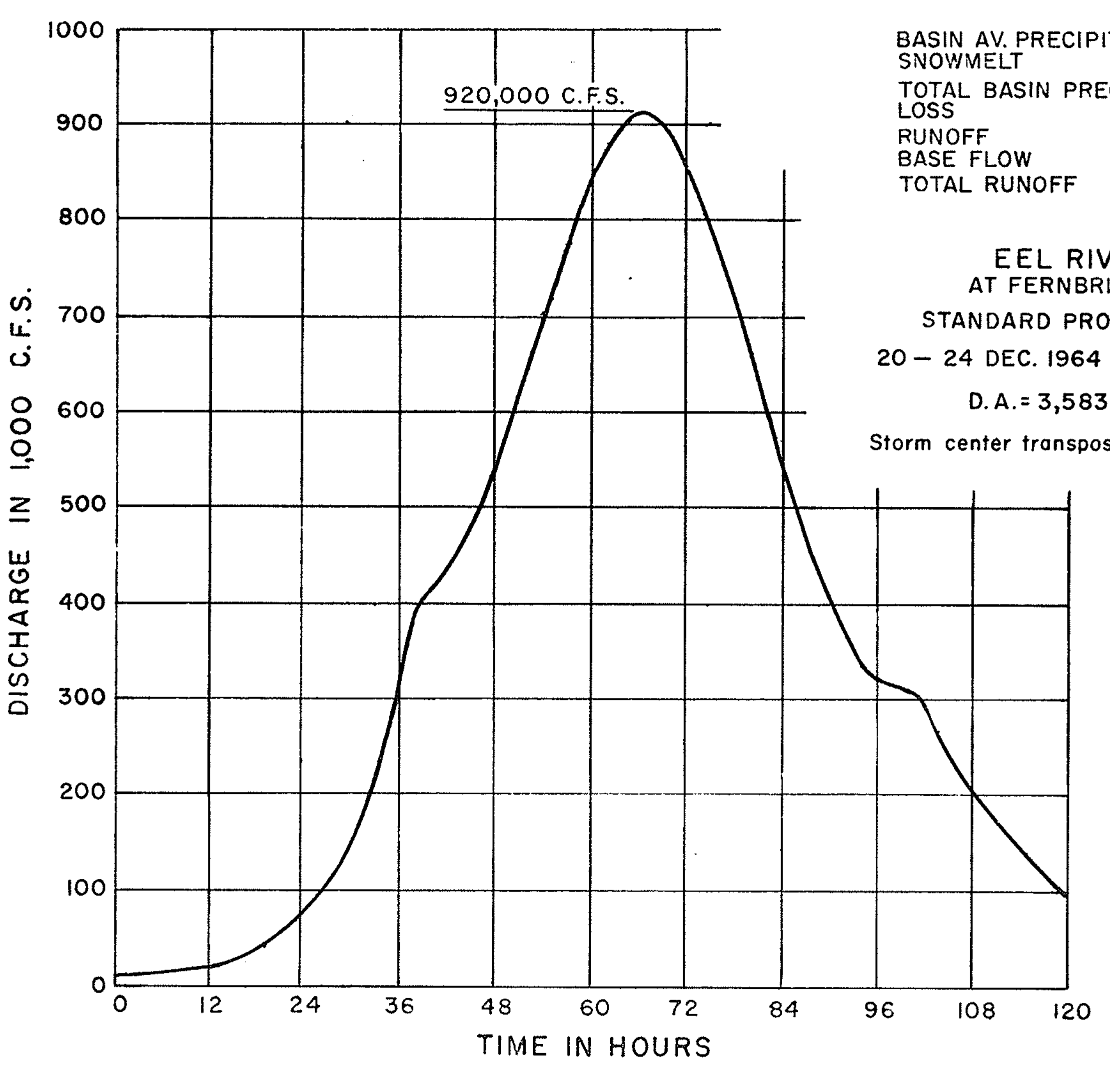
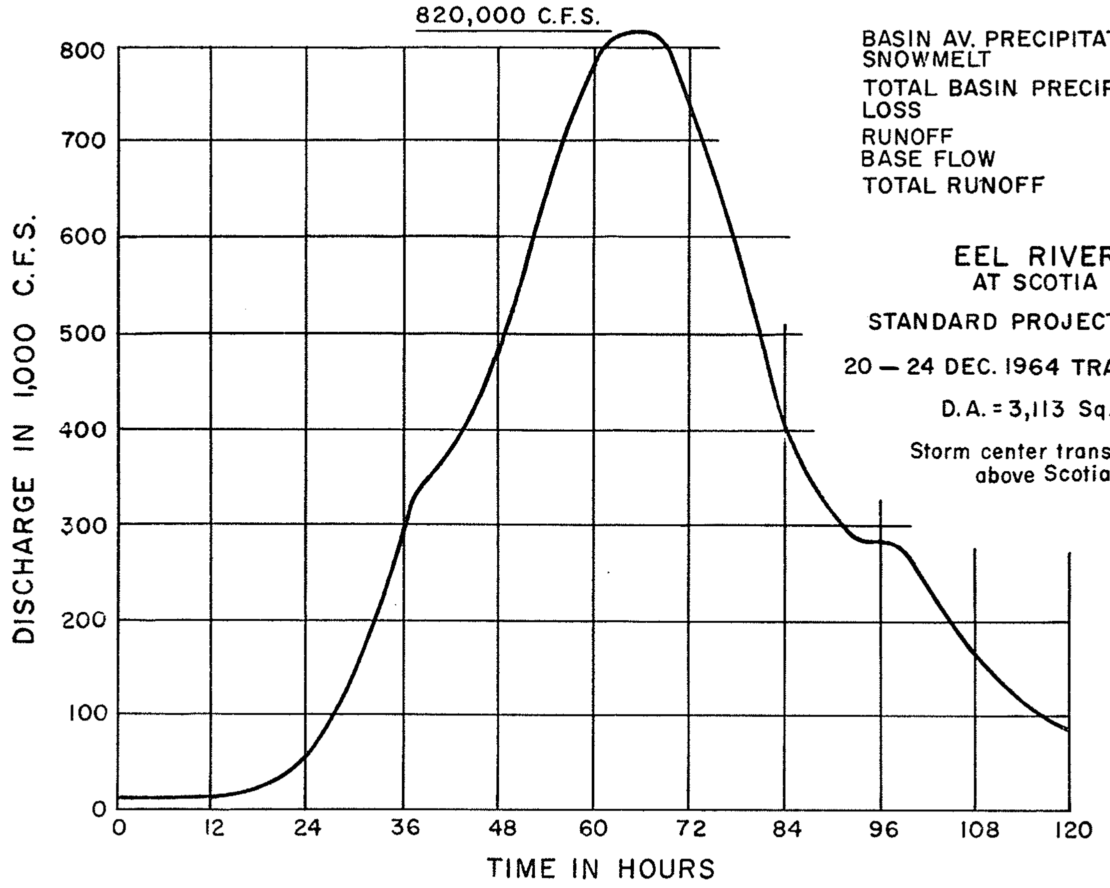
ON
WATER RESOURCES DEVELOPMENT
FOR
MIDDLE FORK EEL RIVER
STANDARD PROJECT FLOOD
HYDROGRAPHS
20-24 DEC. 1964 TRANSPOSITION
IN 17 SHEETS SHEET NO. 3
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C. OF E.
DRAWN: A B.W. FILE NO.
TRACED: A.V.S. TO ACCOMPANY REPORT 60-46-1
CHECKED: W.R.T. DATED: APRIL 1968

PLATE B-3



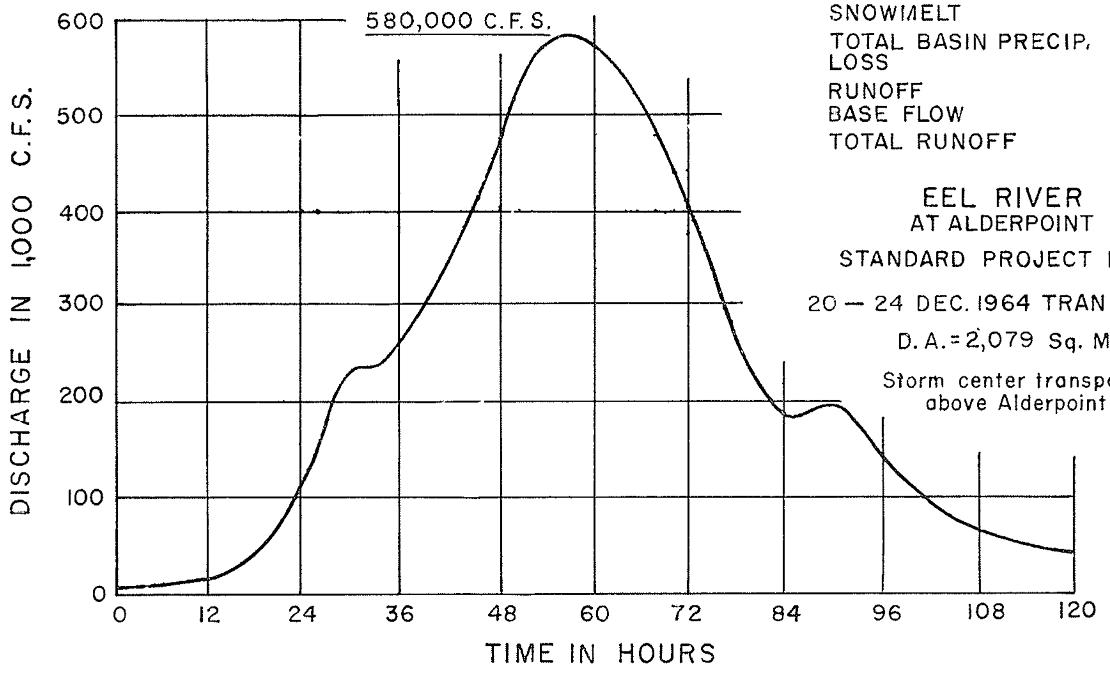
| | |
|---|---|
| BASIN AV. PRECIPITATION | 22.7" 1/ |
| SNOWMELT | 0.9" |
| TOTAL BASIN PRECIP. | 23.6" |
| LOSS | 5.1" |
| RUNOFF | 18.5" |
| BASE FLOW | 1.7" |
| TOTAL RUNOFF | 20.2" |

**EEL RIVER**
AT FERNBRIDGE
STANDARD PROJECT FLOOD
20 — 24 DEC. 1964 TRANSPOSITION
D. A. = 3,583 Sq. Mi.
Storm center transposed above Scotia



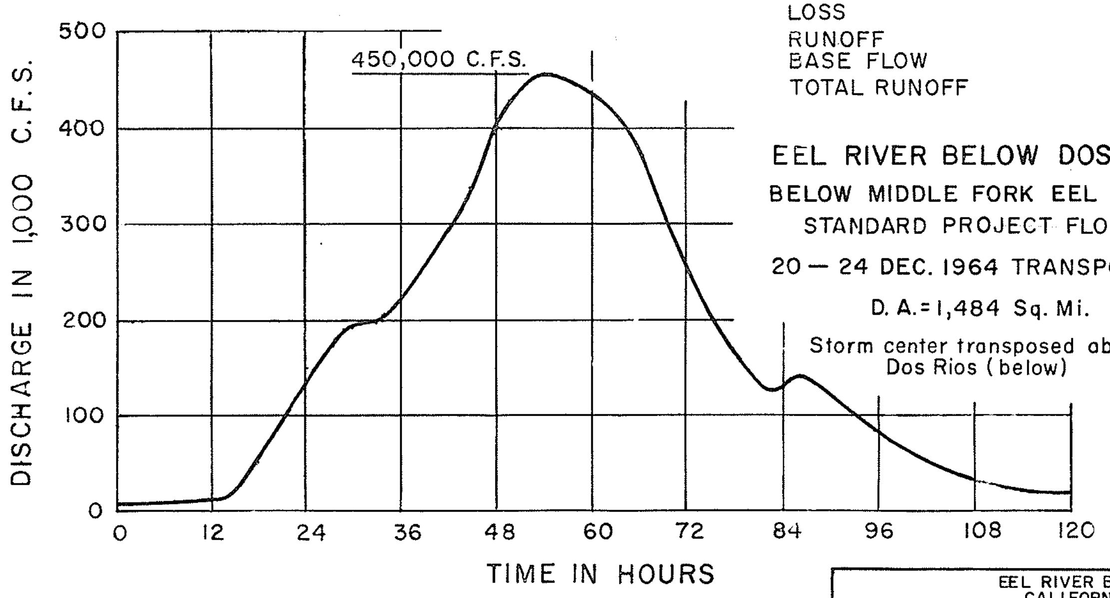
| | |
|---|---|
| BASIN AV. PRECIPITATION | 22.7" 1/ |
| SNOWMELT | 0.9" |
| TOTAL BASIN PRECIP. | 23.6" |
| LOSS | 5.1" |
| RUNOFF | 18.5" |
| BASE FLOW | 1.7" |
| TOTAL RUNOFF | 20.2" |

**EEL RIVER**
AT SCOTIA
STANDARD PROJECT FLOOD
20 — 24 DEC. 1964 TRANSPOSITION
D. A. = 3,113 Sq. Mi.
Storm center transposed
above Scotia



| | |
|---|---|
| BASIN AV. PRECIPITATION | 22.5" 1/ |
| SNOWMELT | 1.4" |
| TOTAL BASIN PRECIP. | 23.9" |
| LOSS | 5.1" |
| RUNOFF | 18.8" |
| BASE FLOW | 1.8" |
| TOTAL RUNOFF | 20.6" |

**EEL RIVER**
AT ALDERPOINT
STANDARD PROJECT FLOOD
20 — 24 DEC. 1964 TRANSPOSITION
D. A. = 2,079 Sq. Mi.
Storm center transposed
above Alderpoint



| | |
|---|---|
| BASIN AV. PRECIPITATION | 23.2" 1/ |
| SNOWMELT | 1.7" |
| TOTAL BASIN PRECIP. | 24.9" |
| LOSS | 4.8" |
| RUNOFF | 20.1" |
| BASE FLOW | 2.0" |
| TOTAL RUNOFF | 22.1" |

**EEL RIVER BELOW DOS RIOS**
BELOW MIDDLE FORK EEL RIVER
STANDARD PROJECT FLOOD
20 — 24 DEC. 1964 TRANSPOSITION
D. A. = 1,484 Sq. Mi.
Storm center transposed above
Dos Rios (below)

NOTE:
1/ SEE PLATE B-2 FOR RAINFALL DISTRIBUTION.

EEL RIVER BASIN
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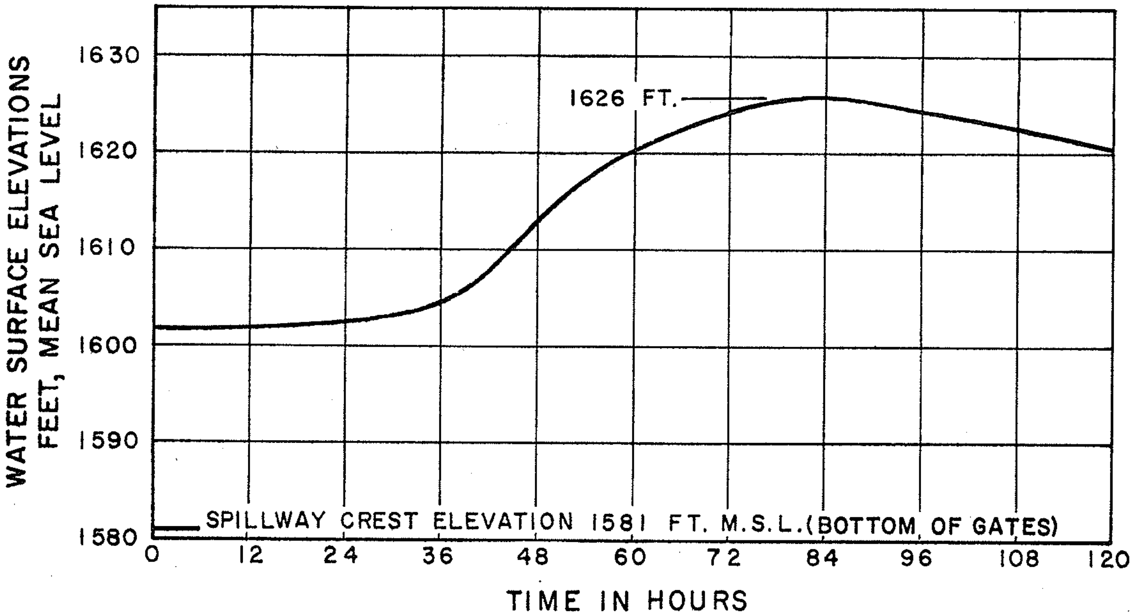
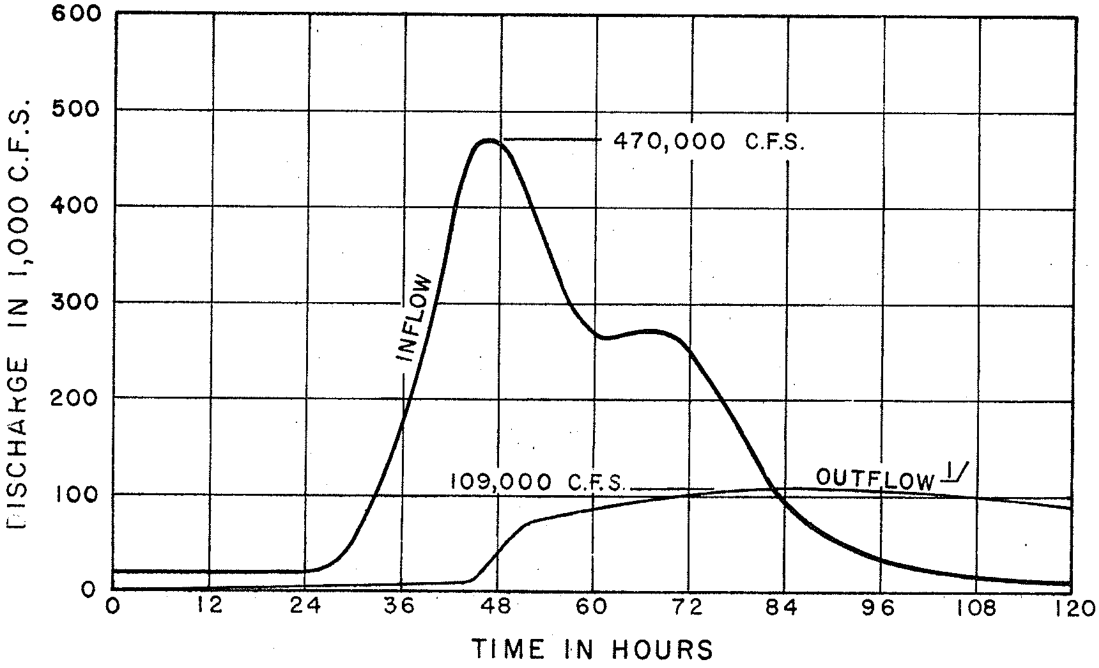
MIDDLE FORK EEL RIVER

## STANDARD PROJECT FLOOD HYDROGRAPHS

20 — 24 DEC. 1964 TRANSPOSITION
IN 17 SHEETS SHEET NO. 4
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C. OF E.
DRAWN: A.B.W FILE NO.
TRACED: A. V. S. TO ACCOMPANY REPORT 60-46-1
CHECKED: D. R. B. DATED: APRIL 1968



RESERVOIR STAGE HYDROGRAPH 1/



DISCHARGE HYDROGRAPH

DRAINAGE AREA = 745 SQ. MI.

PROBABLE MAXIMUM PRECIPITATION = 35.5" 2/
SNOWMELT = 2.1"
TOTAL MAXIMUM PRECIPITATION = 37.6"
LOSSES = 8.5"
RUNOFF = 29.1"
BASE FLOW = 3.5"
TOTAL RUNOFF = 32.6"
= 1,300,000 AC.-FT.

NOTES:

1/ SPILLWAY DISCHARGE AND RESERVOIR STAGE BASED ON THREE 30' X 44' GATES.

2/ RAINFALL DISTRIBUTION SIMILAR TO STORM OF 21-23 DECEMBER 1955.

EEL RIVER BASIN
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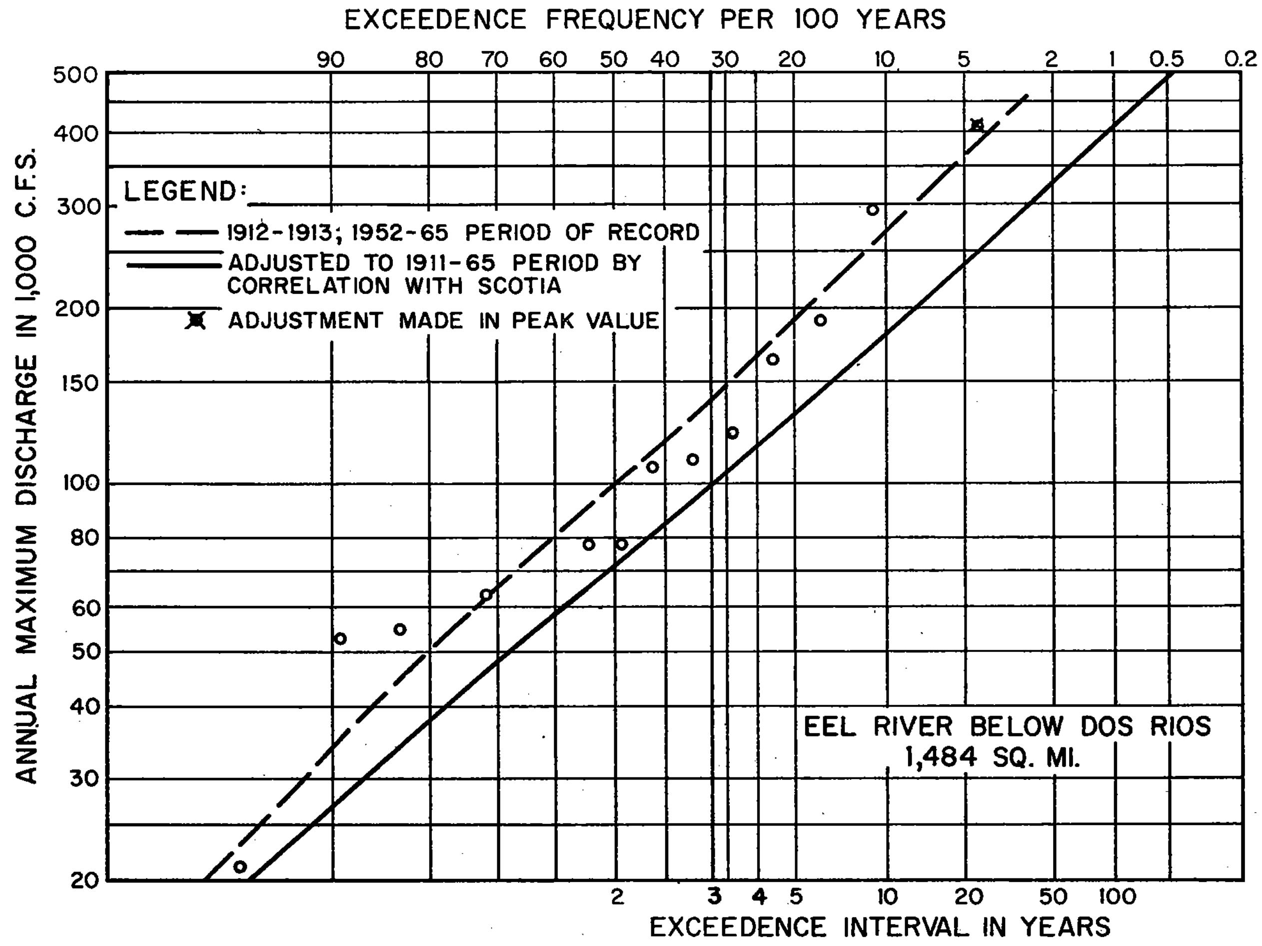
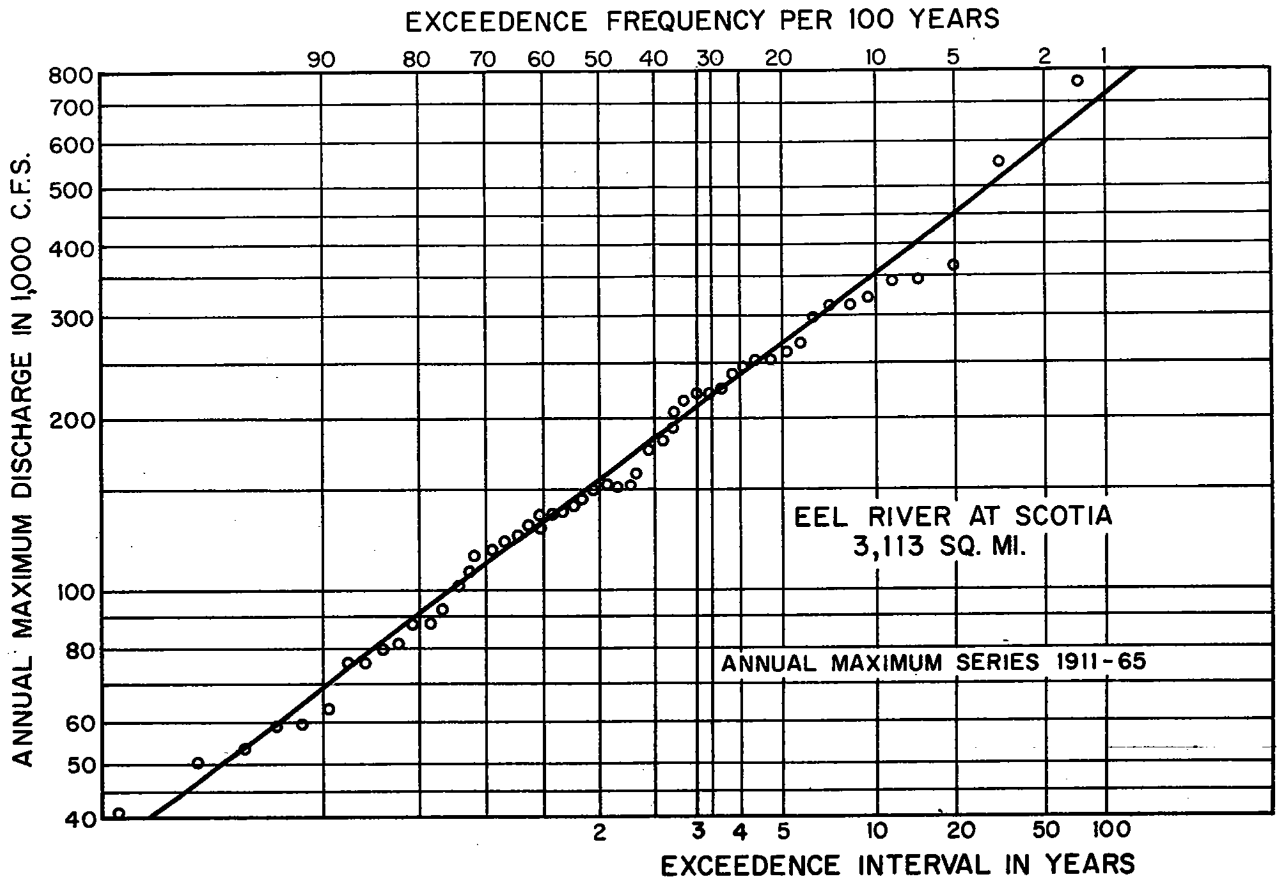
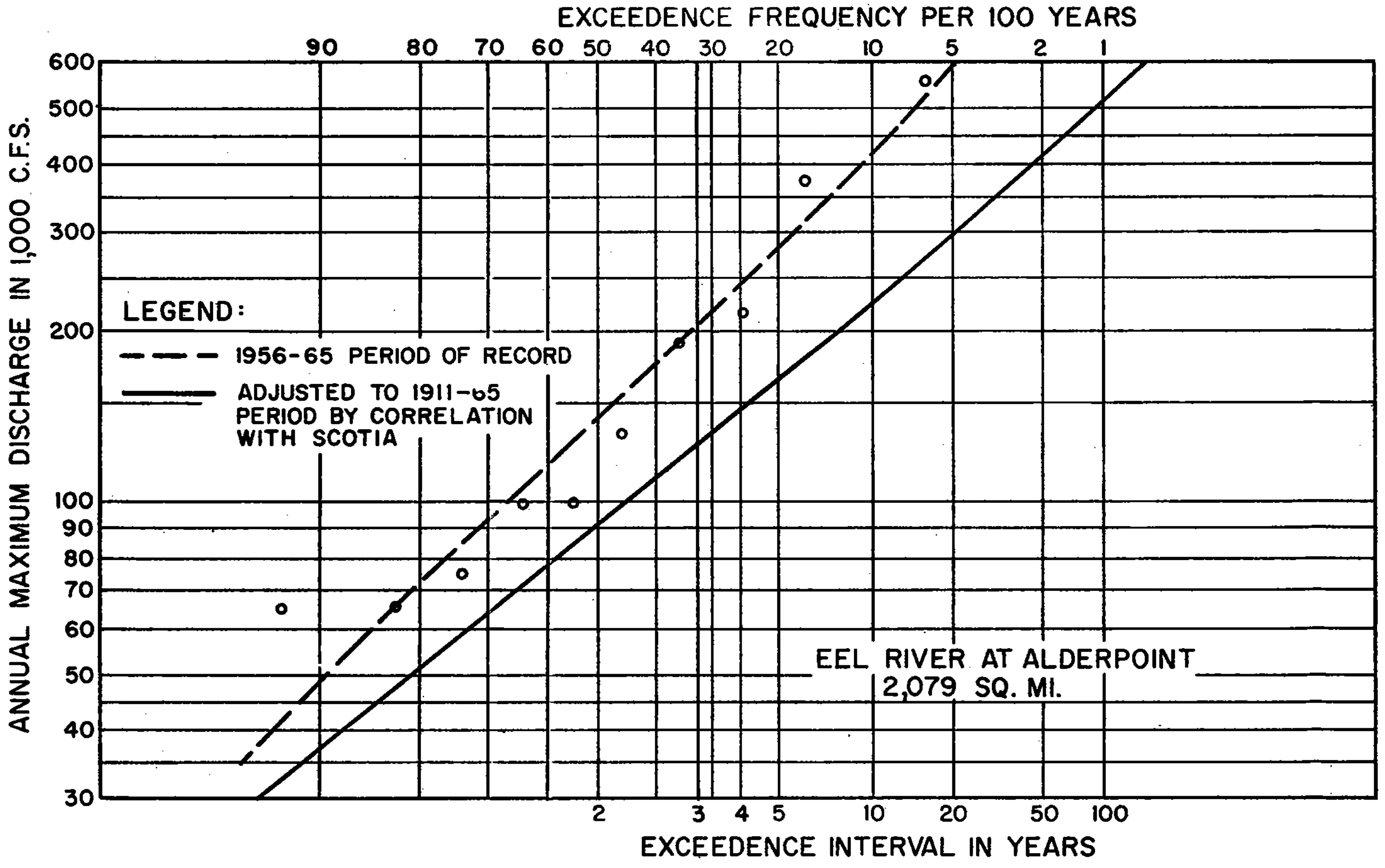
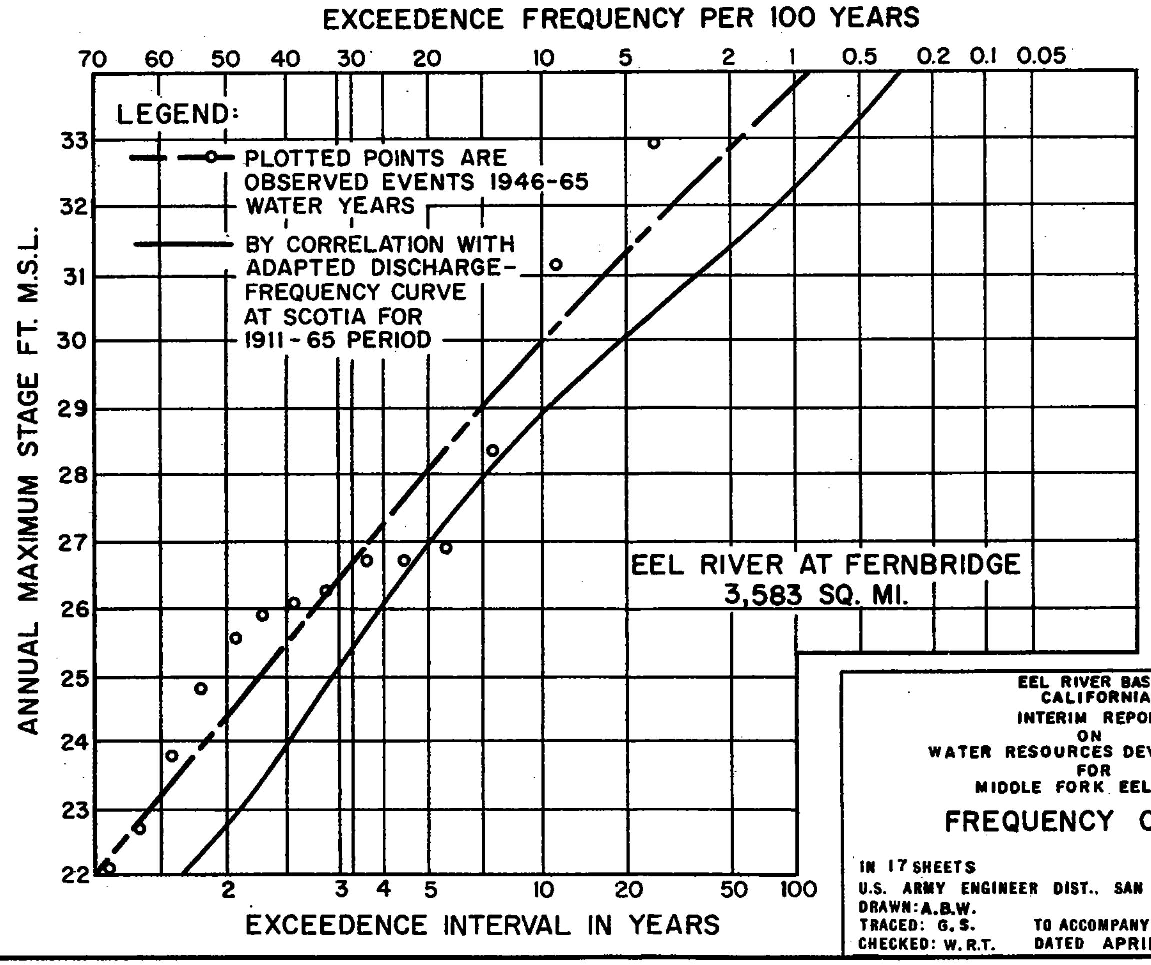
## HYDROLOGIC DATA
## SPILLWAY DESIGN FLOOD
## DOS RIOS DAM

IN 17 SHEETS SHEET NO. 5
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C. OF E.
DRAWN: W. J. B. FILE NO.
TRACED: A.L.G. TO ACCOMPANY REPORT 60-46-1
CHECKED: D. R. B. DATED: APRIL 1968









EEL RIVER BASIN
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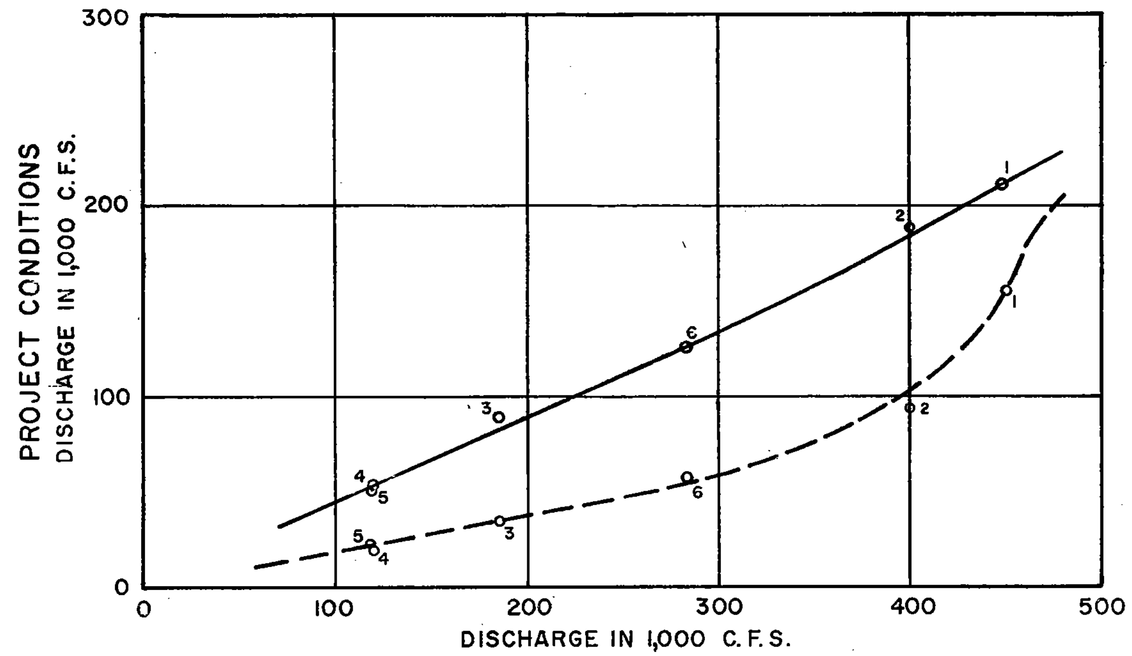
## FREQUENCY CURVES

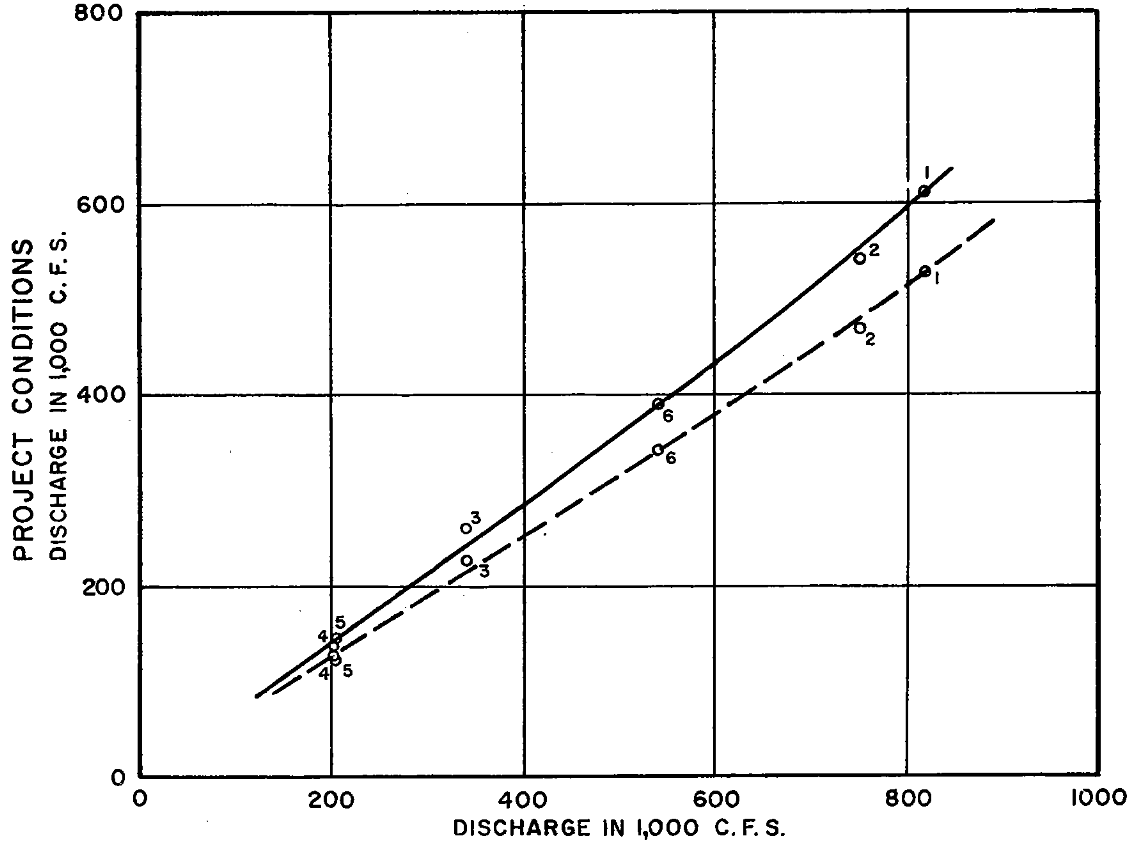
IN 17 SHEETS SHEET NO. 6
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E
DRAWN: A.B.W. FILE NO.
TRACED: G.S. TO ACCOMPANY REPORT 60-46-1
CHECKED: W.R.T. DATED APRIL 1968

PLATE B-6



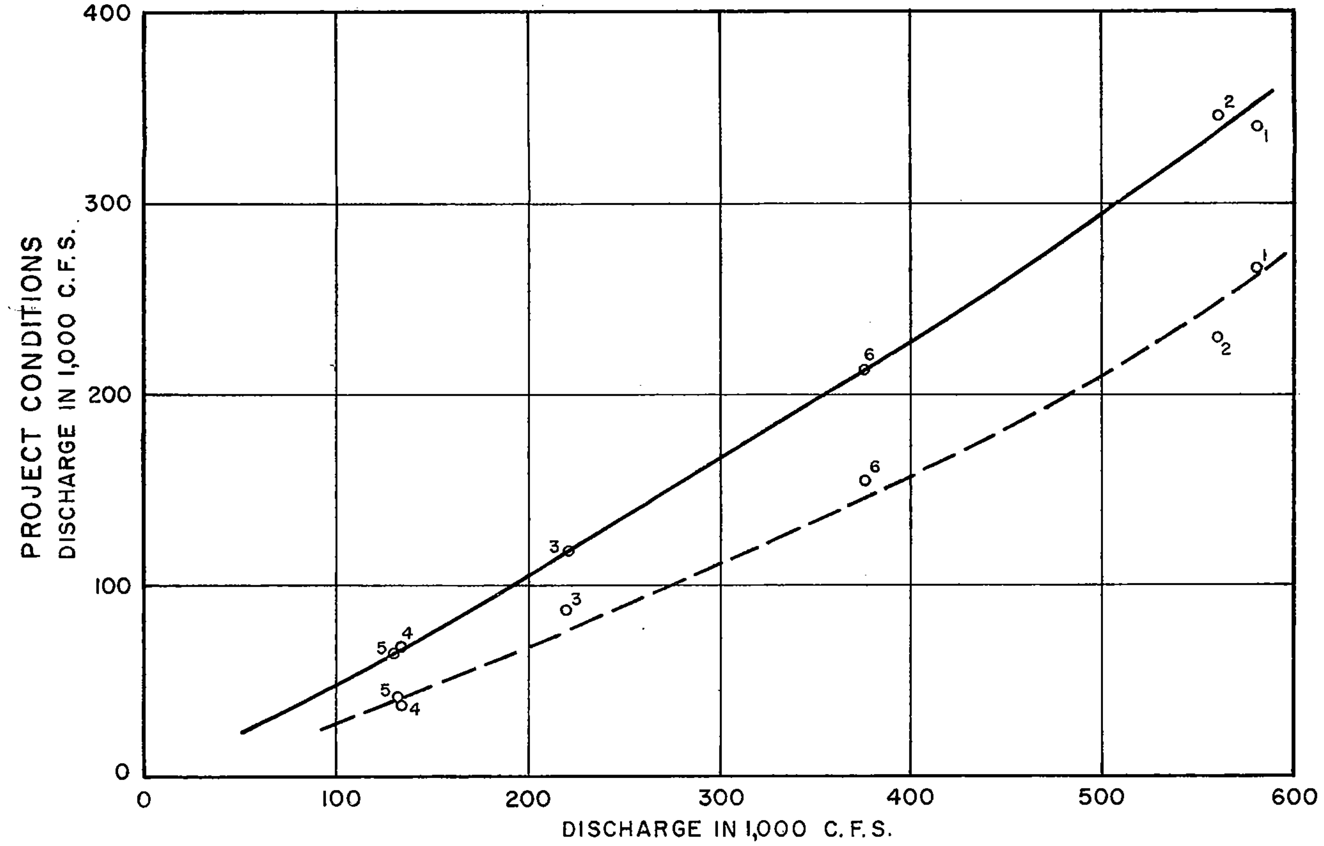
PRE-PROJECT CONDITIONS

EEL RIVER BELOW DOS RIOS



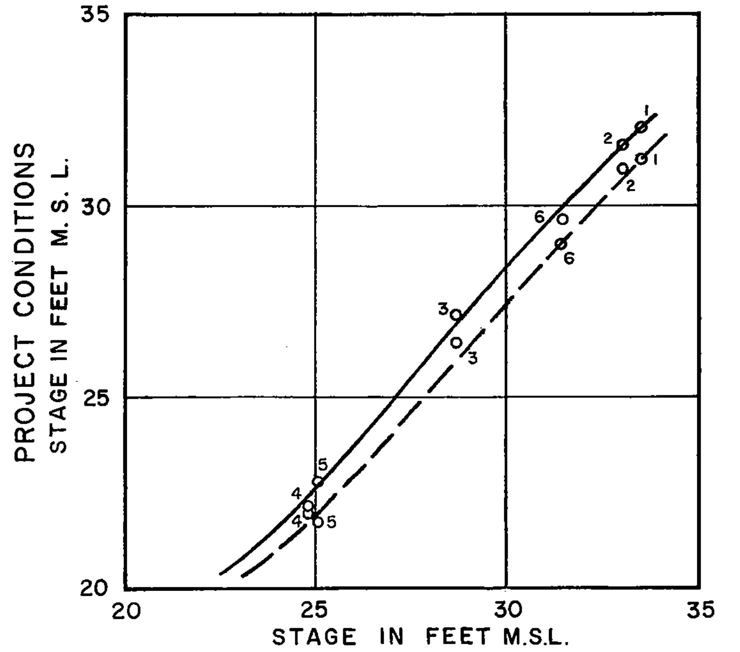
PRE-PROJECT CONDITIONS

EEL RIVER AT SCOTIA



PRE-PROJECT CONDITIONS

EEL RIVER AT ALDERPOINT



PRE-PROJECT CONDITIONS

EEL RIVER AT FERNBRIDGE

LEGEND

—— DOS RIOS PROJECT
— — DOS RIOS AND ENGLISH RIDGE PROJECTS

EVENTS

1. STANDARD PROJECT FLOOD
2. DECEMBER 1964 FLOOD
3. FEBRUARY 1960 FLOOD
4. FEBRUARY 1958 FLOOD
5. JANUARY 1956 FLOOD
6. DECEMBER 1955 FLOOD

NOTE:

CURVES ARE BASED ON THE ASSUMPTIONS GIVEN IN FOOTNOTE I, TABLE B-3 AND PRESENT LEVEES IN EEL RIVER DELTA.

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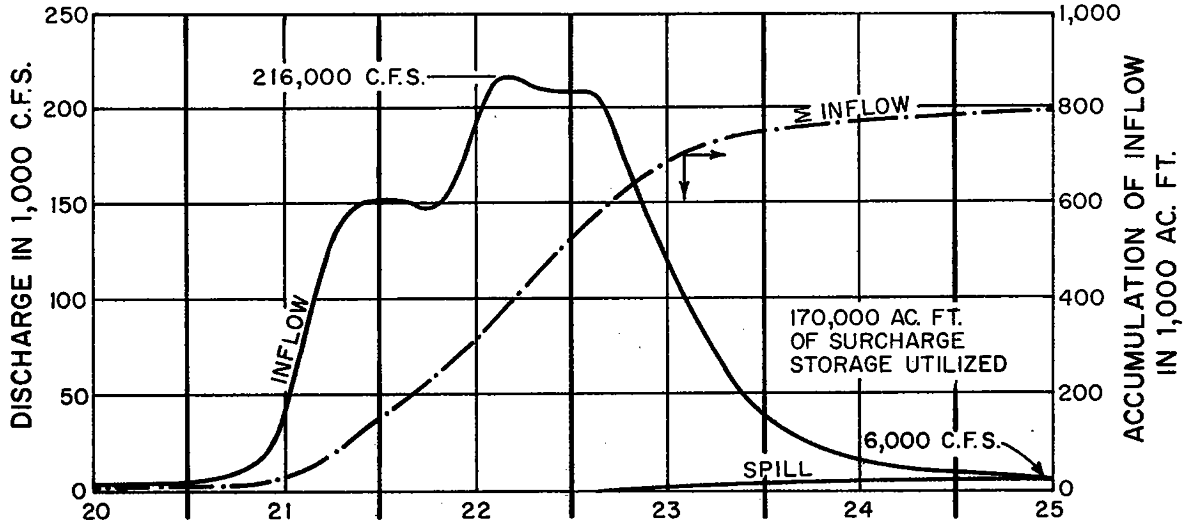
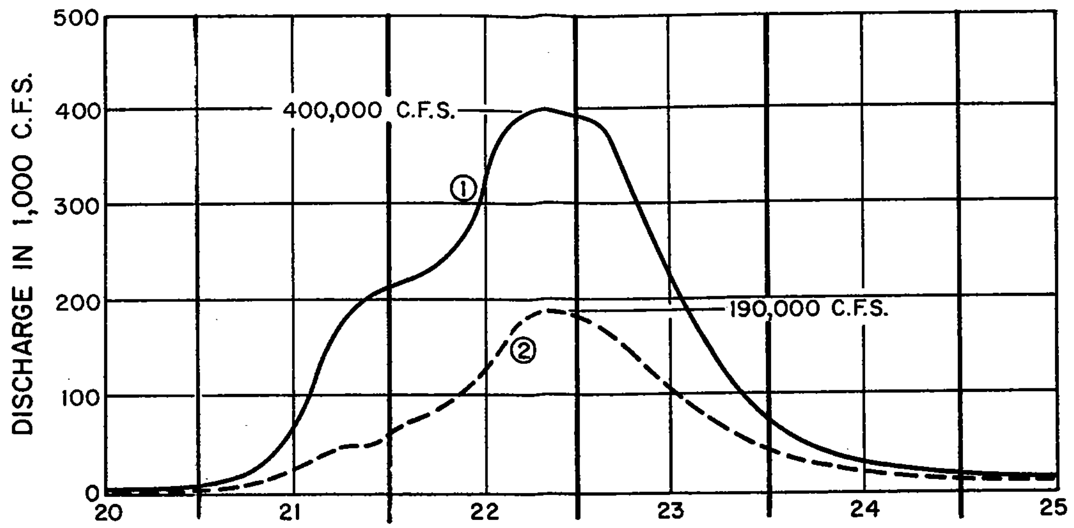
## DISCHARGE AND STAGE AVERAGE REDUCTION CURVES

IN 17 SHEETS SHEET NO. 7
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C. OF E.
DRAWN: W. J. B. FILE NO.
TRACED: D. N. TO ACCOMPANY REPORT 60-46-1
CHECKED: W. R.T. DATED: APRIL 1968

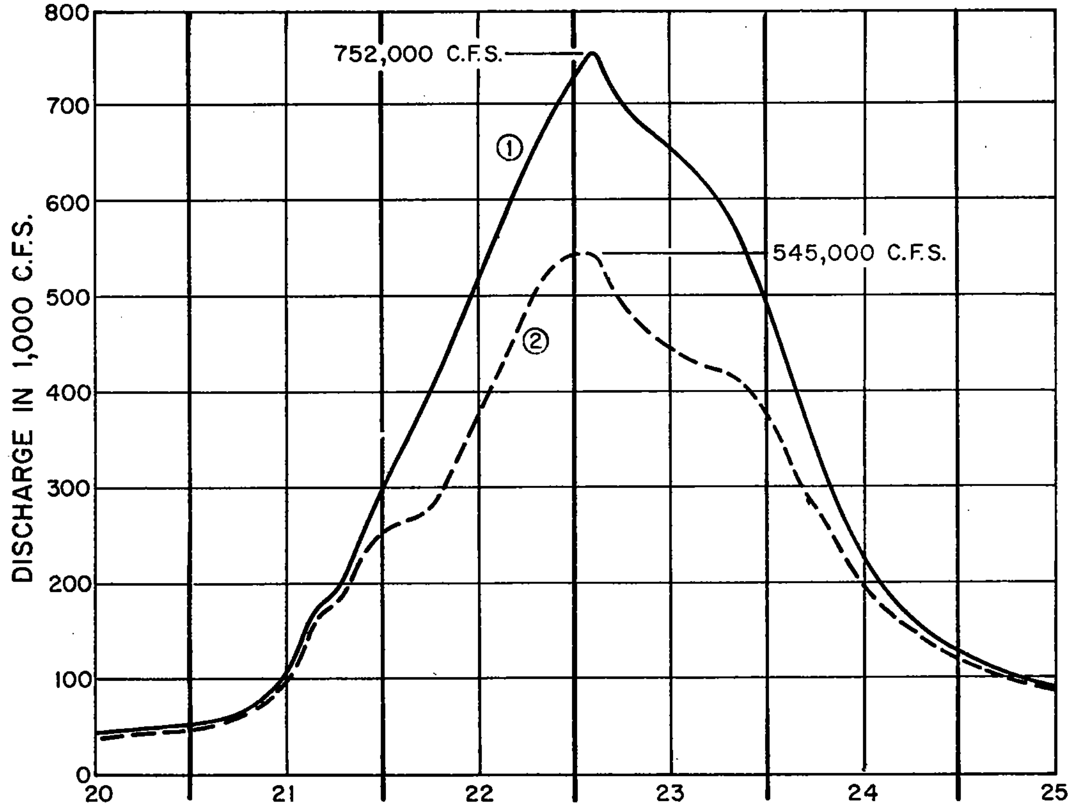
PLATE B-7



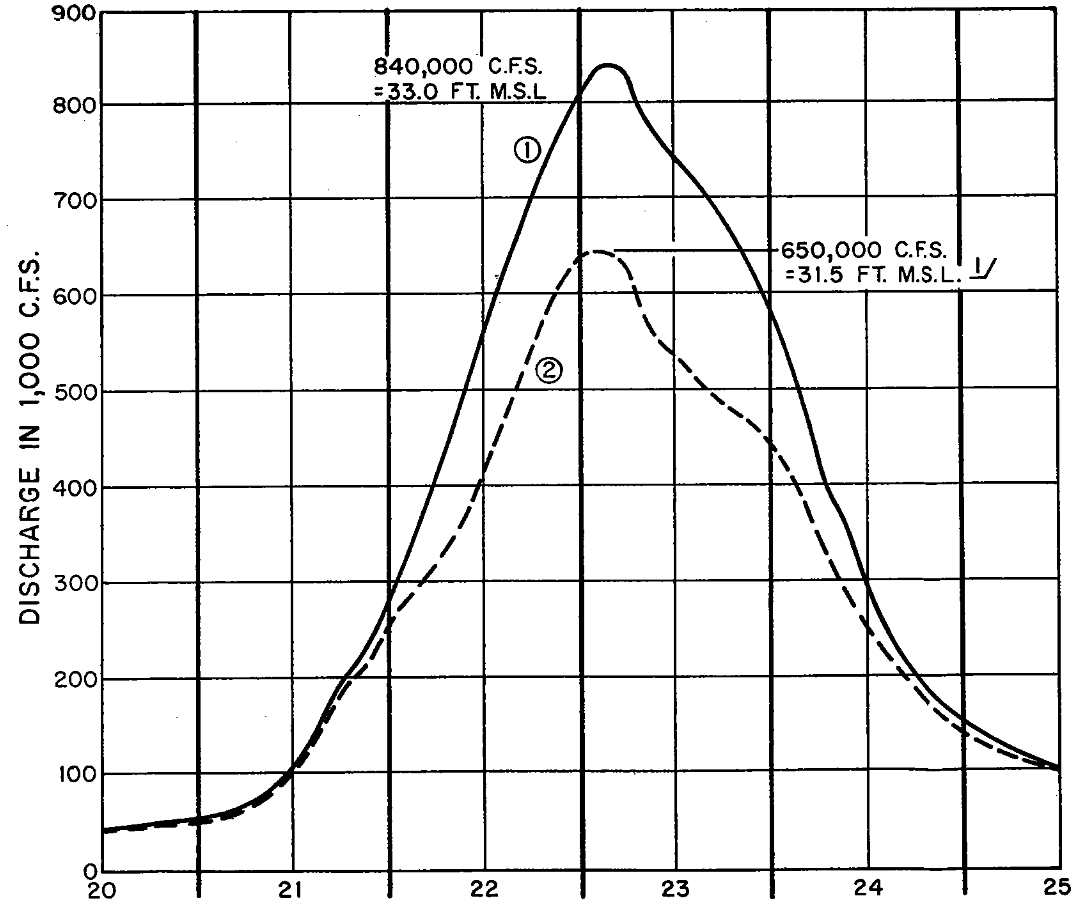
DECEMBER 1964
DOS RIOS DAMSITE (computed)
D.A. = 745 Sq. Mi



DECEMBER 1964
EEL RIVER BELOW DOS RIOS (computed)
D.A. = 1,484 Sq. Mi.



DECEMBER 1964
EEL RIVER AT SCOTIA
D.A. = 3,113 Sq. Mi.



DECEMBER 1964
EEL RIVER AT FERNBRIDGE
D.A = 3,583 Sq. Mi.

**LEGEND**

① NATURAL HYDROGRAPH

② HYDROGRAPH WITH REGULATION BY DOS RIOS DAM WITH 600,000 ACRE FEET FLOOD CONTROL STORAGE

NOTE:

1/ ASSUMING PRESENT CONDITIONS OF LEVEES IN EEL RIVER DELTA.

EEL RIVER BASIN
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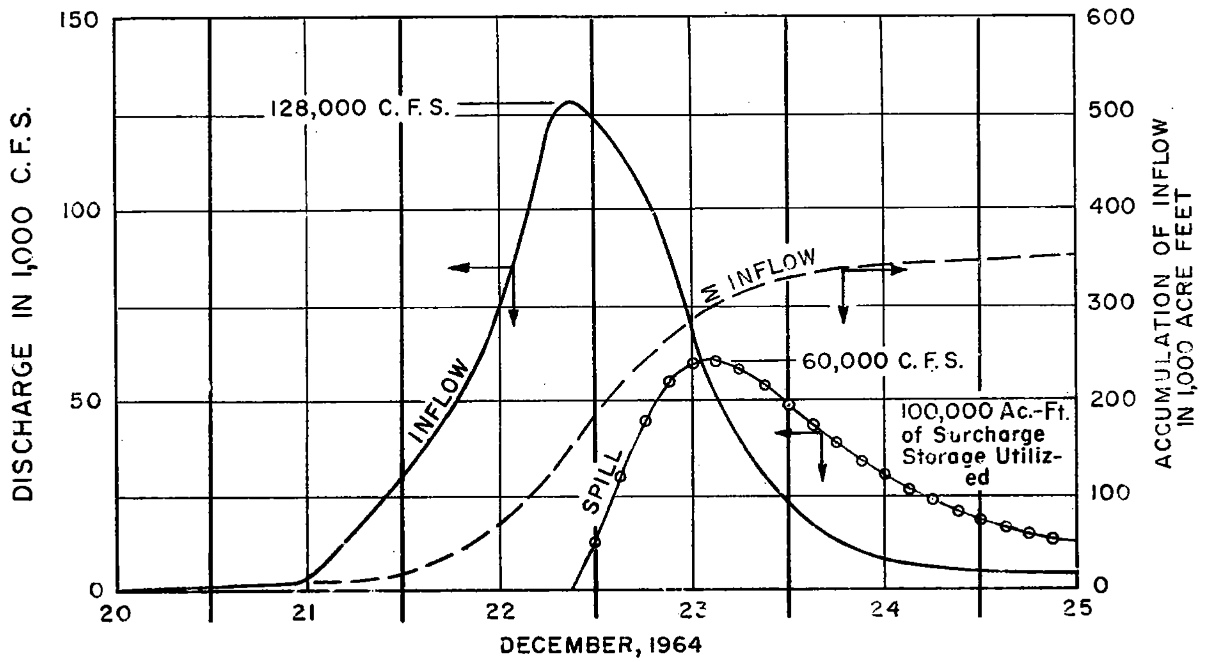
## DISCHARGE HYDROGRAPHS
20 - 25 DECEMBER 1964
DOS RIOS DAM OPERATION

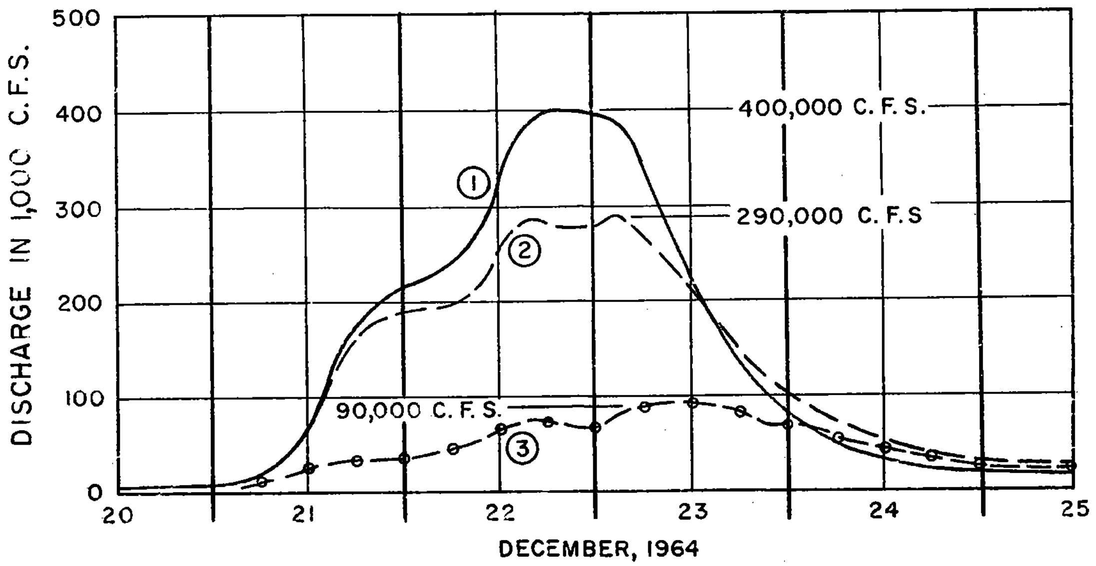
IN 17 SHEETS SHEET NO. 8
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C. OF E.
DRAWN: W. J. B. FILE NO.
TRACED: A. L. G. TO ACCOMPANY REPORT 60-46-1
CHECKED: M. H. B. DATED: APRIL 1968

PLATE B - 8



ENGLISH RIDGE DAMSITE

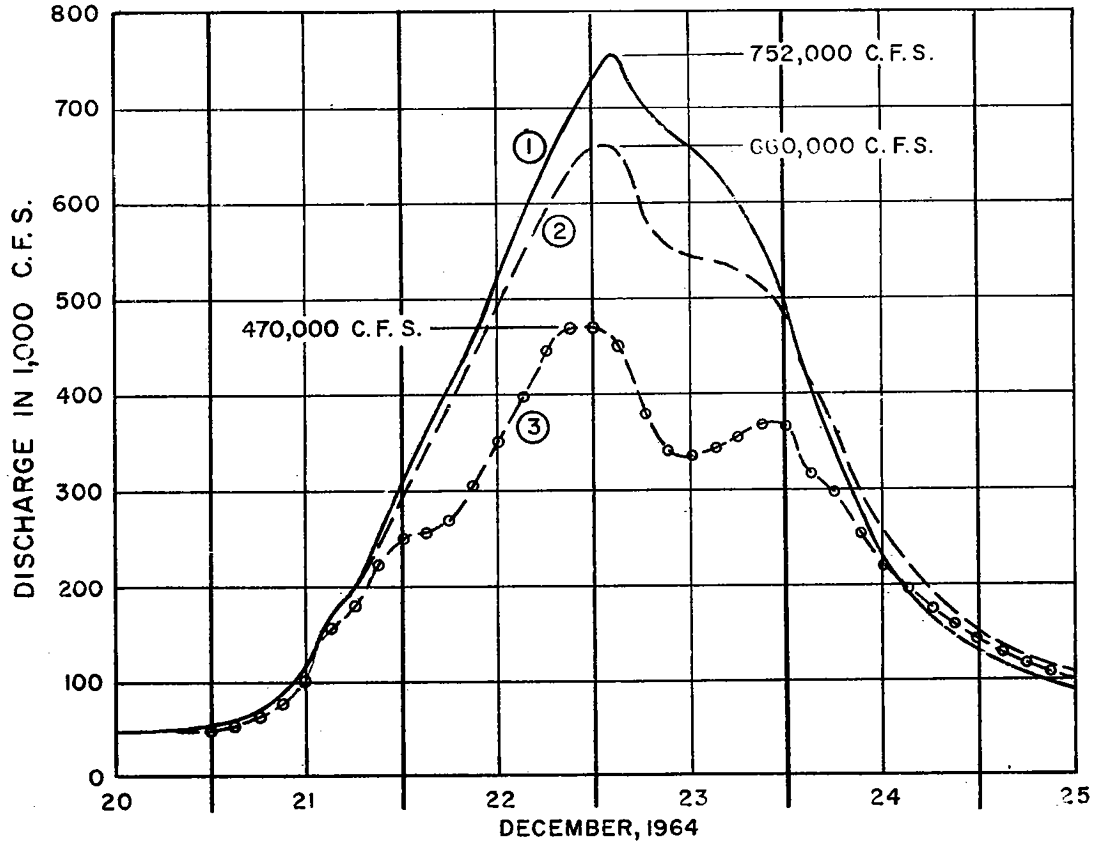
D.A. = 488 SQ. MI.



EEL RIVER BELOW DOS RIOS

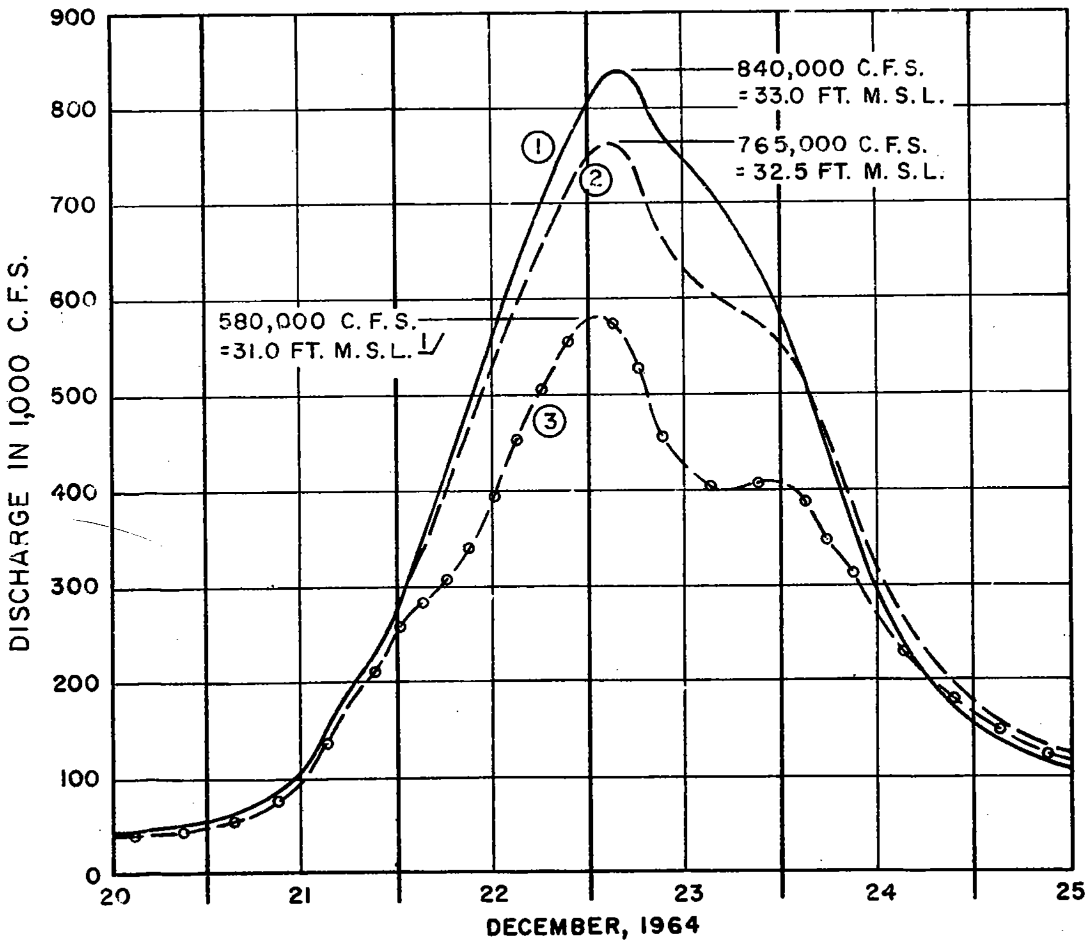
(Below confluence with Middle Fork Eel River)

D.A. = 1,484 SQ. MI.



EEL RIVER AT SCOTIA

D.A. = 3,113 SQ. MI.



EEL RIVER AT FERNBRIDGE

(Below confluence with Van Duzen River)

D.A. = 3,583 SQ. MI.

LEGEND

① NATURAL HYDROGRAPH.

② HYDROGRAPH WITH REGULATION BY ENGLISH RIDGE DAM WITH 140,000 Ac.-Ft. FLOOD CONTROL STORAGE.

③ HYDROGRAPH WITH REGULATION BY ENGLISH RIDGE DAM WITH 140,000 Ac.-Ft. FLOOD CONTROL STORAGE AND WITH DOS RIOS DAM WITH 600,000 Ac.-Ft. FLOOD CONTROL STORAGE.

NOTE:

1/ ASSUMING PRESENT CONDITIONS OF LEVEES IN EEL RIVER DELTA.

EEL RIVER BASIN
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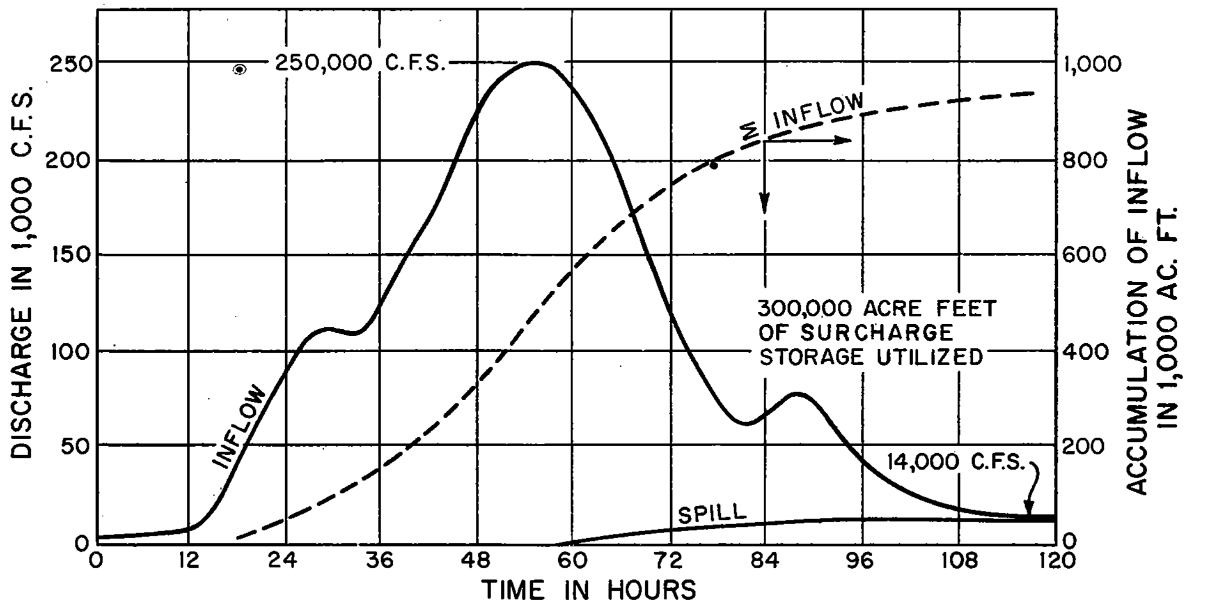
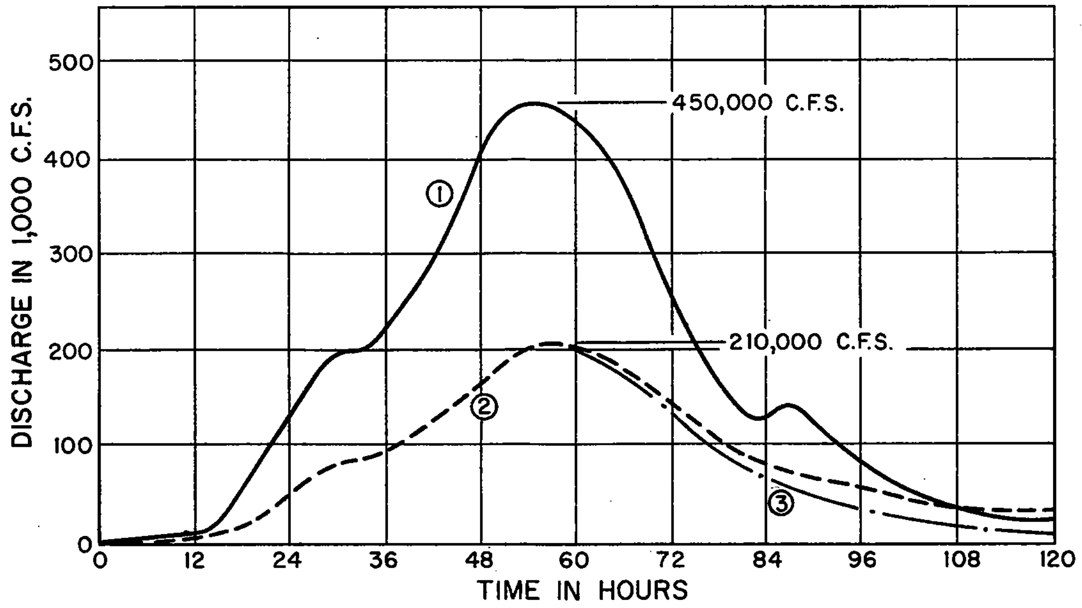
FOR
MIDDLE FORK EEL RIVER
DISCHARGE HYDROGRAPHS
20-25 DEC. 1964 FLOOD
ENGLISH RIDGE DAM OPERATION
IN 17 SHEETS SHEET NO. 9
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C. OF E.
DRAWN: W.J.B. FILE NO.
TRACED: J.J. TO ACCOMPANY REPORT 60-46-1
CHECKED: D.R.B. DATED: APRIL 1968

PLATE B-9

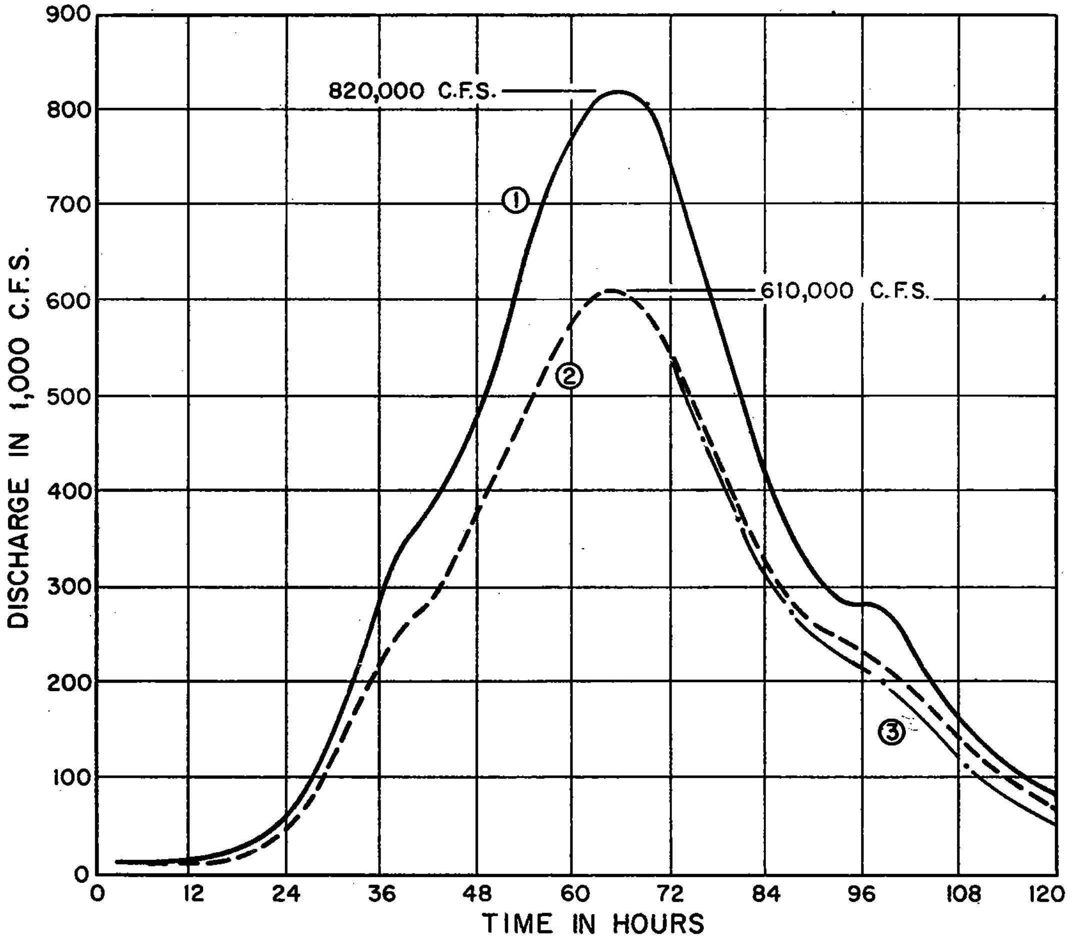


DOS RIOS DAMSITE
D.A. = 745 Sq. Mi.

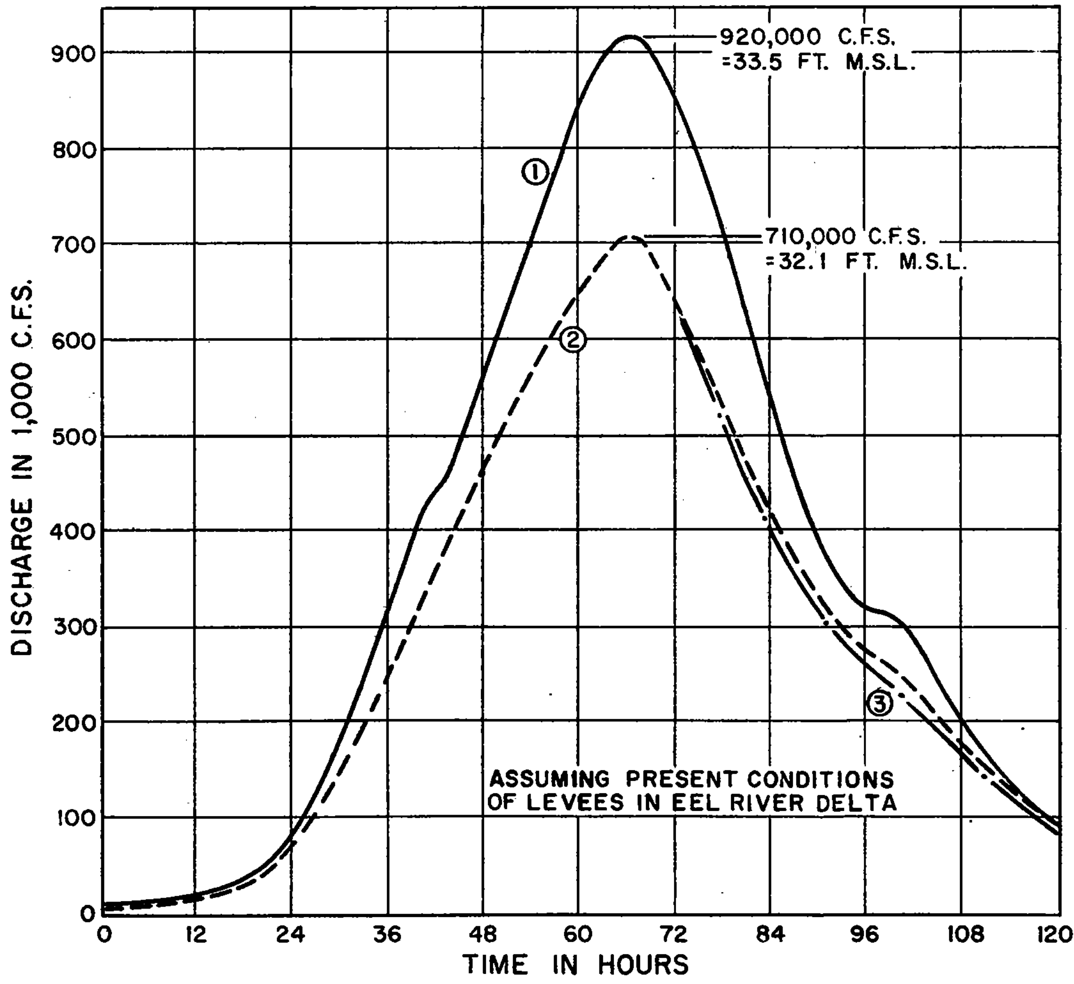
NOTES: THESE HYDROGRAPHS ILLUSTRATE THE REDUCTION IN DISCHARGES ON THE EEL RIVER, DOWNSTREAM OF DOS RIOS DAM.
HYDROGRAPHS WERE DERIVED BY UNIT HYDROGRAPHS AND TRANSPOSITION OF 21-24 DEC. 1964 STORM CENTERED OVER A 3,100 SQ. MI. AREA.



EEL RIVER BELOW DOS RIOS
(Below confluence with Middle Fork Eel River)
D.A. = 1,484 Sq. Mi.



EEL RIVER AT SCOTIA
D.A. = 3,113 Sq. Mi.



EEL RIVER AT FERNBRIDGE
(Below confluence with Van Duzen River)
D.A. = 3,583 Sq. Mi.

LEGEND

① NATURAL HYDROGRAPH

② HYDROGRAPH WITH REGULATION BY DOS RIOS DAM WITH 600,000 ACRE FEET FLOOD CONTROL STORAGE

③ MAXIMUM REDUCTION OBTAINABLE BY COMPLETE RESERVOIR CONTROL.

EEL RIVER BASIN
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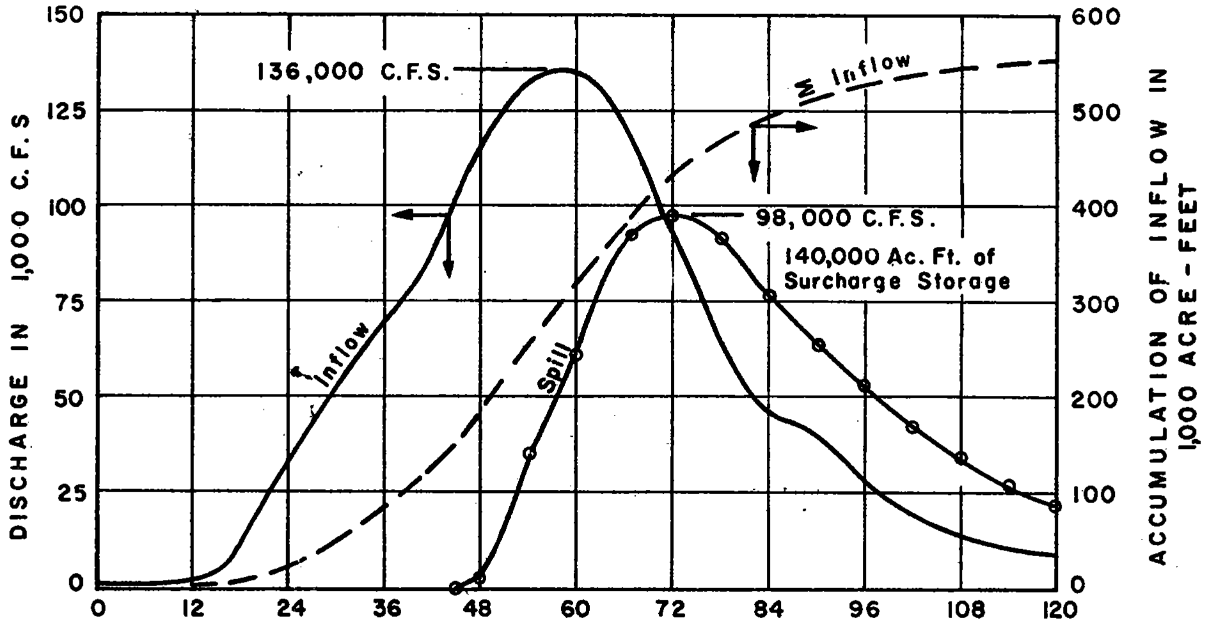
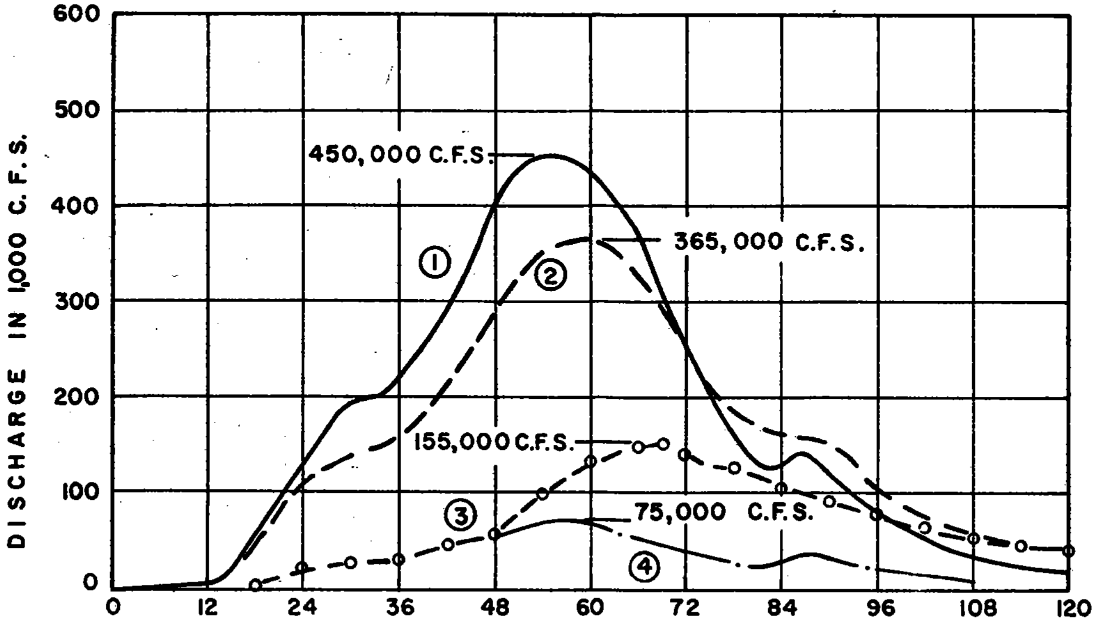
FOR
MIDDLE FORK EEL RIVER
**DISCHARGE HYDROGRAPHS**
**STANDARD PROJECT FLOOD**
**DOS RIOS DAM OPERATION**
IN 17 SHEETS SHEET NO. 10
U.S. ARMY ENGINEER DIST. SAN FRANCISCO, C. OF E.
DRAWN: W. J. B. FILE NO.
TRACED: R. K. TO ACCOMPANY REPORT
CHECKED: M. H. B. DATED: APRIL 1968 60-46-1

PLATE B-10

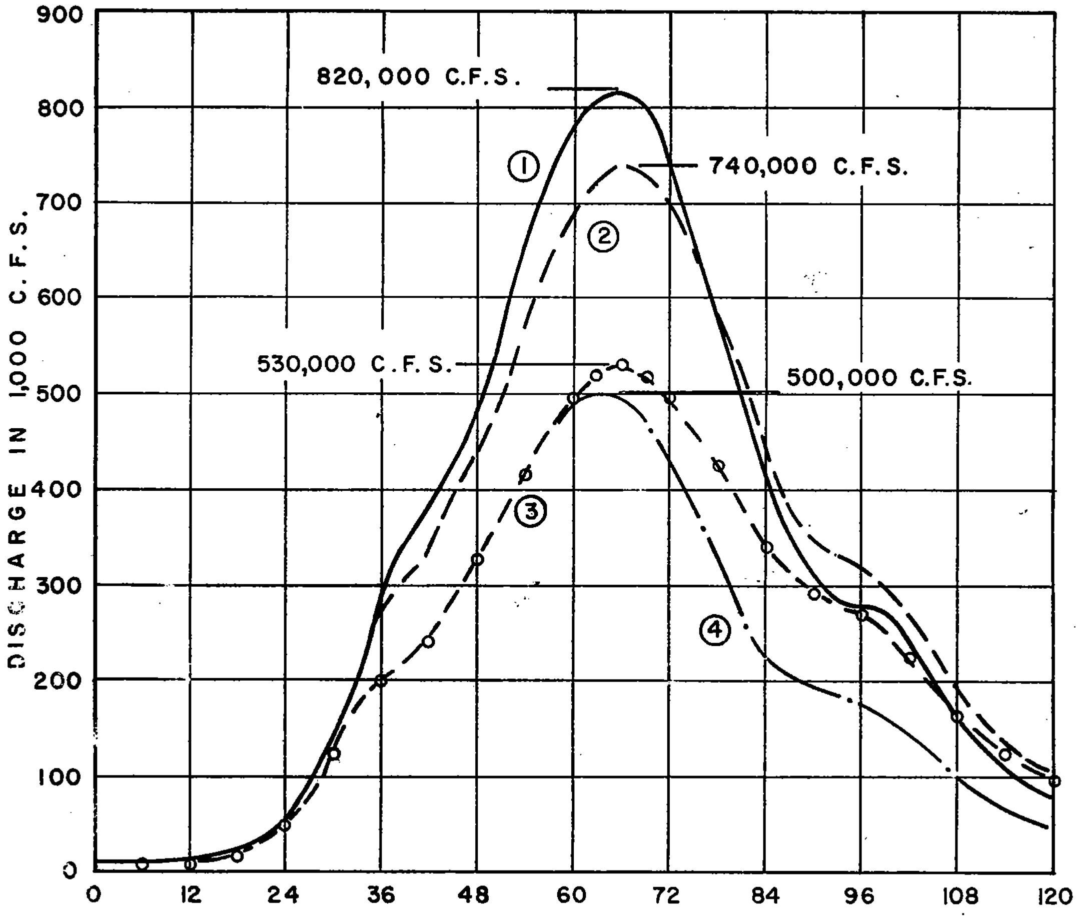
NOTES: HYDROGRAPHS WERE DERIVED BY UNIT HYDROGRAPHS AND TRANSPOSITION OF 21-24 DEC. 1964 STORM CENTERED OVER A 3,100 SQ. MI. AREA.
THESE HYDROGRAPHS ILLUSTRATE THE REDUCTION IN DISCHARGES ON THE EEL RIVER, DOWNSTREAM OF ENGLISH RIDGE AND DOS RIOS DAMS.



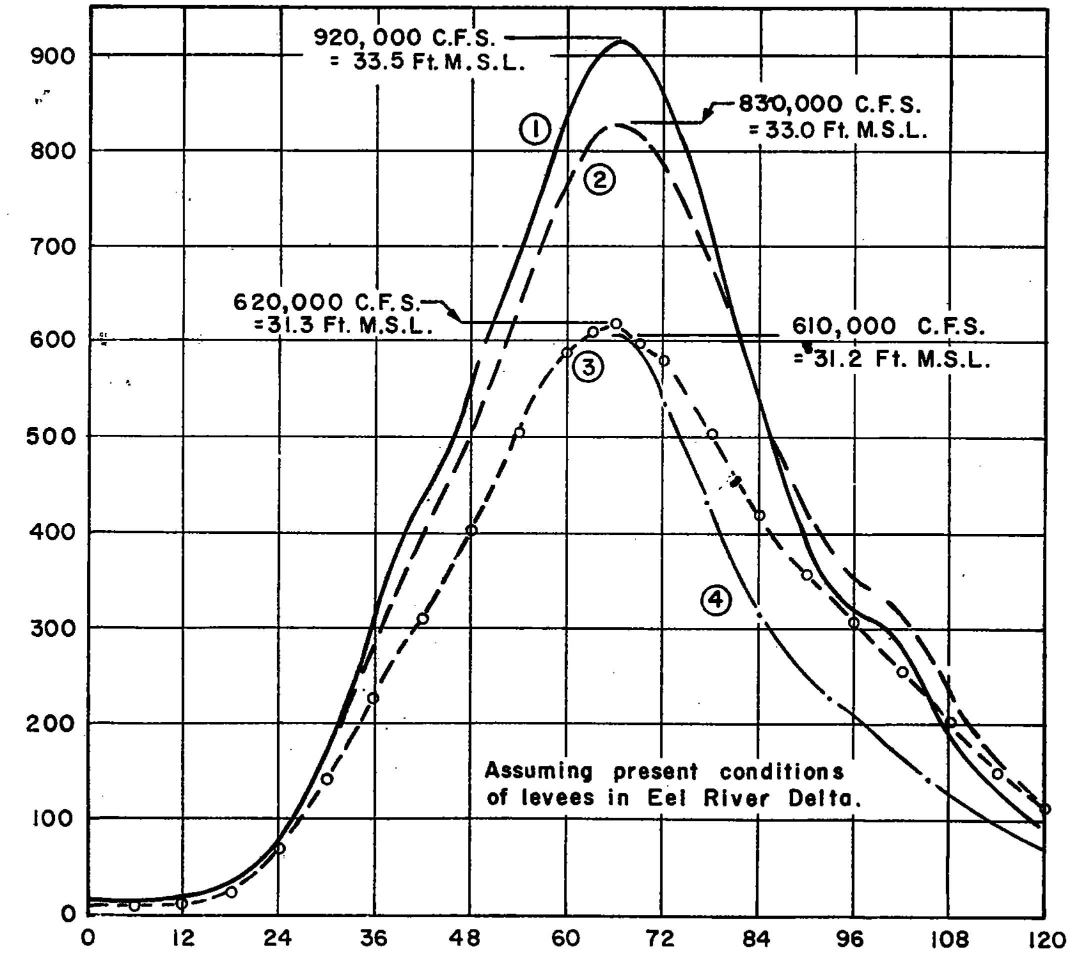
TIME IN HOURS
ENGLISH RIDGE DAMSITE
D.A. = 488 SQ. MI.



TIME IN HOURS
EEL RIVER BELOW DOS RIOS
(Below confluence with Middle Fork Eel River)
D.A. = 1,484 SQ. MI.



TIME IN HOURS
EEL RIVER AT SCOTIA
D.A. = 3,113 SQ. MI.



TIME IN HOURS
EEL RIVER AT FERNBRIDGE
(Below confluence with Van Duzen River)
D.A. = 3,583 SQ. MI.

LEGEND:

① Natural Hydrograph

② Hydrograph with Regulation By English Ridge Dam with 140,000 Ac. Ft. Flood Control Storage

③ Hydrograph with Regulation By English Ridge Dam with 140,000 Ac. Ft. Flood Control Storage And Dos Rios Dam with 600,000 Ac. Ft. Flood Control Storage

④ Maximum reduction obtainable by complete control at both reservoirs.

EEL RIVER BASIN
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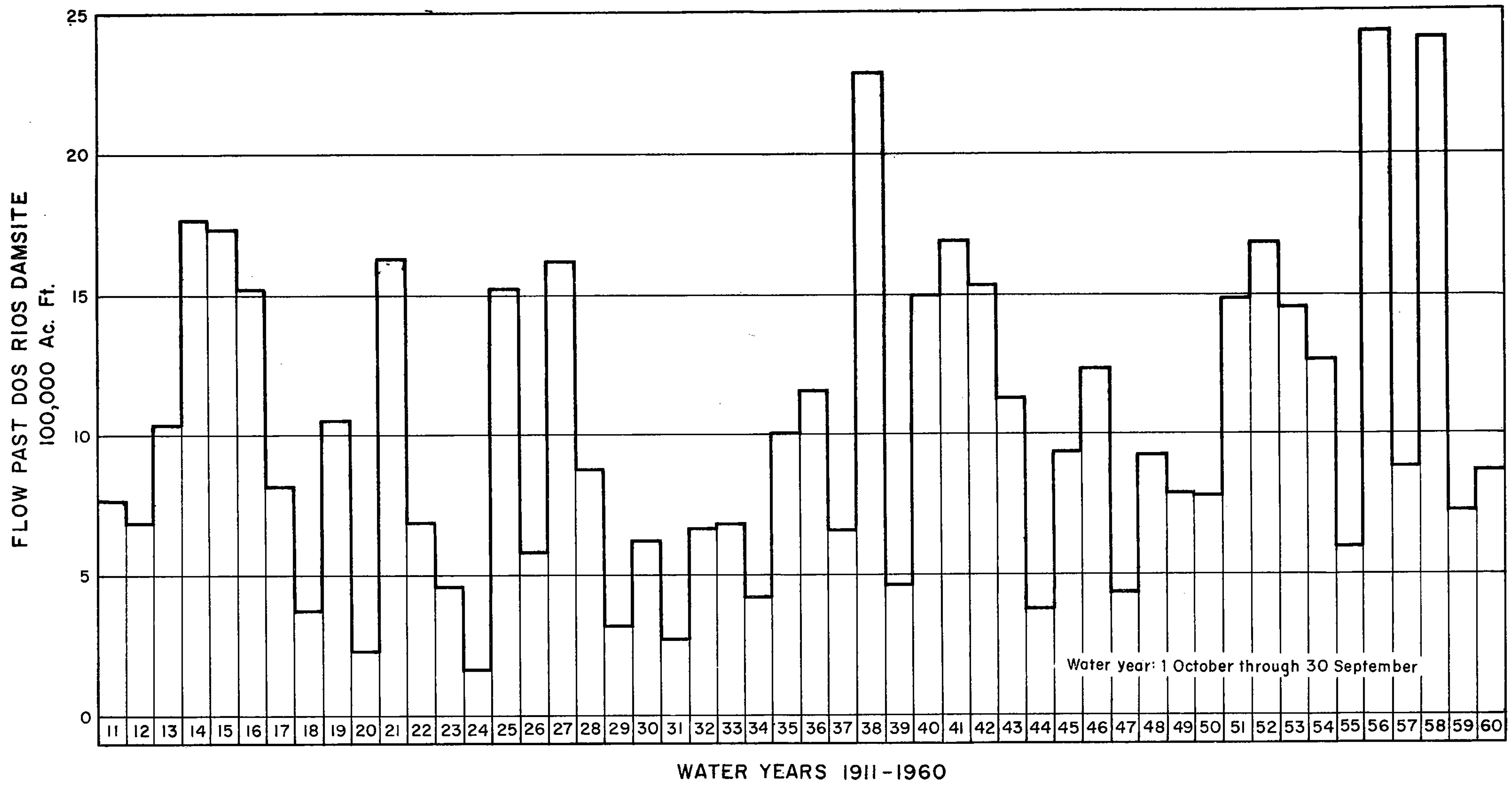
FOR
MIDDLE FORK EEL RIVER
DISCHARGE HYDROGRAPHS
STANDARD PROJECT FLOOD
ENGLISH RIDGE DAM OPERATION
IN 17 SHEETS SHEET NO. 11
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C. OF E.
DRAWN: W. J. B. FILE NO.
TRACED: J. J. TO ACCOMPANY REPORT 60-46-1
CHECKED: D. R. B. DATED: APRIL 1968

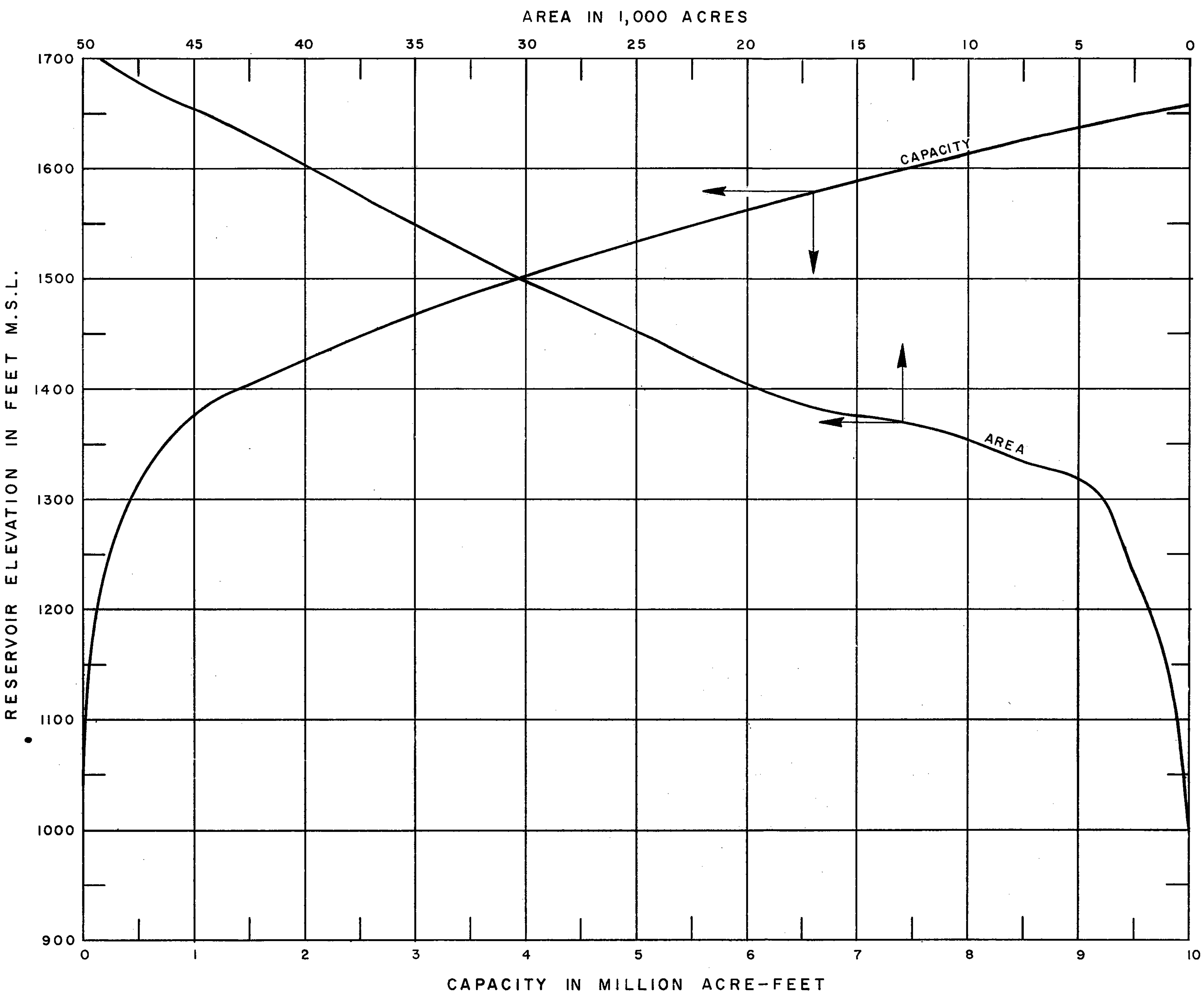


EEL RIVER BASIN
CALIFORNIA
INTERIM REPORT
ON
WATER RESOURCES DEVELOPMENT
FOR
MIDDLE FORK EEL RIVER

## FLOW PAST DOS RIOS DAMSITE

IN 17 SHEETS SHEET NO. 12
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C. OF E.
DRAWN: L. C. FILE NO.
TRACED: M. S. TO ACCOMPANY REPORT 60-46-1
CHECKED: M. H. B. DATED APRIL 1968

PLATE B-12



## NOTE

STREAMBED ELEVATION = 920 FT. M.S.L
BOTTOM OF WATER SUPPLY POOL
ELEVATION = 1425 FT. M.S.L.
TOP OF WATER SUPPLY POOL, AND BOTTOM
OF FLOOD CONTROL POOL ELEV. 1587 FT. M.S.L.;
TOP OF FLOOD CONTROL POOL
ELEVATION = 1602 FT. M.S.L.;
CREST OF DAM ELEVATION = 1650 FT. M.S.L.

THESE CURVES HAVE BEEN DEVELOPED FROM THE FOLLOWING SOURCES: ELEVATIONS 920 TO 1300; STATE OF CALIFORNIA, D.W.R., DOS RIOS RESERVOIR MAP, 1" = 400 FT. SCALE, DATED 11/59 (20 FT. CONTOUR INTERVALS). ELEVATIONS 1300 TO 1700; U.S.G.S QUAD SHEETS, 1:62,500 SCALE (50 FT. CONTOUR INTERVALS).

EEL RIVER BASIN
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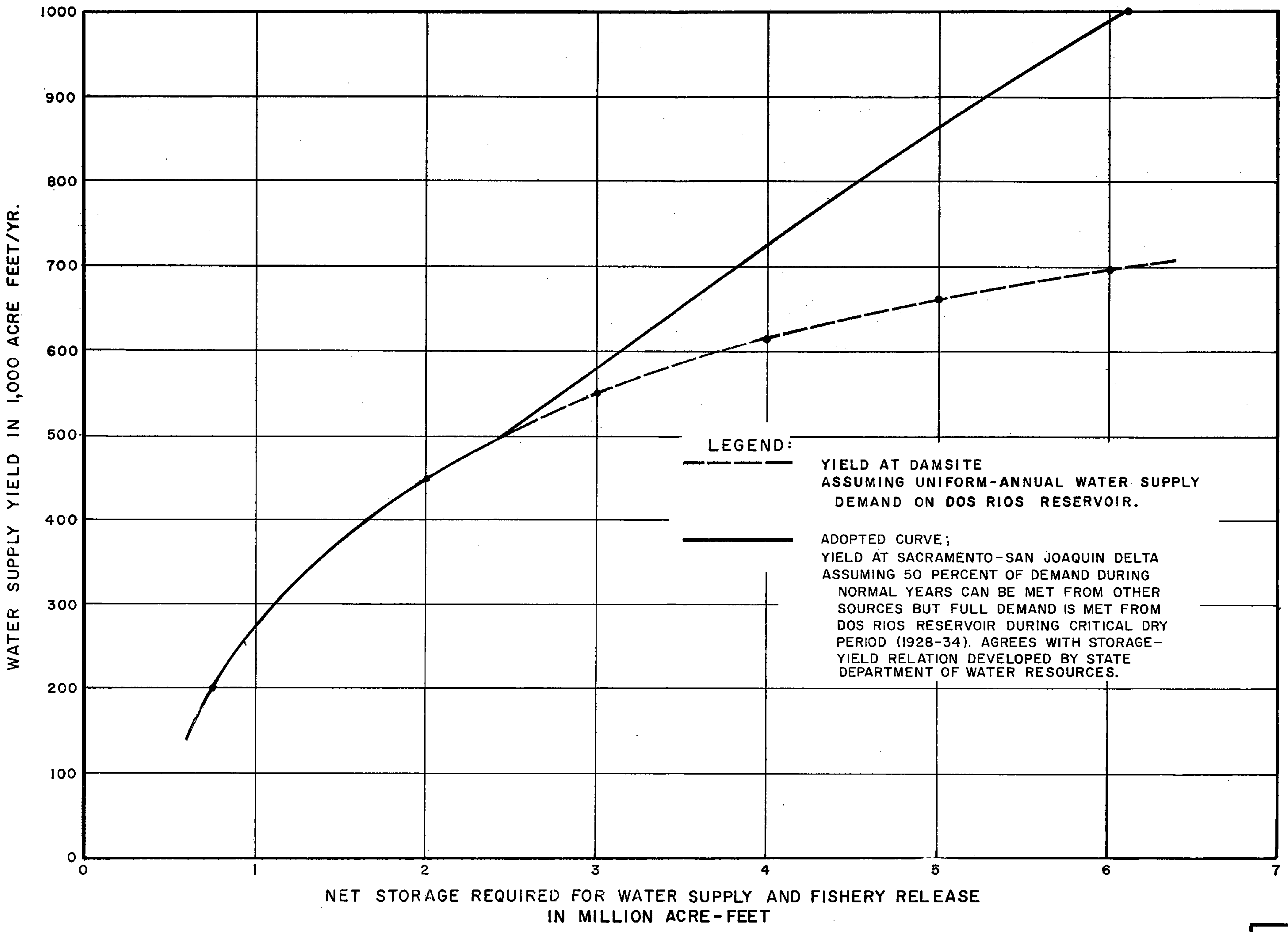
FOR
MIDDLE FORK EEL RIVER
**DOS RIOS RESERVOIR**
**AREA AND CAPACITY CURVES**
IN 17 SHEETS SHEET NO. 13
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C. OF E.
DRAWN: W.J.B. FILE NO.
TRACED: G.M.S. TO ACCOMPANY REPORT 60-46-1
CHECKED: D.R.B. DATED: APRIL 1968



NOTE:

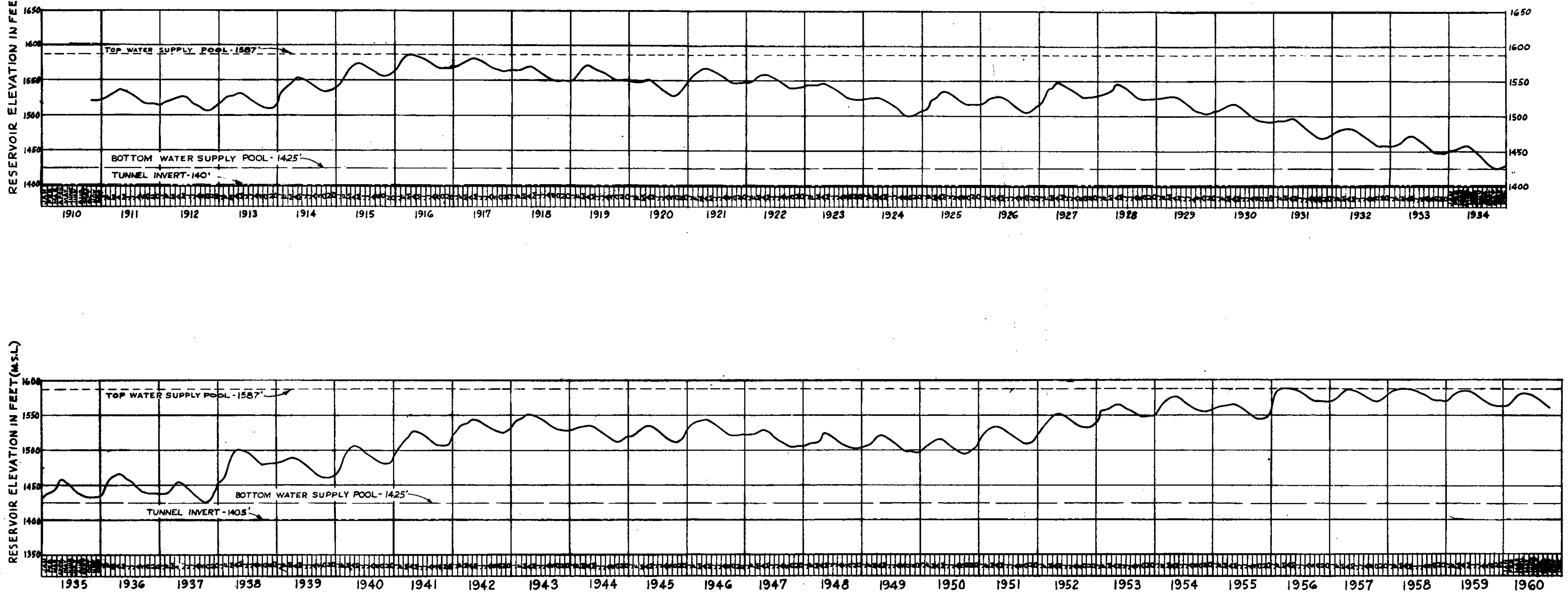
CURVES ARE BASED ON ESTIMATED RUNOFF DURING THE PERIOD 1910-65.

YIELD IS BASED ON PROVIDING 213,000 ACRE-FEET PER YEAR FOR FISHERIES MITIGATION AND LOCAL USE.

EVAPORATION IS ESTIMATED AT 2.5 FEET PER YEAR

EEL RIVER BASIN
CALIFORNIA
INTERIM REPORT
ON
WATER RESOURCES DEVELOPMENT
FOR
MIDDLE FORK EEL RIVER
STORAGE YIELD CURVES
DOS RIOS RESERVOIR
IN 17 SHEETS SHEET NO. 14
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E
DRAWN: W.J.B. FILE NO.
TRACED: G.S. TO ACCOMPANY REPORT 60-46-1
CHECKED: M.H.B. DATED: APRIL 1968

PLATE B-14



Stage Hydrograph is Based on Uniform
Annual Water Supply Demand of 660,000 Ac. Ft.
At Damsite.

Notes:

| | |
|---|---|
| Water Supply Pool And Fishery Release | 5,000,000 Ac. Ft. |
| Dead Storage | 2,000,000 Ac. Ft. |
| Mandatory Releases And Fishery Mitigation | 217,000 Ac. Ft./Yr.<br>1 Oct. - 31 May 350 C.F.S.<br>1 Jun. - 30 Sept. 200 C.F.S. |

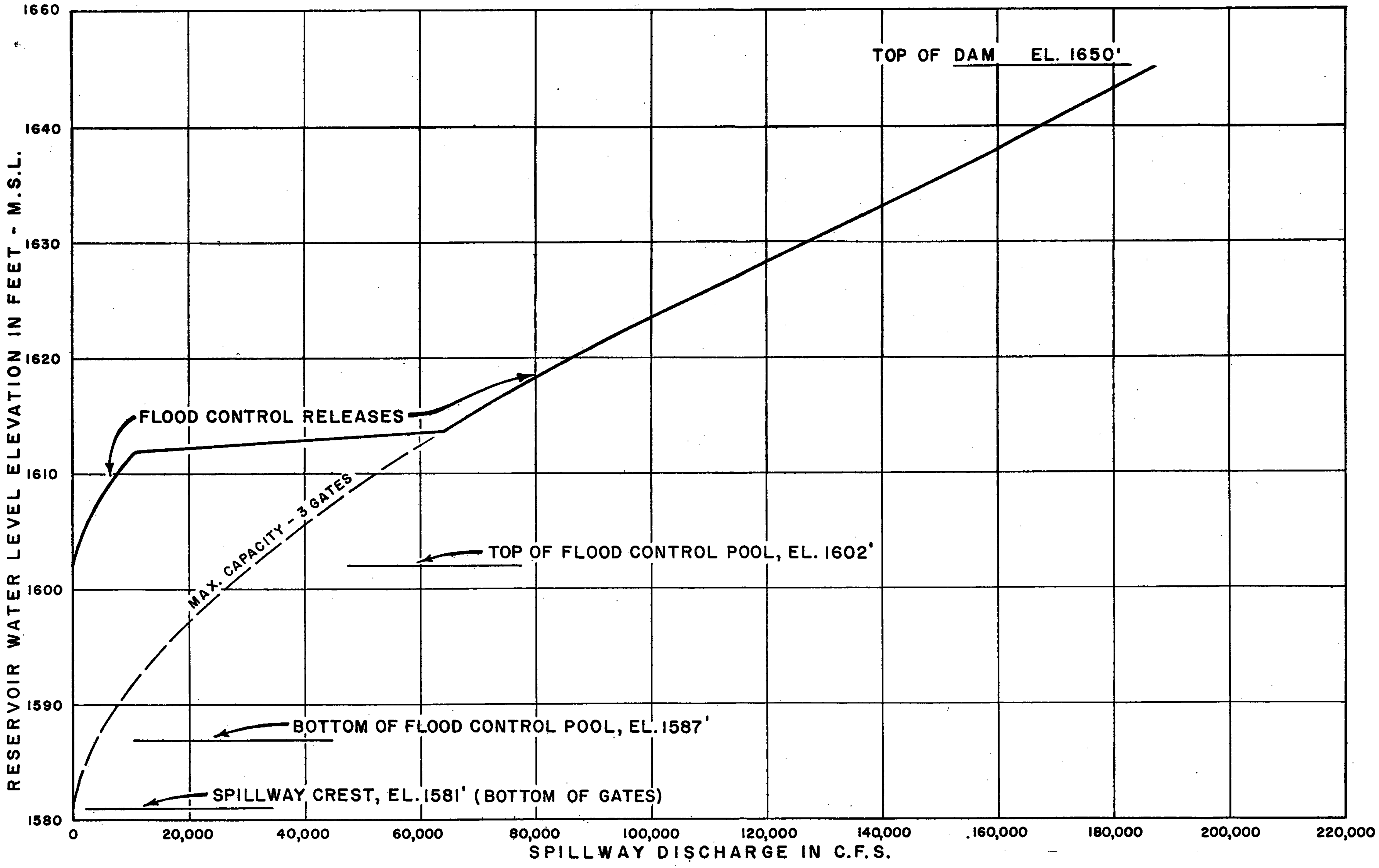
Top of Water Supply Pool Routing
Does not show Operation for
Flood Control.

EEL RIVER BASIN
CALIFORNIA
INTERIM REPORT
ON
WATER RESOURCES DEVELOPMENT
FOR
MIDDLE FORK EEL RIVER

## DOS RIOS SITE
## RESERVOIR STAGE HYDROGRAPH

IN 17 SHEETS
SHEET NO. 15
U.S. ARMY ENGINEER DISTRICT, SAN FRANCISCO, CORPS OF ENGINEERS
DRAWN: L.C.
TRACED: J.J.P.
CHECKED: M.H.B.
TO ACCOMPANY REPORT
DATED: APRIL 1966
FILE NO.
60-46-1

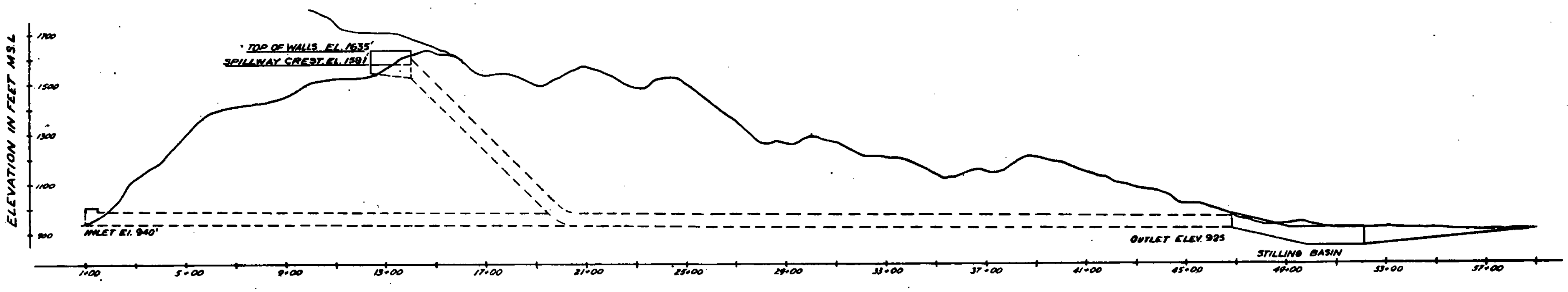
PLATE B-15



NOTE:
30 FT. WIDE BY
44 FT. HIGH CREST
GATES.

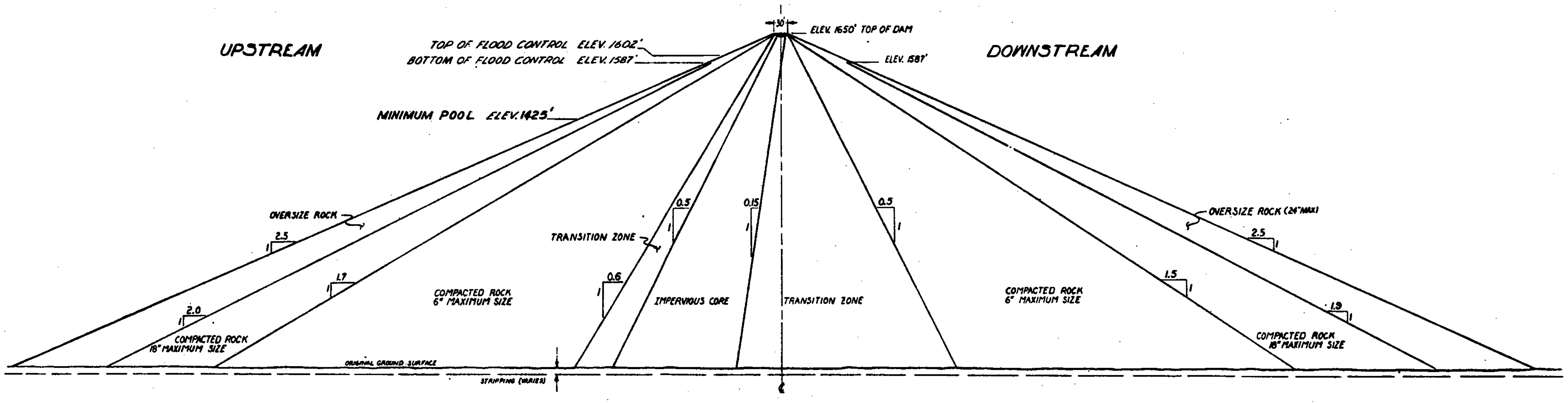
EEL RIVER BASIN
CALIFORNIA
INTERIM REPORT
ON
WATER RESOURCES DEVELOPMENT
FOR
MIDDLE FORK EEL RIVER
SPILLWAY GATES
RATING CURVES
DOS RIOS DAM
IN 17 SHEETS SHEET NO. 16
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E
DRAWN: G.F.T. FILE NO.
TRACED: R.W.S. TO ACCOMPANY REPORT 60-46-1
CHECKED: G.R.P. DATED: APRIL 1968

PLATE B-16



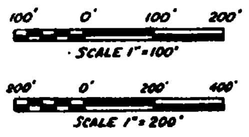
PROFILE OF SPILLWAY AND DIVERSION TUNNEL

SCALE 1" = 200'



EMBANKMENT SECTION

SCALE 1" = 100'

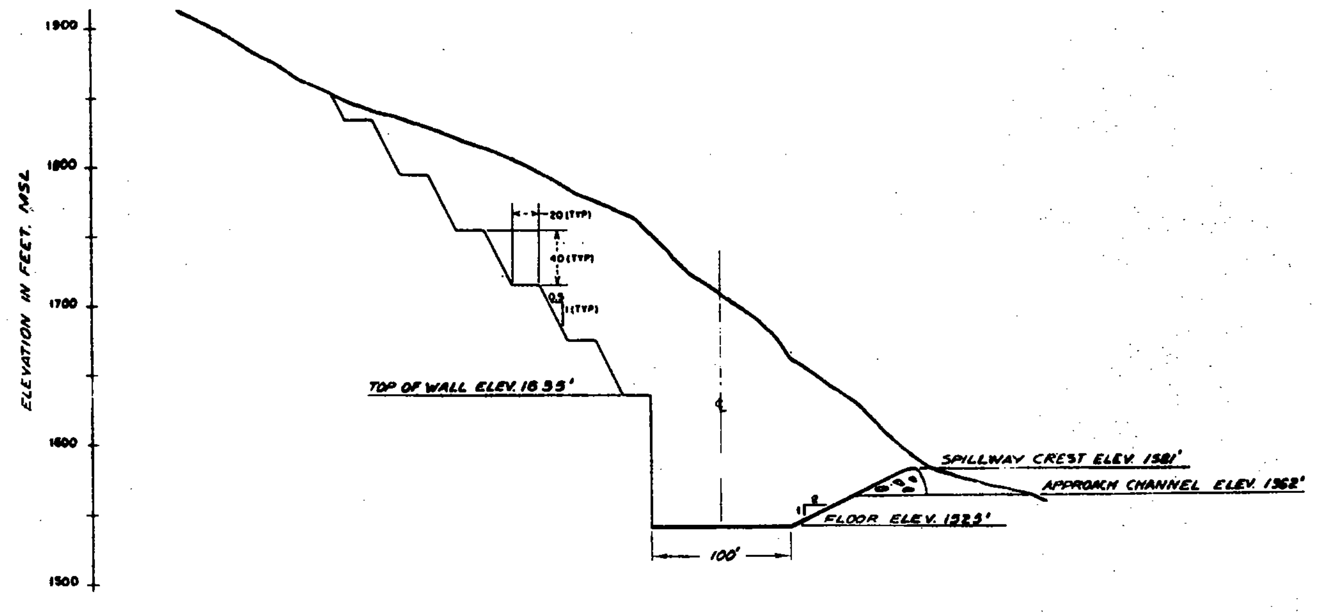


EEL RIVER BASIN
CALIFORNIA
INTERIM REPORT
ON
WATER RESOURCES DEVELOPMENT
MIDDLE FORK EEL RIVER
DOS RIOS DAMSITE

**SPILLWAY PROFILE**
**EMBANKMENT SECTION**

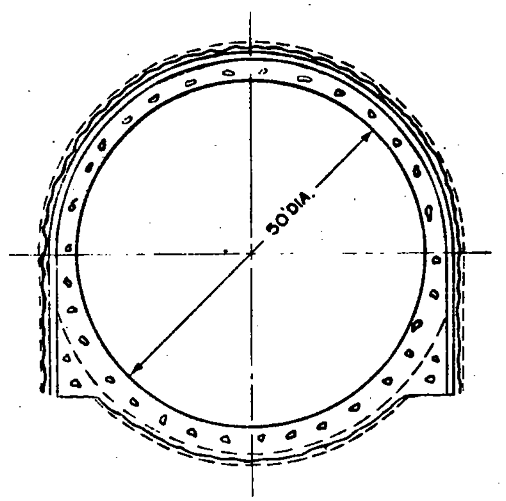
IN SHEET
SHEET NO
U.S. ARMY ENGINEER DISTRICT, SAN FRANCISCO, CORPS OF ENGINEERS
DRAWN: J.W.R.
TRACED:
CHECKED: I.C.C.
TO ACCOMPANY REPORT
DATED APRIL 1960
FILE NO.
60-43-2

PLATE B-17



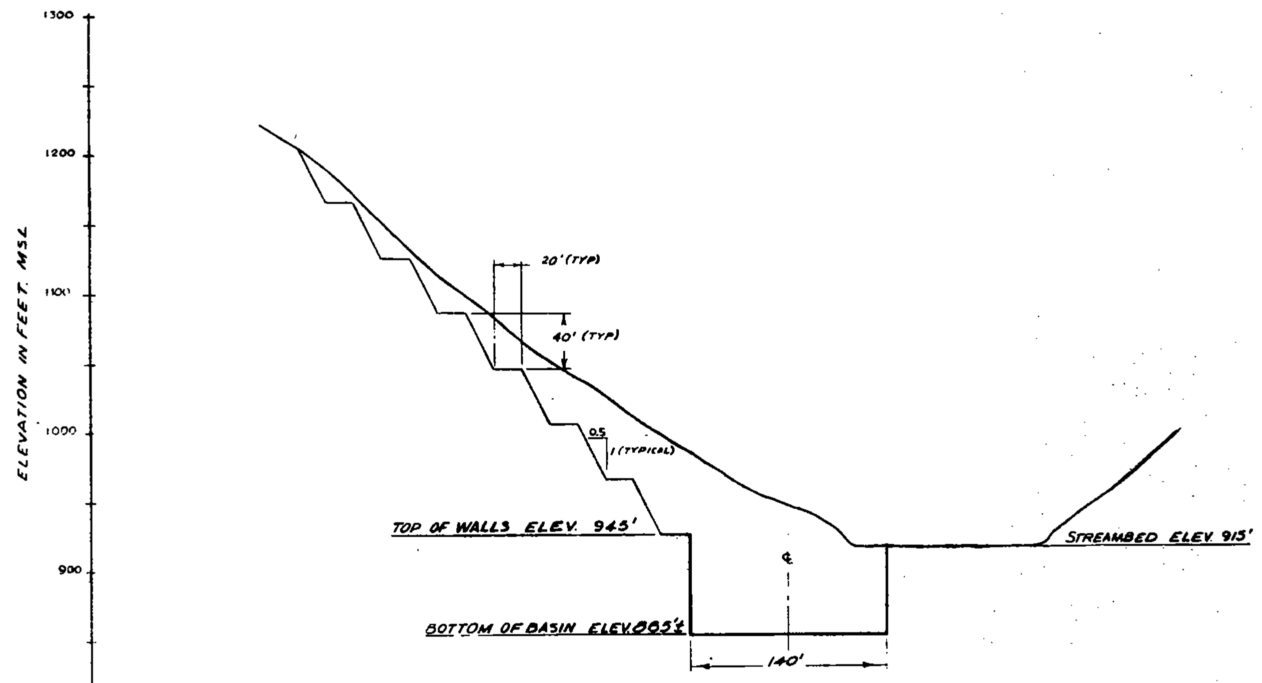
MAXIMUM SPILLWAY CUT SECTION

SCALE 1" = 50'



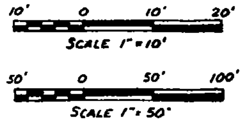
SPILLWAY AND DIVERSION TUNNEL CROSS SECTION

SCALE 1" = 10'



MAXIMUM STILLING BASIN CUT SECTION

SCALE 1" = 50'

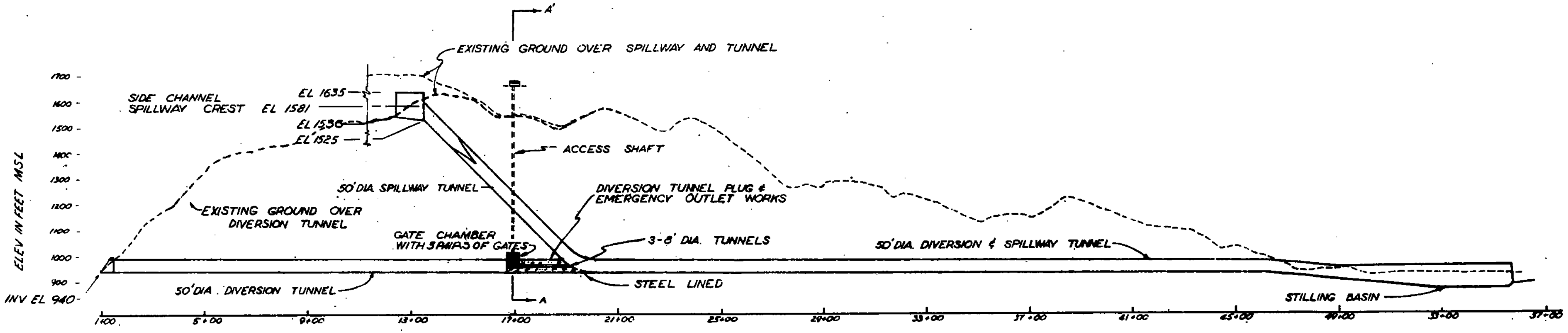


EEL RIVER BASIN
CALIFORNIA
INTERIM REPORT
ON
WATER RESOURCES DEVELOPMENT
MIDDLE FORK EEL RIVER
DOS RIOS DAMSITE

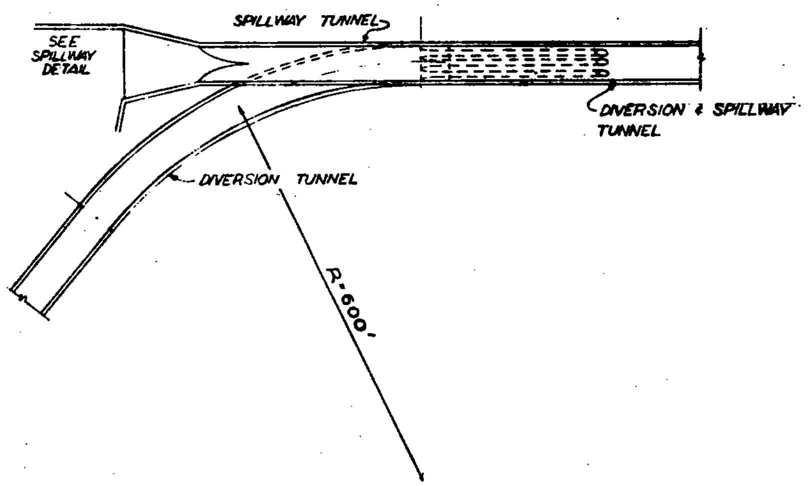
**SECTIONS OF**

**HYDRAULIC STRUCTURES**

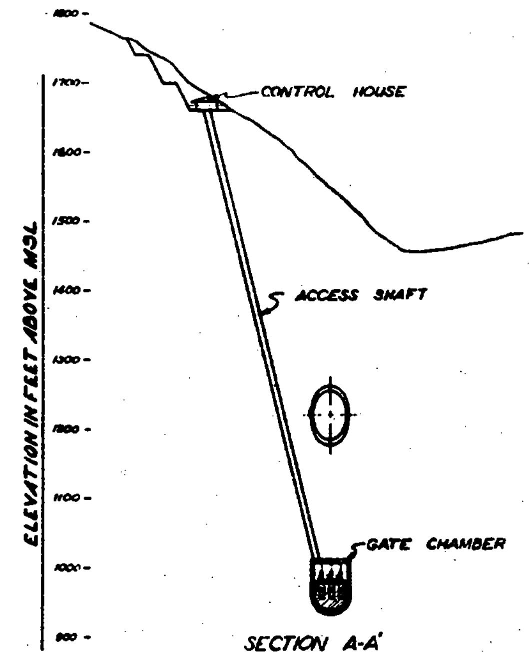
IN . SHEET SHEET NO.
U.S. ARMY ENGINEER DISTRICT, SAN FRANCISCO, CORPS OF ENGINEERS
DRAWN: J.O. FILE NO.
TRACED: TO ACCOMPANY REPORT 60-43-2
CHECKED: I.C.C. DATED: APRIL 1968



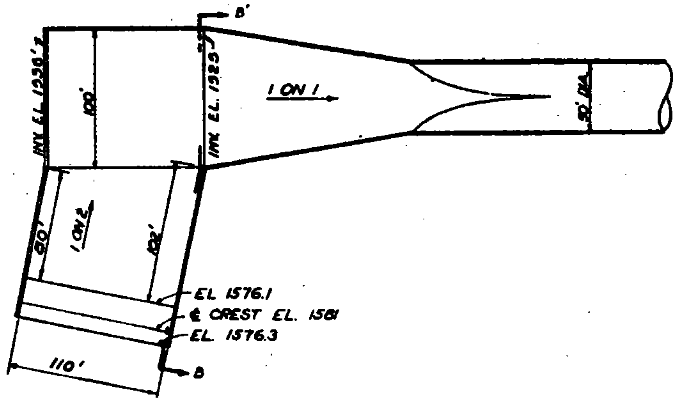
PROFILE OF SPILLWAY AND DIVERSION TUNNEL



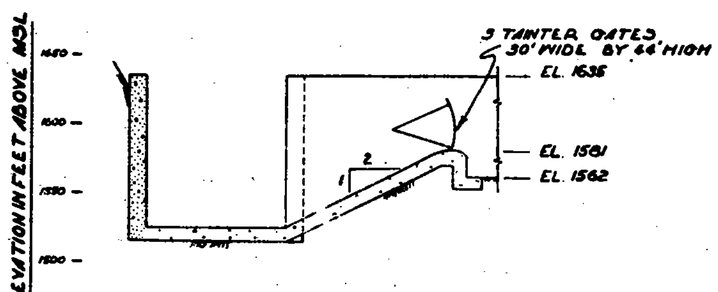
PARTIAL PLAN



SECTION A-A'



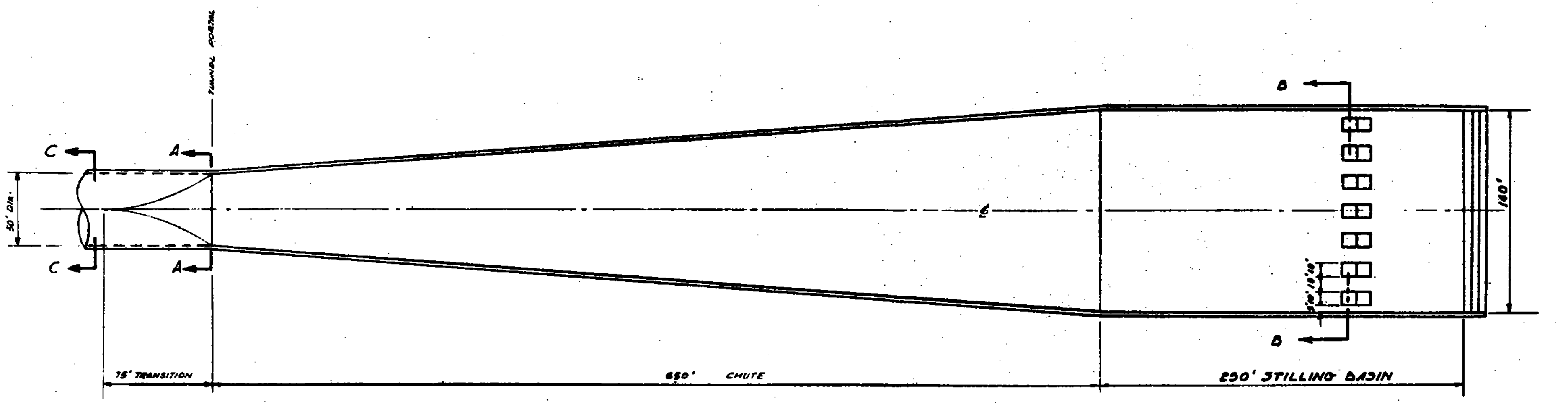
SIDE CHANNEL SPILLWAY PLAN



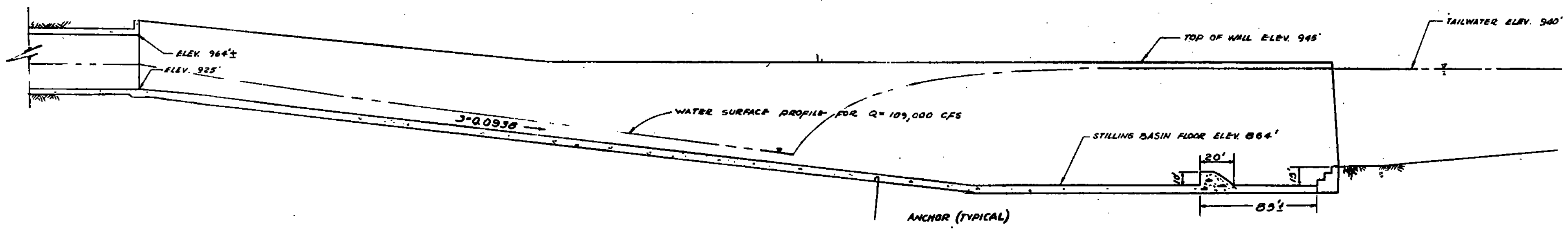
SECTION B-B'

EEL RIVER BASIN
CALIFORNIA
INTERIM REPORT
ON
WATER RESOURCES DEVELOPMENT
MIDDLE FORK EEL RIVER
DOS RIOS DAMSITE
**DETAILS OF**
**SIDE CHANNEL SPILLWAY**
IN SHEET SHEET NO.
U.S. ARMY ENGINEER DISTRICT, SAN FRANCISCO, CORPS OF ENGINEERS
DRAWN J.O. FILE NO.
TRACED 60-43-2
CHECKED I.C.C.
TO ACCOMPANY REPORT
DATED APRIL 1968

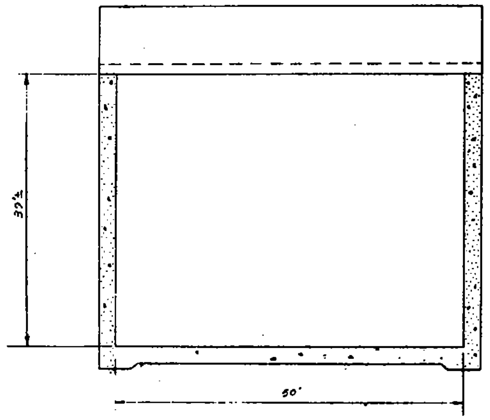
PLATE B-19



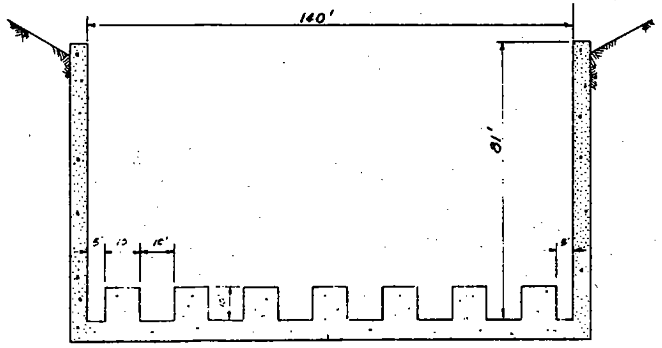
PLAN
SCALE: 1" = 40'



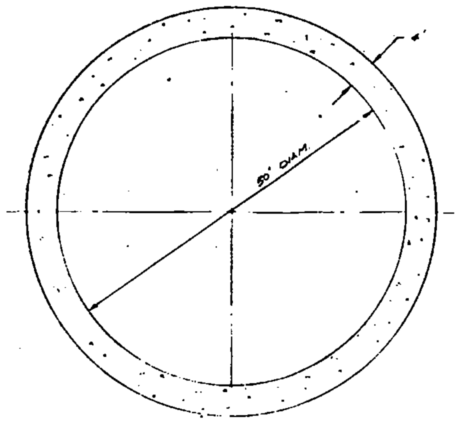
℄ PROFILE
SCALE: 1" = 40'



SECTION A-A
SCALE: 1" = 10'



SECTION B-B
SCALE 1" = 20'



SECTION C-C
SCALE 1" = 10'

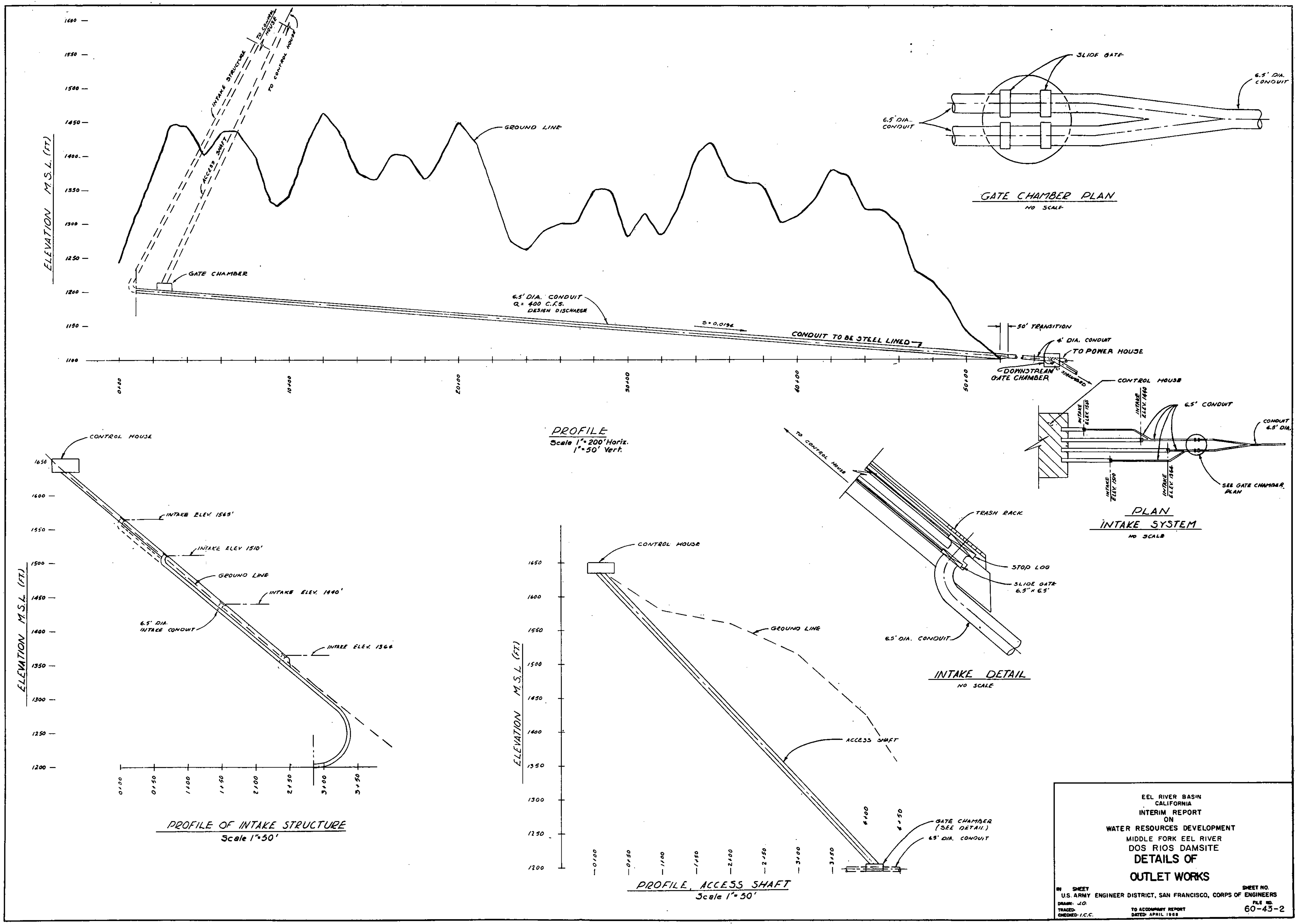
EEL RIVER BASIN
CALIFORNIA
INTERIM REPORT
ON
WATER RESOURCES DEVELOPMENT
MIDDLE FORK EEL RIVER
DOS RIOS DAMSITE

**DETAILS OF**

**SPILLWAY STILLING BASIN**

IN SHEET
SHEET NO.
U.S. ARMY ENGINEER DISTRICT, SAN FRANCISCO, CORPS OF ENGINEERS
DRAWN: F.Y.
TRACED:
CHECKED: I.C.C.
TO ACCOMPANY REPORT
DATED: APRIL 1968
FILE NO.
60-43-2

PLATE B-20



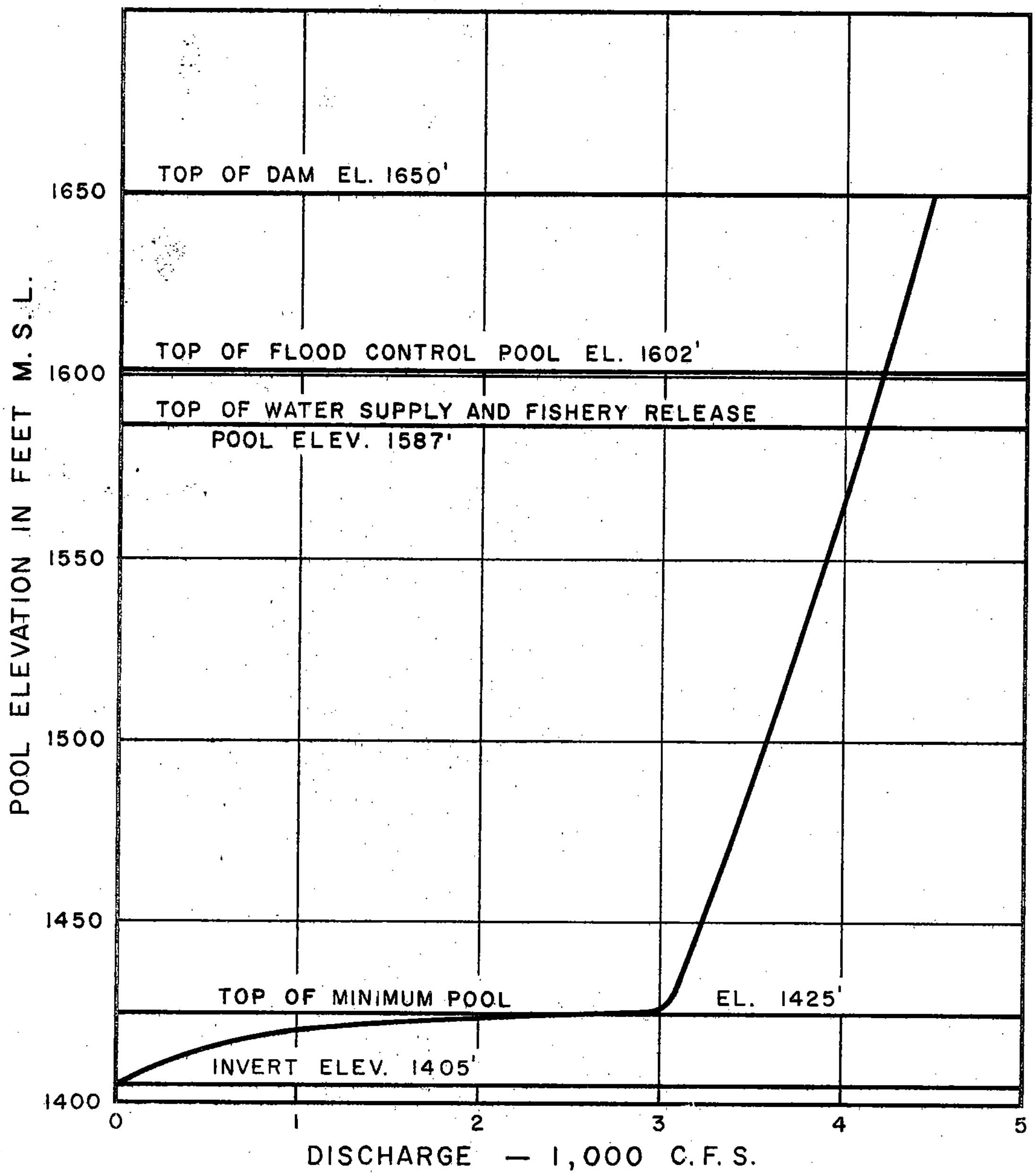
EEL RIVER BASIN
CALIFORNIA
INTERIM REPORT
ON
WATER RESOURCES DEVELOPMENT
MIDDLE FORK EEL RIVER
DOS RIOS DAMSITE

**DETAILS OF**

**OUTLET WORKS**

IN SHEET
SHEET NO.
U.S. ARMY ENGINEER DISTRICT, SAN FRANCISCO, CORPS OF ENGINEERS
DRAWN: J.O.
TRACED:
CHECKED: I.C.C.
TO ACCOMPANY REPORT
DATED: APRIL 1968
FILE NO.
60-43-2

PLATE B-21



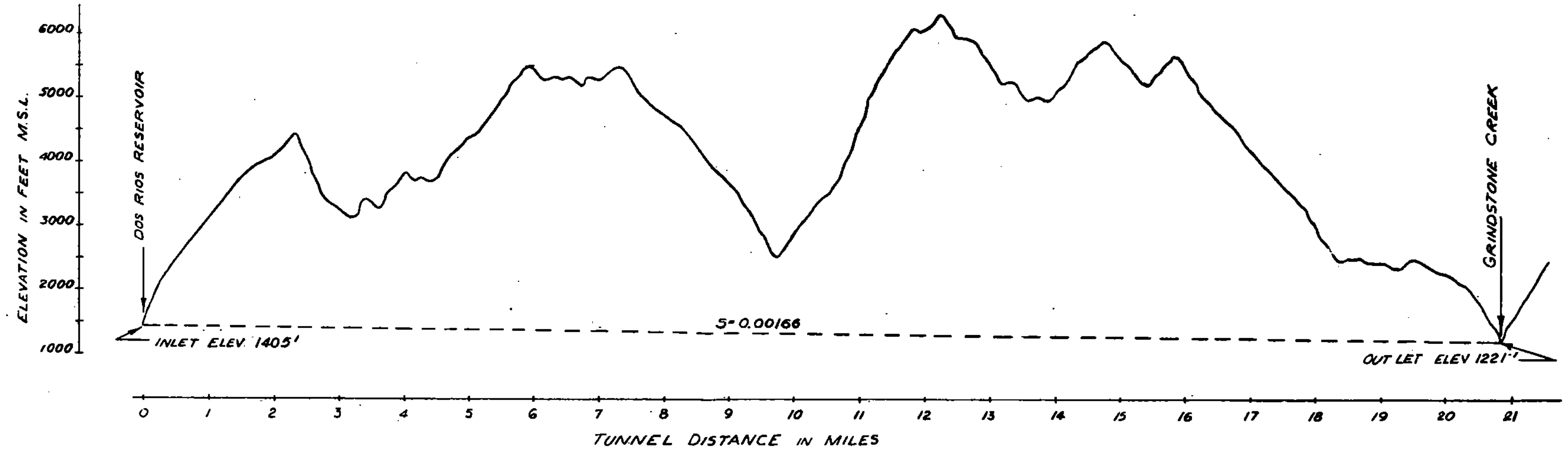
NOTES:

17-FOOT DIAMETER TUNNEL
"n" = 0.012

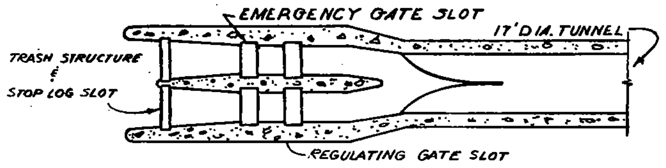
EEL RIVER BASIN
CALIFORNIA
INTERIM REPORT
ON
WATER RESOURCES DEVELOPMENT
FOR
MIDDLE FORK EEL RIVER

## DISCHARGE RATING CURVE
## GRINDSTONE TUNNEL

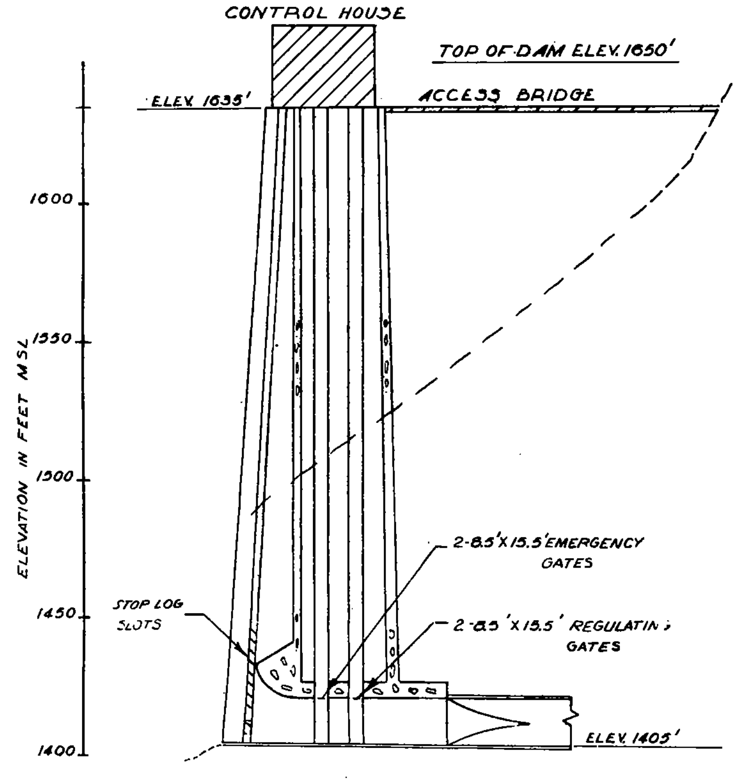
IN 17 SHEETS SHEET NO. 17
U. S. ARMY ENGINEER DIST., SAN FRANCISCO, C. OF E.
DRAWN: G. R. P.
TRACED: R. T. T.
CHECKED: V. G.
TO ACCOMPANY REPORT
DATED: APRIL 1968
FILE NO.
60-46-1



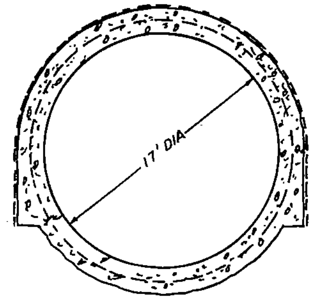
PROFILE OF GRINDSTONE TUNNEL



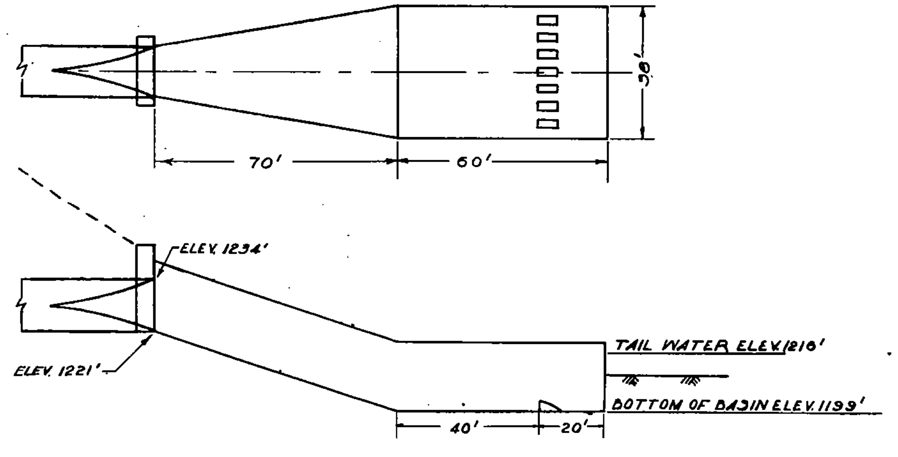
PLAN OF INTAKE STRUCTURE
SCALE 1" = 20'



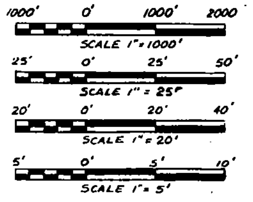
SECTION OF INTAKE STRUCTURE
SCALE 1" = 25'



CROSS SECTION OF TUNNEL
SCALE 1" = 5'



PLAN AND PROFILE OF OUTLET STILLING BASIN
SCALE 1" = 20'



EEL RIVER BASIN
·CALIFORNIA
INTERIM REPORT
ON
WATER RESOURCES DEVELOPMENT
MIDDLE FORK EEL RIVER
DOS RIOS DAMSITE

**GRINDSTONE TUNNEL**

**PROFILES AND SECTIONS**

IN SHEET
SHEET NO.
U.S. ARMY ENGINEER DISTRICT, SAN FRANCISCO, CORPS OF ENGINEERS
DRAWN: J.O.
TRACED:
CHECKED: I.C.C.
TO ACCOMPANY REPORT
DATED: APRIL 1968
FILE NO.
60-43-2

PLATE B-23

EEL RIVER BASIN, CALIFORNIA

INTERIM REPORT
ON
WATER RESOURCES DEVELOPMENT
FOR
MIDDLE FORK EEL RIVER

## APPENDIX C

## GEOLOGY, SOILS AND SOURCES OF CONSTRUCTION MATERIALS

## TABLE OF CONTENTS

## TABLE OF CONTENTS (Continued)

## TABLE OF CONTENTS (Continued)

### PLATES

# EEL RIVER BASIN, CALIFORNIA

# INTERIM REPORT
# ON
# WATER RESOURCES DEVELOPMENT
# FOR
# MIDDLE FORK EEL RIVER

## APPENDIX C

## GEOLOGY, SOILS AND SOURCES OF CONSTRUCTION MATERIALS

## INTRODUCTION

### C-1. PURPOSE

The purpose of this appendix is to present and discuss the preliminary data on geology, soils, and sources of construction materials for the Dos Rios Damsite.

### C-2. SCOPE

Presented in this appendix are discussions of the regional and damsite geology, the subsurface explorations, foundation conditions, design of the rockfill dam, and results of investigations of the sources of construction materials. Also included are geologic drawings, locations and logs of exploration of the foundation and borrow areas. Details of the proposed dam and appurtenant facilities are discussed in Appendix F.

### C-3. PROPOSED PROJECT

The Dos Rios Damsite is located on the Middle Fork of the Eel River, about 20 airline miles north of Willits, California. The Middle Fork drainage basin is largely in Mendocino County but includes portions of Trinity, Glenn and Lake Counties. A 730-foot high, zoned rockfill embankment with a side channel, gated spillway is planned. The total volume of the embankment would be approximately 30.6 million cubic yards. The dam would impound about 7.6 million acre-feet of water to top flood control pool at elevation 1602 and would provide flood control, water supply and recreation. A 21-mile transbasin conveyance tunnel is planned to divert water eastward from the Dos Rios Reservoir to the Sacramento Valley where it would be incorporated in the California State Water Project.

## GEOLOGY

### C-4. GEOMORPHOLOGY

Dos Rios Damsite is in the northern Coast Ranges Province of California. The damsite is on the Middle Fork Eel River about 3 miles upstream from the confluence with the main stem of the Eel. The Middle Fork drains an area of about 745 square miles and is the largest subbasin within the Eel River drainage basin. Elevations in the subbasin range from 900 feet at the confluence to 7500 feet at the crest of the mountains to the east. Topography within the basin is similar to that in the rest of the province, i.e., sharp crested northwest-trending ridges, V-shaped canyons and a trellis drainage pattern. Large-scale landslides are also prominent features of the terrain. Much of the Middle Fork stream course is superimposed across the regional northwest trend and can be classified as an "antecedent" stream. Geological evidence indicates the present course of the river was established prior to regional uplift, folding and faulting that occurred during the Pliocene epoch. The downcutting of the stream kept pace with the uplift and thus retained much of its original course. An excellent example is at the damsite where the Middle Fork has carved a steep-walled canyon through a resistant sandstone ridge directly across the regional trend.

## C-5. RESERVOIR GEOLOGY

Rocks underlying the Middle Fork Eel River Basin are generally representative of the rocks of the northern Coast Ranges Province in that they are chiefly units of the Franciscan assemblage. Graywacke sandstone including lesser amounts of shale, greenstone (altered basalt), chert, schist, conglomerate and serpentine are the dominant rock types. The record of post-Franciscan cycles of erosion, deposition and uplift is represented in the Middle Fork Basin by the general coincidence of ridge tops, and the presence of post-Franciscan sediments. These sediments consist of early and middle Tertiary marine sediments near the damsite, and Pliocene and Quaternary sediments in Round Valley, about five miles northeast of the damsite. Quaternary terraces along the river at elevations of a few feet to as much as 900 feet above the channel, coupled with the fact that most of the streams are presently deepening their channels, provide evidence of continued regional uplift in recent geologic time.

C-6. One of the most prominent topographical features of the basin is Round Valley, a semi-circular, flat-floored, seven-mile wide valley that appears to be a fault block or graben that was downfaulted after the Miocene epoch. The amount of downthrow is not known, but wells drilled in the valley floor have penetrated as much as 860 feet of alluvial deposits without encountering bedrock. This means that the top of rock beneath the valley floor is at least 800 feet lower in elevation than the rock in the channel of Mill Creek (the outlet for

Round Valley) and 400 feet lower in elevation than the rock in the channel at the Dos Rios damsite. The floor of the valley slopes gently toward the southeast from an elevation of 1425 feet along its northwest margin to about 1300 feet at the head of Mill Creek Canyon in the southeast corner of the valley. Fault displacements along the margins of the valley created closed basin conditions at times in the geologic past, resulting in ponding and the accumulation of fine-grained lake deposits on the floor of the valley which now form confining layers and give rise to artesian water conditions in the central and eastern parts of the valley.

C-7. Landslides, some of which are tremendous in size, are probably the most striking features of the terrain in the Middle Fork Eel River Basin. The slides are widespread, but appear to be particularly concentrated along major shear zones that traverse this region from southeast to northwest. In general, the slides are of the complex slump or debris flow type. Many of them are inactive, or at least in a state of limited equilibrium, and probably date back to the Pleistocene epoch. Another common form of slope failure is known as "soil creep mantle." Areas, particularly on the steeper slopes, that are covered with thick residual soils exhibit abundant evidence of imperceptible type movements. Inundation by reservoir waters would probably reactivate many of the slides in addition to creating new slides in creep mantle areas and in other potentially unstable slopes. Sudden, catastrophic slide movements that could cause overtopping of the dam, however, are highly unlikely due to the type of landslides and the kind of materials involved. Based on a preliminary data developed by the State of California Department of Water Resources, there is an estimated 500,000 acre-feet of landslide debris situated above the maximum reservoir water surface. Consideration has been given to the volume of slide debris in the determination of the minimum pool.

## C-8. SEISMICITY

During the years between 1928 and the present, which is the period of the most accurate records, there were no strong earthquakes recorded within 30 miles of the damsite. But 10 comparatively small earthquakes (Richter magnitude 3.0 to 3.9) were centered within the same 30-mile radius, nine of which were more than 15 miles from the damsite. Plate C-1 shows the epicentral locations of earthquakes and traces of major faults. The adjoining areas, a short distance to the northwest and southeast, are highly active. Limits of the affected areas surrounding strong shocks centered in either of these areas included the dam and reservoir area. Thus, it is reasonable to assume the proposed structures would be shaken periodically by future earthquakes. Though there are a number of major shear zones and faults traversing this region, none of them have been described in the literature as active. The condition of the materials in the shear zones, amount of displacement on the faults along the margins of Round Valley, and presence of abandoned stream terraces perched on the canyon walls are strong evidences that this region was highly unstable in the relatively recent geologic past. An additional freeboard allowance of 15 feet would be provided for seismic effects in accordance with ETL 1110-2-17 dated 28 February 1967.

## C-9. EXPLORATION

a. Previous investigations. Previous investigations at the site were of a reconnaissance nature and were performed by the Department of Water Resources at various times beginning about 1958. During 1959, a private corporation made a cursory examination of the site and described it in their "Report on Eel River Investigation," for the Los Angeles Metropolitan Water District. No drilling was done during either of these investigations. Detailed investigations of landslide conditions in the reservoir area were undertaken by the Department of Water Resources in 1966 as part of an overall Middle Fork Eel River Basin landslide study. Investigations included in this study are detailed geologic mapping, topographic surveys, auger and core borings, and the installation of instruments to monitor movements. Eleven slope indicators were installed in 1966 in landslides in the Salt Creek, Elk Creek, Etsel Damsite and the Eel River Ranger Station areas of the reservoir. The Department of Water Resources undertook detailed geologic studies of the proposed Grindstone Tunnel alignment in 1964. These studies include several types of geophysical surveys, core drilling in areas of interest, and areal geologic mapping.

b. Present investigations. Field investigations by the San Francisco District began in 1964, with the drilling of 13 auger borings in a potential impervious borrow area located about 2 miles northeast of the damsite (see Plate C-4). Geologic mapping in the foundation areas, alternative spillway saddle north of the site, and at various potential quarry sites followed in the summer of 1966. Additional mapping of selected features was done in 1967. Subsurface exploration in the foundation area of the embankment consisted of five 4-inch diameter core borings: two holes on each abutment and one hole in the channel. About 620 linear feet were drilled, with an average core recovery of 97 percent. Two seismic lines were run in the channel near the axis of the proposed dam in order to determine the thickness of the stream deposits and to obtain a velocity in the rock underlying the channel deposits. In addition to the exploration and field studies by the District for the preparation of this report, the Department of Water Resources is continuing their investigations on the landslide conditions in the Middle Fork Basin, potential rock sources for construction of the embankment, and geologic conditions along the Grindstone Tunnel alignment.

## C-10. DAMSITE GEOLOGY

### a. General.

(1) The damsite is in a deep narrow gorge having a fairly straight channel. Vertical to near vertical bare rock walls line both sides of the 140-foot wide channel and stand 30 to 60 feet high (see Plates C-2 and C-3). Slopes above the inner gorge on both sides of the canyon extend upward at an average of 35 to 40 degrees, or 1 vertical on 1.3 to 1.4 horizontal. Rock exposures are frequent and the overburden is thin on the abutment slopes. Shallow tributary draws interrupt the rather straight contours of the abutments.

(2) In the foundation area of the dam, the river flows on an east-west course, parallel to the general strike of the bedding. The orientation of both the channel and bedding is out of phase with

the regional northwest geologic trend, indicating that the river was superimposed on existing structural features prior to regional uplift. Sound rock conditions at the damsite grade rapidly into less desirable conditions away from the site. Within 2500 feet upstream and downstream of the embankment, the rocks are badly deformed and landslides predominate the landscape. Similar conditions appear to exist both north and south of the damsite.

(3) Rocks underlying the foundation area of the embankment are members of the Franciscan assemblage. Except for a small amount of chert and greenstone, the rocks consist of graywacke sandstone containing minor interbedded shales. Typically the sandstone is blue-gray to greenish gray, massively bedded, fine to medium grained, well cemented and hard. Shale accounts for about 5 percent of the section and occurs as laminae, small inclusions, and thin discontinuous interbeds throughout the sandstone. All of the rocks are closely to moderately fractured as a result of crustal disturbances during the geologic past. Cores recovered during drilling show that, in general, the sandstone is closely fractured and jointed to a depth of about 10 to 15 feet, and moderately to widely fractured below that depth. The joints are reasonably tight and are randomly oriented. The presence of iron stains and thin clay coatings on fracture surfaces in the drill cores indicate that the fractures on the abutments are open to percolating waters to a depth of about 45 feet, except in the area around core hole 1F-3 on the left abutment where slight staining and thin clay coatings were found on some fractures to the bottom of the hole at a depth of 150 feet (see Plate C-5). Many of the fractures

and joints have been healed by secondary quartz and calcite. The shales are usually broken and occasionally sheared. Bedding in the foundation area is poorly developed but has a consistent east-west strike (parallelling the stream) and a southward dip that varies between near vertical in the channel to 50 degrees at crest elevation in both abutments.

(4) The geologic structure in the areas surrounding the site appear to be somewhat more complex and less obvious than in the foundation area due to the pervasive shearing of the rocks, thick residual soils, and numerous landslides that mask outcrops. Referring to Plates C-2 and C-3, the steep attitudes of the bedding in the channel and shallower dips in the upper parts of the abutments imply that the damsite may be located on either a southward dipping homocline, or on the southern limb of an east-west trending anticline. A series of chert pods high on the left abutment, in the channel about 3000 feet downstream from the dam axis, and on the north side of the river downstream of the site form a loose trend which implies an anticline plunging to the west. However, the attitude of the rocks upstream and to the north of the damsite does not confirm the plunging anticline hypothesis, and suggests that the overall geologic structure is far more complicated. Core drilling and geologic mapping indicate that there is no major fault or shear zone in the channel, though several minor cross faults were found striking nearly normal to the channel. The faults vary in width from less than an inch to as much as 3 feet and are filled with tight plastic fines and rock fragments. Their planes dip generally upstream at angles of 45

to 70 degrees. None of these faults, however, would have a significant effect on the stability of the embankment. The attitude and presence of plastic materials in the fault planes form natural barriers that would tend to preclude seepage beneath the embankment.

b. Left abutment.

(1) The left abutment has a relatively smooth horizontal profile that is broken only by a few shallow draws. The draws are almost perpendicular to the river and appear to be located along extensions of small faults or groups of faults mapped in the channel. The average slope in the abutment area is about 1 vertical on 1.4 horizontal, being slightly steeper in the lower third. Rock exposures occupy about 20 percent of the abutment and the remainder is covered by about 3 feet of soil and slopewash. A conspicuous small flat area adjacent to Hole 1F-2 (see Plate C-2) appears to be a remnant of an ancient rock terrace cut by the river.

(2) Except for a small amount of shale, all of the rock underlying the left abutment is the graywacke sandstone described previously. Weathering is slight and extends to shallow depths. It consists chiefly of minor leaching and staining along fracture surfaces, but does not appear to detract from the overall integrity of the rock. Fractures and joints are closely spaced to a depth of about 10 feet and moderately to widely spaced below that depth, although occasional zones are highly fractured within the latter interval. Core lengths in the widely spaced fracture interval commonly run to 3 feet. The steep stable slopes of the abutment attest to the basically firm character of the rock.

(3) Fractures in core from Hole 1F-2, located in the bottom of a shallow draw 200 feet above the channel, were lightly stained to a depth of 23 feet and contained little or no clay fillings. The lack of staining and clay on fracture surfaces, coupled with a high fluid return during drilling, indicate the fractures are tight below 23 feet. Staining, clay coatings, and partial drill fluid losses indicate that some fractures in the vicinity of core Hole 1F-3 are slightly open to a depth of at least 150 feet. The hole is located near the top of a narrow ridge. These conditions appear to be limited to the upper parts of the narrow noses underlying the left abutment and are probably not representative of the entire abutment. In view of the random orientation and discontinuous nature of the joints and fractures in the rock, the presence of thin clay coatings would probably have little effect on the overall foundation properties of the rock for a rockfill dam.

c. Channel section.

(1) The channel width varies from about 80 to 200 feet within the dam embankment area. It is relatively straight but makes a sharp turn to the south at the upstream toe of the dam, thus affording a good approach for the diversion tunnel portal. A hard and resistant mass of greenstone forms the right channel wall underlying the upstream toe of the embankment. Chert, generally associated with the greenstone, forms three prominent outcrops along the channel wall adjacent to, and across the channel from, the greenstone mass. The chert bodies may be connected under the channel deposits. The remainder of the channel in the foundation area is lined with graywacke sandstone containing minor amounts of shale.

(2) Core Hole 1F-1 crosses beneath the entire width of the channel and reveals that it is underlain by massive sandstone. The core obtained from this hole showed the rock in the channel is substantially less fractured than on the abutments. Fractures are closely spaced to a vertical depth of about 2 feet and widely spaced below about 23 feet. Clay coatings on joint and fracture surfaces were encountered to a depth of about 17 feet below top of rock, but the fractures appear closed below that depth. However, an open fracture at a depth of 82 feet below top of rock was the probable cause of variable drill mud losses for the remainder of the drilling of the hole.

(3) The results of two seismic lines in the stream channel indicate the rock surface underlying the gravel is irregular and has a seismic velocity of about 15,000 feet per second. The stream channel deposits probably average 12 feet in depth and contain a substantial amount of cobbles and boulders.

d. Right abutment. The right abutment has a vertical to near vertical lower slope adjacent to the stream channel and an upper slope that averages about 40 degrees. About 50 percent of the upper slope consists of rock exposures, the remainder has a soil and talus cover that is about a foot thick. Rock exposures on the lower slopes are almost continuous. Tributary draws are less prominent on this abutment but two shallow draws are filled with long tongues of rock debris near the proposed axis of the dam. The debris is from excavation of the county road which crosses the right abutment at about elevation 1600. The abutment is underlain largely by sandstone, with minor amounts of greenstone and chert under the extreme upstream portion, and a lesser amount of shale occurring as very thin interbeds or laminae in the sandstone. The dip of the bedding is to the south, toward the left abutment, and varies from near vertical in the channel section to about 60 degrees at the upper elevations on the abutment. The sandstone is similar to that described previously, i.e., fine to medium grained, well cemented, hard and unweathered except for slight leaching along some fracture surfaces. Jointing and fracturing are generally closely spaced to about 15 feet, and moderately spaced below that depth. The occurrence of fracture fillings is less prevalent on this abutment than on the left. Staining and clay coatings indicate fractures are generally closed below about 45 feet.

e. Spillway, diversion tunnel and outlet works.

(1) Tunnels through the left abutment are planned for the spillway, diverting of the river during construction, and controlled water releases after completion of the dam. All of the tunnels would be fully lined with concrete. The diversion tunnel would be about 4500 feet long and would be excavated almost entirely in sandstone, but may penetrate a 200-foot thick section of thinly-bedded sandstone and shale that crops out at elevations 1250 and 1500 on the left abutment. Except in the extreme downstream segment, the alignment of the tunnel would cut obliquely across the bedding in the rocks. Dips are toward the south at varying angles of 30 to 60 degrees. Reasonably good portal conditions exist in the sandstone at the upstream end. Because of the spacing of the joints and fractures in the rock and the comparatively large diameter of the tunnel,

approximately 60 feet outside diameter, full support would probably be required throughout.

(2) Excavation for the stilling basin would require cuts in sandstone on the left side of the channel and in sandstone, chert and a minor amount of shale on the right side. Structural relationships of the rocks in this area have not been clearly defined. Reversals in the strike and in the dip of the beds were found in outcrops and the chert on the right side of the channel appears to be in fault contact with the underlying sandstone. The fault is a minor feature that appears to be a low angle thrust. Detailed investigations of the structure and relationship of the rocks in the stilling basin area would be accomplished in the final design stages.

(3) A gated, side channel spillway structure is planned which would discharge into a sloping tunnel connecting with the downstream portion of the diversion tunnel. The intake structure and connecting tunnel would probably be excavated in sandstone similar to that expected to be encountered in the diversion tunnel. It too would be approximately 60 feet in outside diameter and would require full support.

(4) The outlet works tunnel supplying water for the fish hatchery and other downstream demands would be a separate tunnel about 4700 feet long. Its excavated diameter would be approximately 9 feet and should penetrate rock units of about the same proportions described for the diversion tunnel. Only light support would probably be required in this tunnel during excavation due to its diameter.

f. Powerhouse. A tentative location for the proposed powerhouse installation is on the left bank of the river approximately a mile and a quarter downstream of the dam axis. A cursory reconnaissance of this area indicates that the powerhouse would be founded on sandstone bedrock similar to that previously described. However, shallow landslide debris masks the entire area. Detailed explorations would be required during the final design stages to ascertain the geologic conditions and required treatment for the preparation of the foundation.

## C-11. GRINDSTONE TUNNEL

a. General. The Grindstone Tunnel is a conveyance facility to transport water from the proposed Dos Rios Reservoir to the west side of the Sacramento Valley for ultimate distribution in the California State Water Project. The tunnel will be about 21 miles long and will have a finished inside diameter of 17 feet. The approximate location of the west portal is near the confluence of Hayseed Creek and Middle Fork Eel River, about 12 miles east of the Dos Rios Damsite. The Department of Water Resources made a preliminary investigation along the tunnel alignment in 1958. Exploratory drilling was begun in areas of interest along the tunnel alignment in 1964, and is still in progress. The program has consisted of geologic mapping, topographic mapping, core drilling, and several types of geophysical surveys. Subsurface exploration to date includes nine holes drilled to explore the eastern half of the alignment. These holes involve a total of 8917 feet, of which 3542 feet were cored. One of the holes was drilled to tunnel grade; the remainder were shallower and were drilled for clarification of geological aspects of the area.

b. Geology. Geology along the tunnel alignment is complex, consisting of northwestward oriented units of the Franciscan assemblage and the Plaskett Formation. Members of the Franciscan Formation consist of: (a) Meta Franciscan Member; slightly metamorphosed Franciscan rocks, predominately slate, slaty shale, phyllite and foliated sandstone; (b) Thatcher Creek Member; predominately shale and graywacke which have been extensively folded and faulted; (c) Skunk Rock Member; predominately highly sheared and faulted shale and sandstone that is characterized by abundant isolated bodies of chert, schist, greenstone and intrusive ultrabasic and acidic rocks. The Plaskett Formation consists largely of rocks of the blue schist facies such as phyllite and quartz-mica schist containing minor amounts of foliated greenstone. The tunnel will penetrate about 3.5 miles of the Plaskett Formation; the remainder will penetrate the aforementioned Franciscan units. Both formations are traversed by several major faults and shear zones. Because of the extensive fracturing and faulting present in all of the rock units, moderate to heavy support would probably be required throughout.

## SOILS

### C-12. FOUNDATION CONDITIONS

a. General. Exploration in the foundation area of the Dos Rios damsite indicates that this site is geologically and topographically capable of supporting a high rockfill dam. The foundation materials in the embankment area are considered structurally strong and would present no unusual foundation problems. The materials consist of massive and moderately fractured sandstones with minor shale members and lesser amounts of chert. No major faults or shear zones pass through these rocks in the embankment area.

b. Abutments. Similar foundation conditions exist on the left and right abutments. These abutments are sparsely covered with thin, discontinuous patches of soil overburden which is underlain mostly by sandstones with some shale. The slopes of these abutments range from 35 to 40 degrees except at the bottom of the canyon where they rise almost vertically from streambed to a height of 30 to 60 feet.

c. Stripping. Stripping requirements to reach sound rock in the embankment area would be approximately 1 to 3 feet on the left and right abutments and from 10 to 15 feet in the stream channel. The streambed sand and gravel would be used as concrete aggregate and/or transition material. None of the material would be suitable for use in the impervious core element of the embankment zoning. There would be no impervious core trench requirements since the embankment would be placed on bedrock for the entire width of the dam.

d. Grouting. Foundation grouting would be required along the entire length of the dam.

e. Drainage Tunnels. Due to the pervious nature of the sandstone abutments, drainage tunnels would be required to collect and dispose of any seepage from the reservoir. These tunnels would be located in both abutments at about the third points of the maximum dam height (approximately elevations 1160 and 1400).

## C-13. DAM DESIGN AND APPURTENANT STRUCTURES

a. Dam. Except for an impervious core element, the dam would be constructed of various zones of rockfill grading from finer rock near the core to a maximum size of 24 inches on the outer slopes. The immediate damsite area would be stripped of all overburden materials, allowing the dam to rest on a foundation of sound rock. The location of the axis of the dam was established on the basis of geologic and topographic considerations. Crest length would be approximately 2100 feet and would be curved upstream on a radius of 4000 feet. Crest elevation would be 1650 for a dam height of 735 feet. This height would include 15 feet of freeboard allowance for seismic effects. The top width of the dam would be 30 feet and the average upstream and downstream slopes would be 1.0 vertical on 2.5 horizontal. A general layout of the dam is shown in Plate C-6.

b. Details of embankment zoning.

(1) Plate C-7 shows the proposed embankment zoning, the upstream and downstream slopes and the various rock zones of the dam.

(2) The central zone would contain the finer grained materials from the impervious borrow areas. This material would be impervious and would be placed as a rolled earthfill.

(3) The transition section would be comprised of filter graded materials and would be placed adjacent to the central impervious core in both the upstream and downstream sections of the dam. The transition material would be compacted in 12-inch lifts and would be graded to prevent the finer grained core material from washing into the rock zones.

(4) The zone adjacent to the transition zone would contain 6-inch maximum size stone and would be compacted in 18-inch lifts. The next zone would contain 18-inch maximum size stone and would be compacted in 24-inch lifts.

(5) The oversized rock zone would contain 24-inch maximum size stone and would be compacted in 36-inch lifts. All stone in the rock zones would be compacted with a 10-ton vibratory roller.

c. Seepage.

(1) The foundation of the dam would be grouted along the impervious core-foundation interface. The grout curtain would consist of three lines 10 feet apart. The center line of holes would be grouted on 5-foot centers with alternate holes 25 and 150 feet deep. The two outside lines would be grouted 25 feet deep on 5-foot centers. Additional holes would be provided in areas of considerable grout take.

(2) Drainage tunnels would be provided for drainage of seepage passing through or around the grout curtain. The tunnels would be located in both abutments at about the third points of the maximum dam height (approximately elevations 1160 and 1400). The tunnels would be driven parallel to the dam axis just downstream from the downstream transition section of the embankment. They would extend horizontally from about the end of the axis a distance of 400 feet toward the river channel. Their inside diameter would be 8 feet and they would be lined with concrete. Drain holes 3 inches in diameter would be drilled through the concrete lining at both the crown and the invert of the tunnel and would extend upward to within 25 feet of the interface between the embankment and the abutment and

downward to the streambed level. The holes should be drilled approximately parallel to the downstream transition slope. Spacing of holes would be based on the arrangement of joint and fracture spacing of the bedrock as determined during excavation of the tunnel. Disposition of the seepage would be through access tunnels to the face of the abutment and by drains from the access tunnel portal to the streambed.

d. Spillway and stilling basin.

(1) The profile of the spillway is shown on Plate C-7 with sections and details on Plates C-8, C-9 and C-10. The maximum cut required for the spillway excavation would be some 400 feet high and would place the spillway in sandstone. This material is sufficiently competent to allow cut slopes of 1 vertical on 0.5 horizontal with berms. The spillway side walls would be vertical and would be bolted to the sandstone bedrock with rockbolts. Three-inch diameter drain holes, located midway between rockbolts, would also be provided for drainage of the rock behind the walls.

(2) The discharge elevation at the downstream portal of the diversion tunnel would be 925. The bottom of the stilling basin would be at elevation 864. The excavation for the stilling basin would require a maximum cut of some 300 feet. This would place the basin mostly in sandstone and chert with a minor amount of shale on the right abutment. Cut slopes would be 1 vertical on 0.5 horizontal with berms. Stilling basin walls would be vertical and would be bolted to the bedrock in the same manner as the spillway walls. A detailed layout of the spillway and stilling basin is shown on Plates C-9 and C-10.

e. Diversion tunnel and emergency outlet works.

(1) Diversion of the river during the construction period would be provided for by means of a diversion tunnel, 50 feet in diameter, located in the left abutment. The plan of the diversion tunnel and emergency outlet works is shown on Plate C-6. A profile of the tunnel is shown on Plate C-7 and a typical section on Plate C-10.

(2) For the majority of its length, the diversion tunnel would be excavated in hard sandstone, but it may penetrate a 200-foot thick bed of thinly bedded sandstone and shale. Light to moderate support would be needed in that portion of the tunnel that penetrates the sandstone. Heavy support may be required in the 200-foot section of sandstone and shale. The entire length of the tunnel would be lined with concrete.

## C-14. GRINDSTONE TUNNEL

Exploration along the Grindstone tunnel alignment indicates that most of the tunnel could be driven by conventional means. The tunnel would require concrete lining along its entire length. Because of the extensive fracturing and faulting in all of the rock units moderate to heavy support would probably be required throughout. In the final design stages, detailed surface mapping and geophysical exploration would be necessary for more reliable predictions of tunneling conditions. Detailed subsurface exploration would also be required in the portal areas.

## SOURCES OF CONSTRUCTION MATERIAL

### C-15. GENERAL

a. Availability. Adequate supplies of suitable materials for use in the construction of the dam are available within a haul distance of approximately 2 miles. Impervious fill material for the core element would be obtained from an explored source two miles northeast of the damsite. Several potential sources of rock exist within one mile of the damsite.

b. Quantities. The dam would contain approximately 30.6 million cubic yards of embankment materials in place. This would include 24.3 million cubic yards for the rockfill zones, and 6.3 million cubic yards for the impervious core element. There would be available approximately 2.6 million cubic yards of material from the excavations for the dam, spillway and outlet works. All of this material would be suitable for use as rockfill. There would be little, if any, impervious material available from the required excavations. An additional 21.7 million cubic yards of rock would be required from the rock quarry areas.

### C-16. IMPERVIOUS MATERIAL

The impervious borrow area is located approximately 2 miles northeast of the damsite. The area was drilled in 1964 by the Corps of Engineers and is at present the only explored source of impervious borrow material. A total of 13 holes was drilled using a bucket auger, 24 inches in diameter. Most of the materials encountered were gravelly, sandy, and silty clays. It contains approximately

48 million cubic yards of usable impervious material. Requirements for the impervious core are 6.3 million cubic yards. Plate C-4 shows the location of the borrow area. Logs of auger borings are shown on Plate C-13.

## C-17. ROCKFILL

Sufficient rock of a suitable quality appears to be available from several sources within approximately 1 mile of the damsite. Several potential quarry sites are shown on Plate C-4. Area R-2 is presently being drilled by the Department of Water Resources; however, none of the other proposed rock sources have been investigated except for brief reconnaissance and some geologic mapping. Riprap will also be obtained from these borrow areas.

a. Borrow area R-1. Area R-1 is within the proposed reservoir area immediately upstream from the embankment on the north side of the river. An estimated 29 million cubic yards of sandstone and a minor amount of greenstone are available in this area. The sandstone appears to be similar to the sandstone in the embankment area and has an overburden depth of approximately 5 feet.

b. Borrow area R-2. The upper portion of the hill forming the right abutment contains area R-2. Rock in the hill is closely to moderately fractured sandstone with approximately 10 percent shale interbeds and minor amounts of chert. The hill contains an estimated 24 million cubic yards of rock that may be suitable for the embankment.

c. Borrow area R-3. Area R-3 is an upstream extension of the sandstone that forms the left abutment of the damsite. The sandstone appears to be the same quality as that in the embankment area. There would be an estimated 26 million cubic yards of rock available from this area.

d. Borrow area R-4. Area R-4 consists of small greenstone and sandstone noses that could be quarried as a supplemental source. Approximately 2.8 million cubic yards of usable rock are available in these two noses. In addition, the area could possibly serve as a fish hatchery site after being quarried.

e. Borrow area R-5. Area R-5 is located approximately one mile from the damsite. Rock in the area is closely to moderately fractured, moderately weathered greenstone containing minor amounts of chert. An estimated 20 million cubic yards of rock would be available in this area. The greenstone may extend southward beyond the area shown on Plate C-4, and could contain a total of 40 million cubic yards.

f. Additional borrow areas. Several additional potential quarry sites are located west of the main stem of the Eel River at distances ranging from 4 to 7 miles from the damsite.

## C-18. CONCRETE AGGREGATE

Requirement for concrete aggregate for the dam and appurtenant structures would be approximately 250,000 cubic yards and for Grindstone tunnel and appurtenances 400,000 cubic yards. This amount of material could be obtained from the stream channel excavation in the foundation area of the damsite. However, the channel deposits are coarse, consisting of poorly graded, rounded gravels, cobbles and boulders, indicating considerable crushing and processing may be necessary. An alternative source of concrete aggregate could be obtained from quarrying operations of the hard sandstones but would also require crushing and processing.

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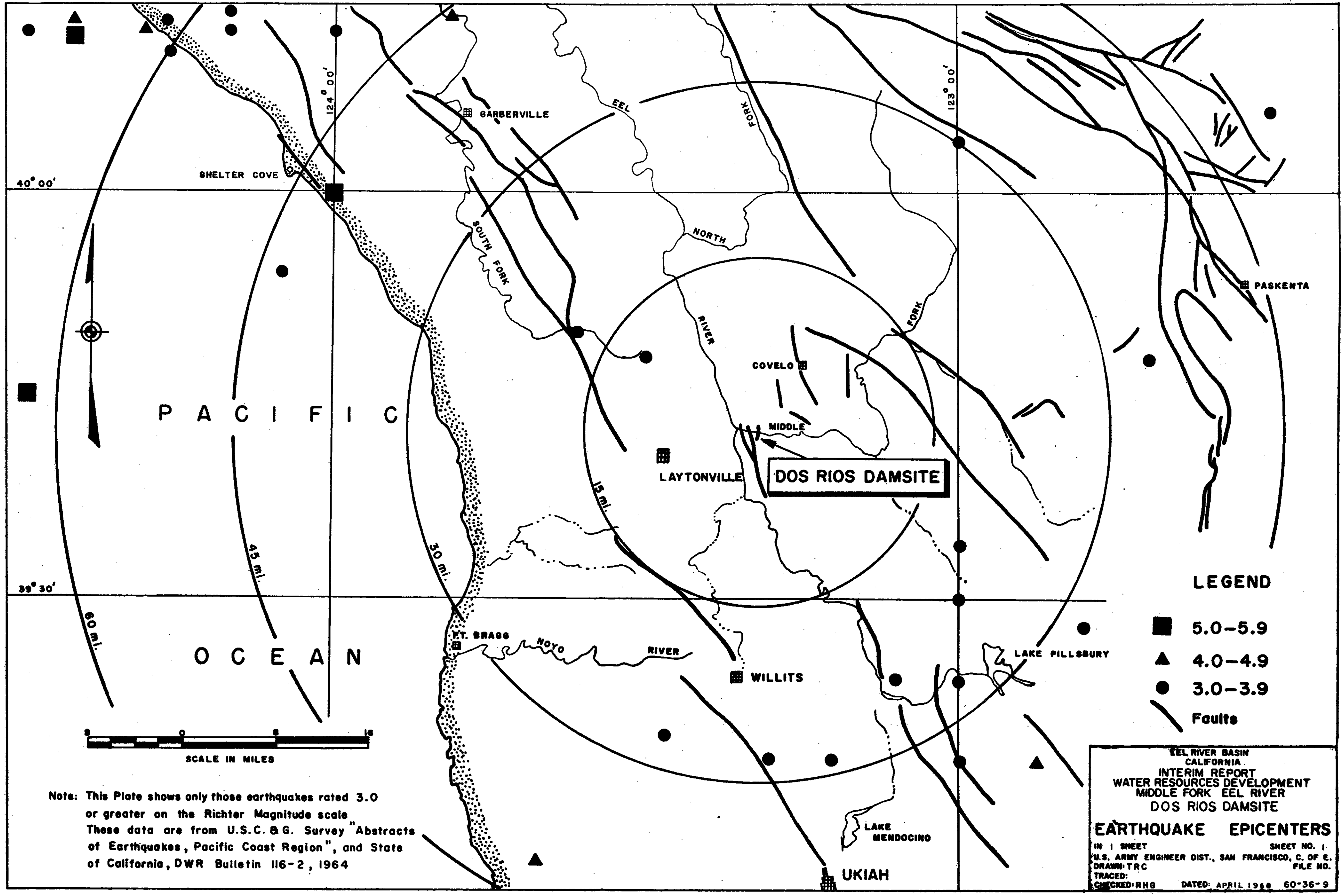
4. Irwin, W.P., "Geologic Reconnaissance of the Northern Coast Ranges and Klamath Mountains, California." California Division of Mines and Geology, Bulletin 179, 1960.
5. "Engineering Geology of Dos Rios-Grindstone Tunnel," Department of Water Resources, State of California, Office Report, December 1964.



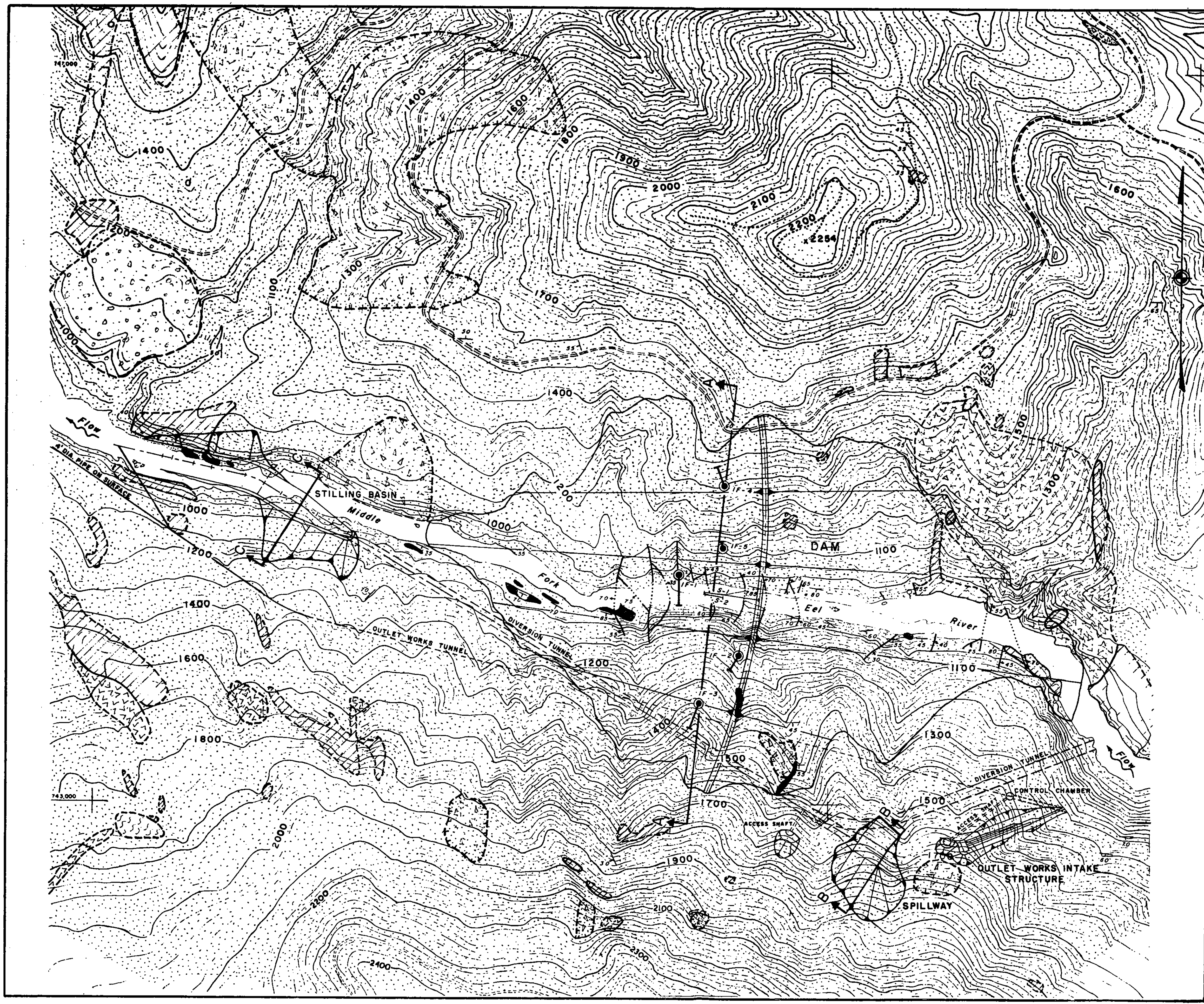
Note: This Plate shows only those earthquakes rated 3.0
or greater on the Richter Magnitude scale.
These data are from U.S.C.&G. Survey "Abstracts
of Earthquakes, Pacific Coast Region", and State
of California, DWR Bulletin 116-2, 1964

EEL RIVER BASIN
CALIFORNIA
INTERIM REPORT
WATER RESOURCES DEVELOPMENT
MIDDLE FORK EEL RIVER
DOS RIOS DAMSITE

## EARTHQUAKE EPICENTERS

IN 1 SHEET — SHEET NO. 1
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C. OF E.
DRAWN: TRC — FILE NO.
TRACED:
CHECKED: RHG — DATED: APRIL 1968 — 60-36-9

PLATE C-1



See Plate C-5 for logs of core borings.

See Plate C-3 for geologic sections.

Topography is based on California Department of Water Resources photogrammetric survey of 1960

EEL RIVER BASIN
CALIFORNIA
INTERIM REPORT
WATER RESOURCES DEVELOPMENT
MIDDLE FORK EEL RIVER
DOS RIOS DAMSITE

## DAMSITE GEOLOGY & LOCATION OF EXPLORATIONS

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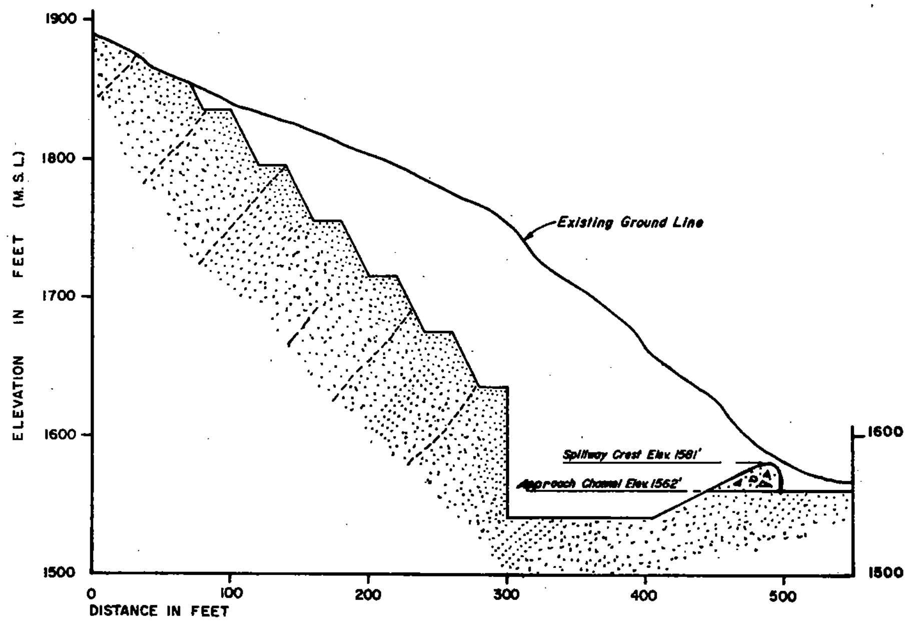
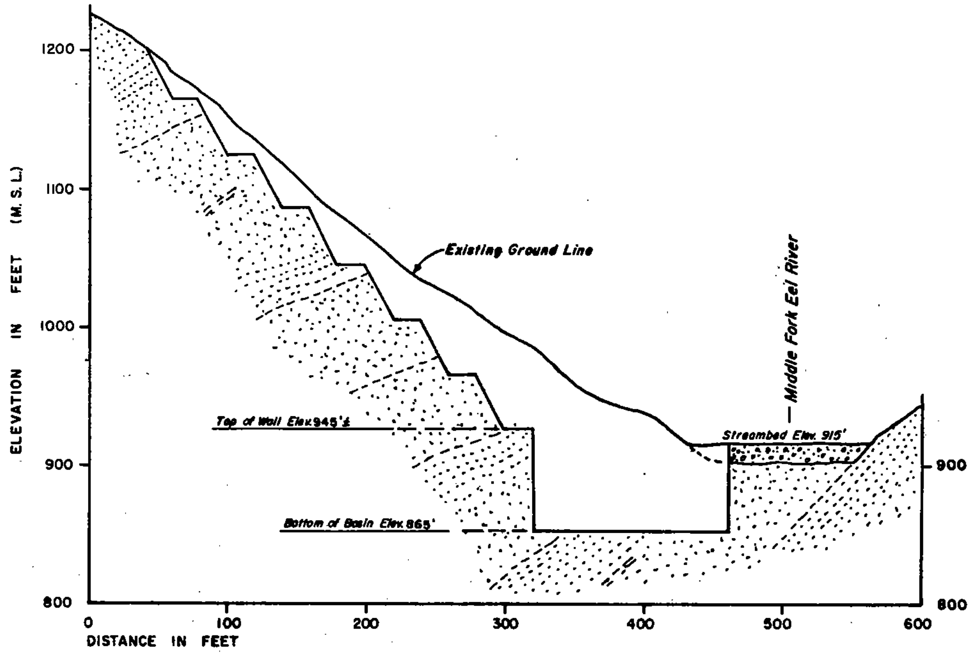
TRACED: TC — TO ACCOMPANY REPORT — 60-36-9
CHECKED: RHG — DATED APRIL 1968

PLATE C-2



GEOLOGIC SECTION B-B'
SPILLWAY



GEOLOGIC SECTION C-C'
STILLING BASIN

**EXPLANATION**

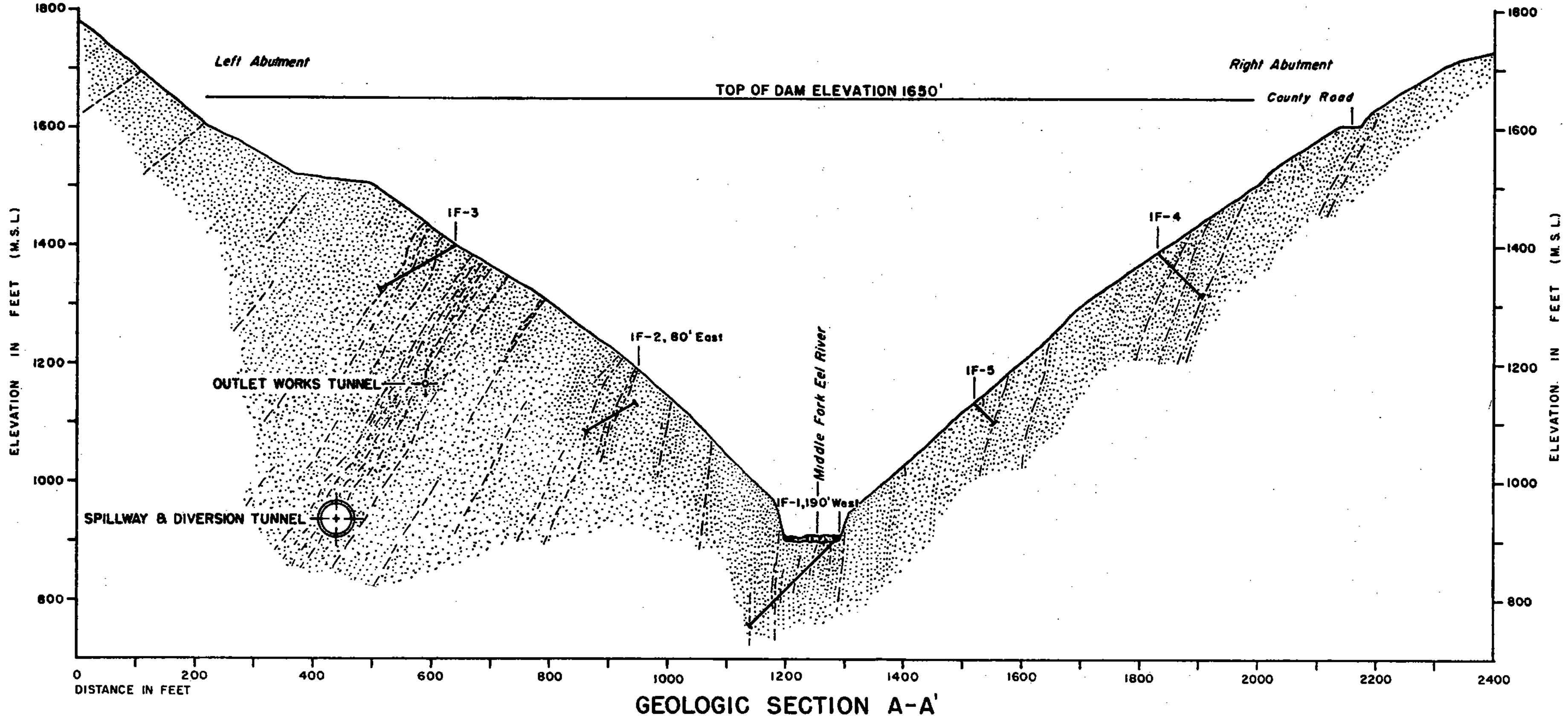
▨ Stream Deposits

▨ Sandstone (graywacke), with minor shale interbeds

IF-1 ⟋ 4-inch I.D. core boring

See Plate C-2 for location of sections and core borings.

See Plate C-5 for logs of core borings.



GEOLOGIC SECTION A-A'

EEL RIVER BASIN
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WATER RESOURCES DEVELOPMENT
MIDDLE FORK EEL RIVER
DOS RIOS DAMSITE

## GEOLOGIC SECTIONS

IN 1 SHEET
SCALE AS SHOWN
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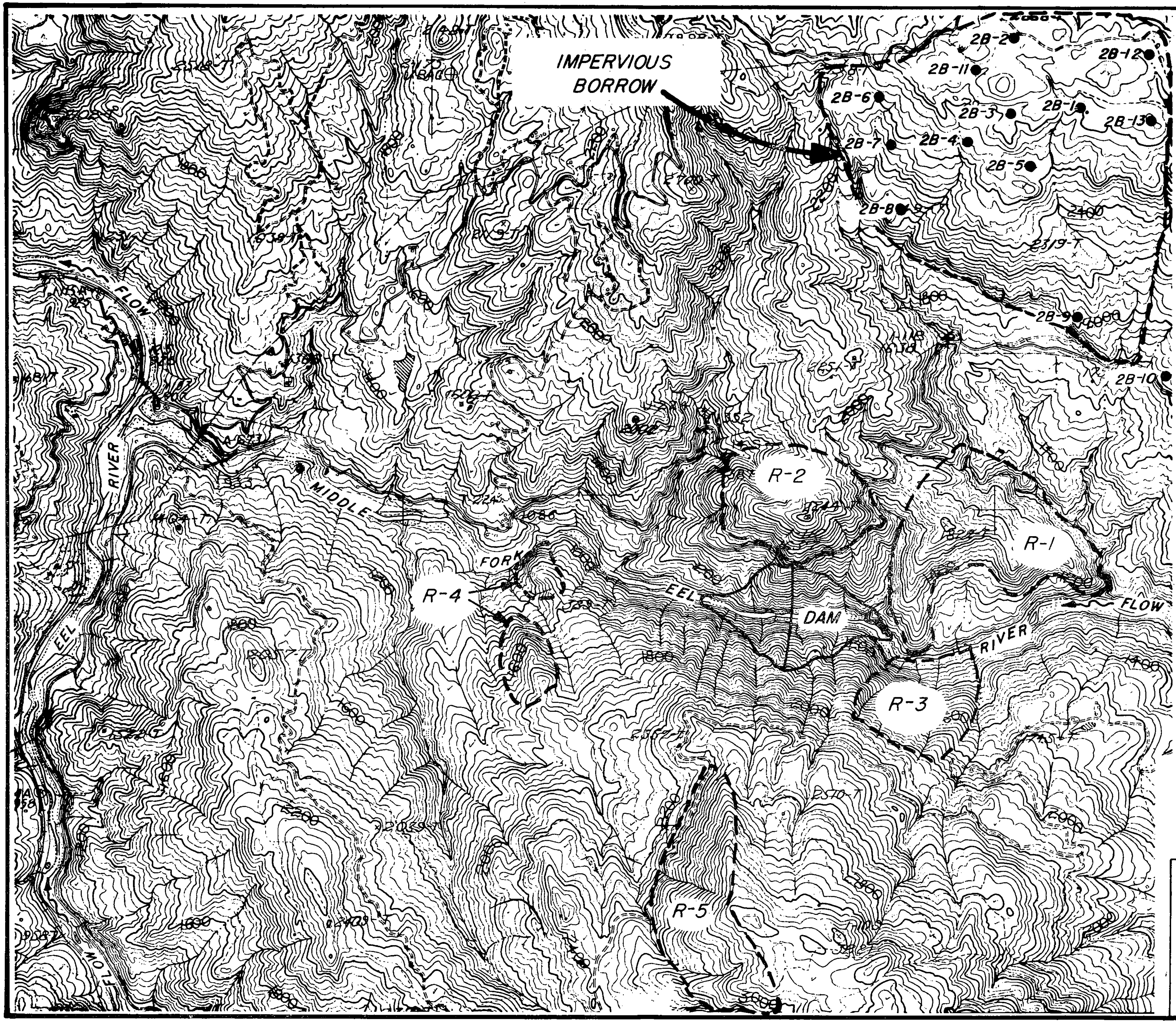
TO ACCOMPANY REPORT
DATED: APRIL 1966
FILE NO.
60-36-9

PLATE C-3



## EXPLANATION

| | |
|---|---|
| R-1 | Potential Rock Source |
| 2B-1● | 24-inch auger boring |

2000 0 2000
SCALE IN FEET

Topographic base map is preliminary issue of U.S.G.S. 1:24000, Laytonville, California quadrangle, 1964

EEL RIVER BASIN
CALIFORNIA
INTERIM REPORT
WATER RESOURCES DEVELOPMENT
MIDDLE FORK. EEL RIVER
DOS RIOS DAMSITE
SOURCES OF CONSTRUCTION
MATERIALS

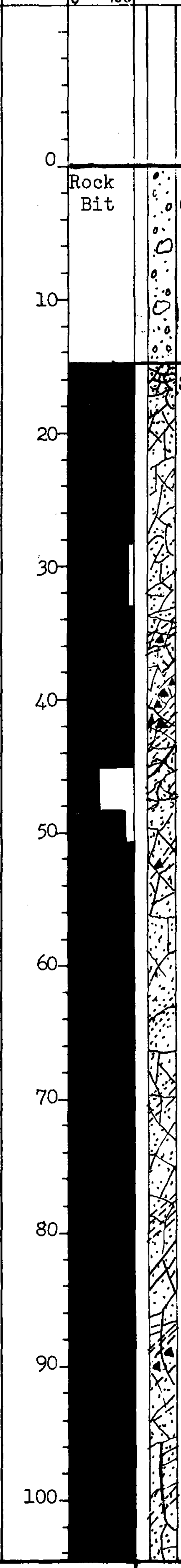
IN 1 SHEET SHEET NO. 1
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C. OF E.
DRAWN: MJS FILE NO.
TRACED:
CHECKED: RHG TO ACCOMPANY REPORT DATED: APRIL 1968 60-36-9

**PLATE C-4**

# CONDENSED LOG

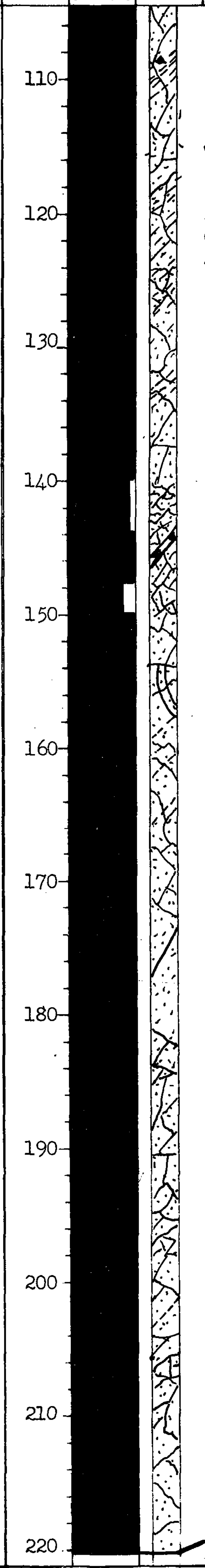
HOLE No. 1F-1 Angle 45° from Vert Bearing South

| ELEV. | DEPTH | DESCRIPTION |
|---|---|---|
| 910 | 0 | Original Ground |
| | 0.0 - 15.0 | OVERBURDEN: (stream deposit), silty sandy gravels with cobbles and boulders up to 1.5'. |
| 899 | | Top of Fresh Rock at 15.0 |
| | | SANDSTONE (graywacke); light gray, hard, fine to medium grained, well cemented, massive few minor shale beds, average dip 60°, closely fractured to 18', moderately fractured to 48', fractures randomly oriented and generally tight with some surfaces stained to 28' and coated with clay film to 42', frequently slickensided, fractures healed with quartz and calcium carbonate common. |
| | | 48-220 mostly widely spaced fractures, core lengths to 3.8'. |



HOLE No. 1F-1 (cont.)

| ELEV. | DEPTH | DESCRIPTION |
|---|---|---|
| | | open fracture at 118.2. |
| | | shale fragments and stringers common at 125.2, 133.3-135.0, 208.9-210.0, 60° dip. |
| 754 | 220 | Bottom of Hole at 220.1 |



EEL RIVER BASIN
CALIFORNIA
INTERIM REPORT
WATER RESOURCES DEVELOPMENT
MIDDLE FORK EEL RIVER
DOS RIOS DAMSITE

## LOGS OF CORE BORINGS
## 1F-1

IN 5 SHEETS SHEET NO. 1
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E
DRAWN: MJS FILE NO.
TRACED:
CHECKED: RHG TO ACCOMPANY REPORT DATED APRIL 1968 60-36-9

| | |
|---|---|
| LOCATION Right Channel | |
| DRILLED BY Diamond Drill Contracting Co. | |
| Drill Rig Joy 22 | |
| Sampler 4-inch double wall core barrel | |
| Depth of Hole 220.1 | Core Recovery 98.6% |
| Angle 45° from Vert. | Bearing South |
| Started 25 Aug 66 | Completed 4 Oct 66 |
| Inspector BI,MS,PH,JBT | Cons d Log by MJS, PH |
| Elev Orig. Ground 910.0 | Elev Top Hole 910.0 |
| Depth Top Weathered Rock - | |
| Depth Top Fresh Rock 15.0 | |
| Depth Water Table 1.0 | Date 1 Oct 66 |

### REMARKS

1. Drilled alternately with mud and water. No fluid loss from 48.3 to 118.2, zero to 75% loss from 118.2 to bottom of hole.
2. Hole cased to 19.0.
3. Bedding planes measured from plane normal to long axis to the core.

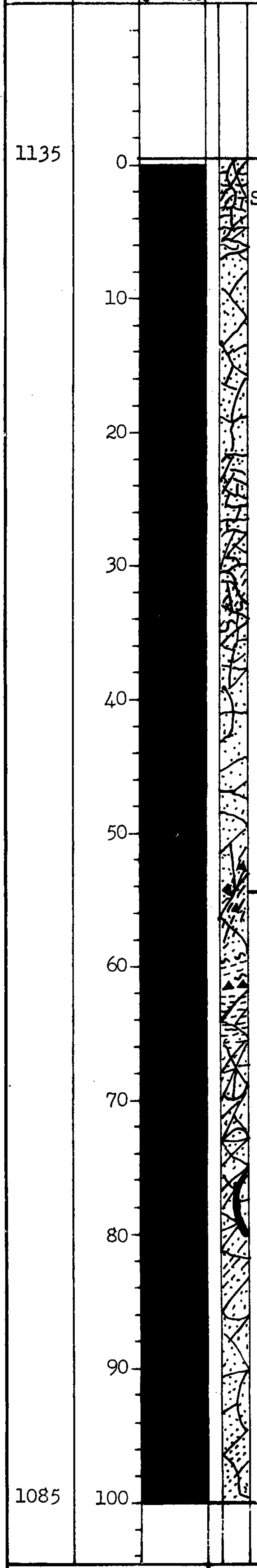
PLATE C-5

# CONDENSED LOG

HOLE No. 1F-2 Angle 60° from Vert Bearing S 30° W

HOLE No. (cont.)

| ELEV. | DEPTH | % REC'Y 0 100 | GRAPHIC LOG | DESCRIPTION |
|---|---|---|---|---|
| | | | | Original Ground<br>and top of Fresh Rock at 0.0 |
| 1135 | 0 | | | 0.0 - 100.0<br>SANDSTONE (graywacke); light gray, hard, fine to very fine grained, well cemented, medium bedded to massive, bedding dips 55°to 80°, fractures closely spaced to 7', moderately to widely spaced with closely spaced zones to bottom of hole, fractures generally tight, lightly stained to 23', randomly oriented, occasionally slickensided, numerous fractures healed with quartz-calcium carbonate, occasional thin shale stringers and fragments. |
| | | | | 54.5 - 69.0<br>thinly bedded shale and sandstone<br>61.7-62.0 soft gougey sheared shale<br>62.0-66.2 massive shale bed |
| | | | | 75.9-80.8, 1/4" seam of clayey sandy gouge parallel to long axis core |
| | | | | 80.3-83.0 shale interbeds dipping 55°to 60°. |
| 1085 | 100 | | | Bottom of Hole at 100.0 |



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CALIFORNIA
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DOS RIOS DAMSITE

## LOGS OF CORE BORINGS
## IF-2

IN 5 SHEETS SHEET NO. 2
U.S. ARMY ENGINEER DIST. SAN FRANCISCO, C OF E
DRAWN: MJS FILE NO.
TRACED: TO ACCOMPANY REPORT
CHECKED: RHG DATED APRIL 1968 60-36-9

| | |
|---|---|
| LOCATION Left Abutment | |
| DRILLED BY Diamond Drill Contracting Co. | |
| Drill Rig Longyear 34 | |
| Sampler 4-inch double wall core barrel | |
| Depth of Hole 100.0 | Core Recovery 100% |
| Angle 60° from Vert. | Bearing S 30° W |
| Started 17 Oct 66 | Completed 21 Oct 66 |
| Inspector BL | Cons'd Log by MJS |
| Elev. Orig. Ground 1135 | Elev. Top Hole 1135 |
| Depth Top Weathered Rock - | |
| Depth Top Fresh Rock 0.0 | |
| Depth Water Table - | Date |

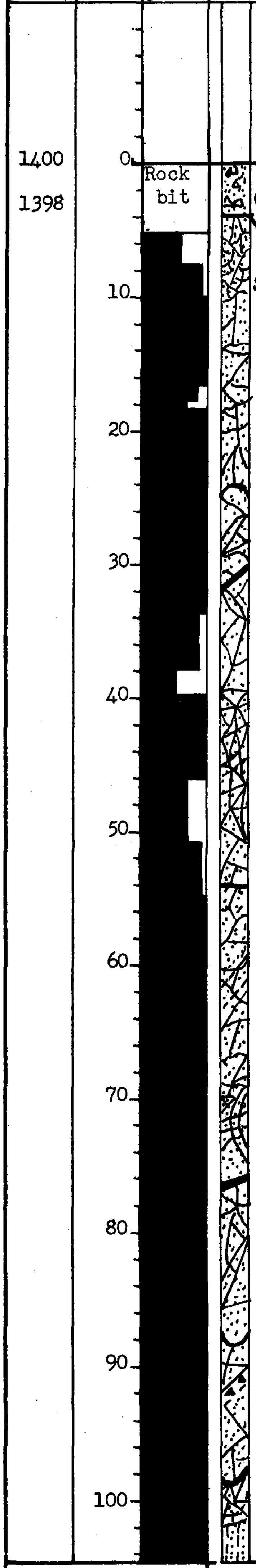
**REMARKS**

1. Hole cored with water to 48.0 and with drill mud to 100.0. Little or no fluid loss below 8.1.
2. Hole cased to 20.0.
3. Bedding planes measured from plane normal to long axis of core.

# CONDENSED LOG

HOLE No. 1F-3 Angle 60° from Vert Bearing S 22° W

| ELEV. | DEPTH | % REC'Y 0 100 | GRAPHIC LOG | DESCRIPTION |
|---|---|---|---|---|



Original Ground

0.0 - 4.0
OVERBURDEN: (Slope wash) clayey sand with abundant rock fragments.
Top of Fresh Rock at 4.0

4.0 - 150.5
SANDSTONE (graywacke); light gray with brown staining and slight leaching along fractures, hard, fine to medium grained, massive, well cemented, closely fractured to 10', moderately fractured with occasional close zones to 120', fractures randomly oriented and appear to be tight but substantial number contain tan clay coating on surfaces, thicker fracture fillings as noted, occasional roots to 100.5', some intervals have vuggy boxwork solution cavities in healed fractures.

color change to light blue-gray at 26.2', with brown-gray zones adjacent to fractures.

progressive decrease in clay coatings from 80' to bottom of hole

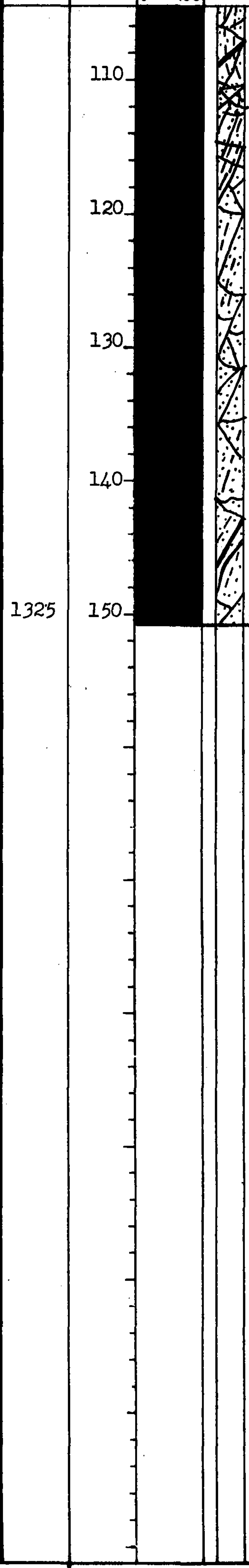
1/4" to 1/2" clay fracture fillings at 54, 89, 99, 109, 144

1" clay fracture filling at 77'

96-140 beds dip 70° to 90°

HOLE No. 1F-3 (cont.)

| ELEV. | DEPTH | % REC'Y 0 100 | GRAPHIC LOG | DESCRIPTION |
|---|---|---|---|---|



widely spaced fracturing below 120', with core lengths to 2-1/2'

Bottom of Hole at 150.5

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## LOGS OF CORE BORINGS
## 1F-3

IN 5 SHEETS SHEET NO. 3
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E
DRAWN: MJS FILE NO.
TRACED: TO ACCOMPANY REPORT
CHECKED: RHG DATED APRIL 1968 60-36-9

| | |
|---|---|
| LOCATION Left Abutment | |
| DRILLED BY Diamond Drill Contracting Co. | |
| Drill Rig Longyear 34 | |
| Sampler 4-inch double wall core barrel | |
| Depth of Hole 150.5 | Core Recovery 97.1% |
| Angle 60° from Vert. | Bearing S 22° W |
| Started 14 Octo 66 | Completed 28 Oct 66 |
| Inspector JBT | Cons'd Log by MJS |
| Elev. Orig. Ground 140.2 | Elev. Top Hole 1400 |
| Depth Top Weathered Rock - | |
| Depth Top Fresh Rock 4.0 | |
| Depth Water Table - | Date - |

**REMARKS**

1. Drilled with mud and with fresh water. Fluid return variable.
2. Hole cased to 8.0.
3. Bedding planes measured from plane normal to long axis of core.

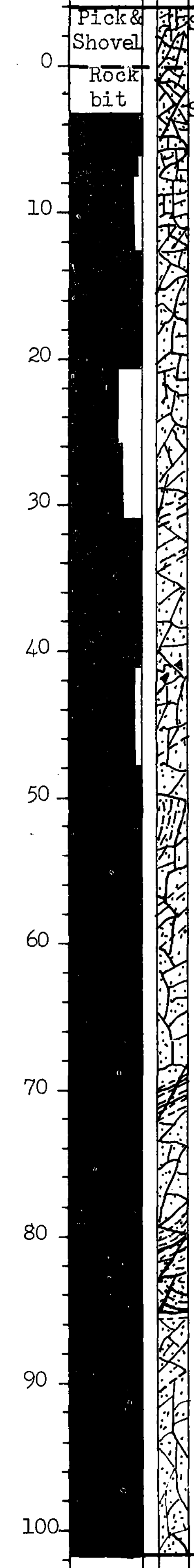
PLATE C-5

## CONDENSED LOG

HOLE No. 1F-4 Angle 45° from Vert Bearing N 17° W

HOLE No. (cont.)

| ELEV. | DEPTH | % REC'Y 0 100 | GRAPHIC LOG | DESCRIPTION |
|---|---|---|---|---|
| 1389 | | | | Original Ground & Top of Fresh Rock |
| | | Pick & Shovel | | SANDSTONE: As below<br>Collar of Hole |
| 1385 | 0 | Rock bit | | 0.0 - 101.6<br>SANDSTONE (graywacke); gray to light blue-gray, hard, very fine to medium grained, medium bedded to massive, well cemented, bedding dip 15°to 30°, closely fractured to 15', moderately fractured with occasional close zones below 15', very slight staining on fractures to 55', clay coatings on some fractures to 42', small roots in few fractures to depth 20; occasional shale laminae and inclusions. |
| 1313 | | | | Bottom of Hole at 101.6 |



| ELEV. | DEPTH | % REC'Y 0 100 | GRAPHIC LOG | DESCRIPTION |
|---|---|---|---|---|

LOCATION Right Abutment

DRILLED BY Diamond Drill Contracting Co.

Drill Rig Longyear 34

Sampler 4-inch double wall core barrel

| | |
|---|---|
| Depth of Hole 101.6 | Core Recovery 95% |
| Angle 45° from Vert. | Bearing N 17° W |
| Started 3 Nov 66 | Completed 11 Nov 66 |
| Inspector JBT | Cons'd Log by MJS |
| Elev. Orig. Ground 1389 | Elev. Top Hole 1385 |

Depth Top Weathered Rock -

Depth Top Fresh Rock 0.0

Depth Water Table - Date

**REMARKS**

1. Drilled with fresh water, no return.
2. Hole cased to 20.0.
3. Bedding planes measured from plane normal to long axis of core.

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MIDDLE FORK EEL RIVER
DOS RIOS DAMSITE

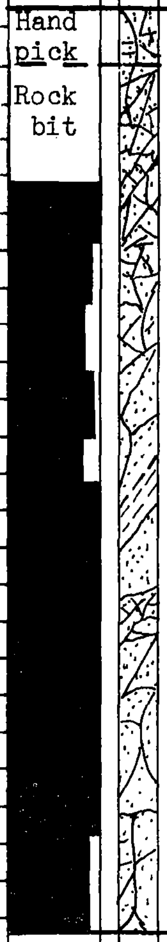
### LOGS OF CORE BORINGS
### IF-4

IN 5 SHEETS SHEET NO. 4
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C OF E
DRAWN: MJS FILE NO.
TRACED: TO ACCOMPANY REPORT
CHECKED: RHG DATED APRIL 1968 60-36-9

PLATE C-5

# CONDENSED LOG

HOLE No. 1F-5 Angle 45° from Vert Bearing N 3° W



| ELEV. | DEPTH | % REC'Y 0 100 | GRAPHIC LOG | DESCRIPTION |
|---|---|---|---|---|
| 1134 | | | | Original Ground & Top of Fresh Rock |
| 1131 | 0 | Hand pick | | Collar of Hole |
| | | Rock bit | | 0.0 - 46.5<br>SANDSTONE (graywacke); medium gray to blue-gray, hard, fine grained, well cemented, medium bedded, bedding dips 25°to 40°, closely fractured to 16', moderately fractured below 16', randomly oriented and generally tight, with clay on some surfaces to 36', slight staining to bottom of hole. |
| | 10 | | | |
| | 20 | | | |
| | 30 | | | |
| | 40 | | | |
| 1100 | | | | |
| | | | | Bottom of Hole at 46.5 |
| | 50 | | | |

HOLE No. (cont.)

| ELEV. | DEPTH | % REC'Y 0 100 | GRAPHIC LOG | DESCRIPTION |
|---|---|---|---|---|
| | | | | |

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DOS RIOS DAMSITE

LOGS OF CORE BORINGS
IF-5

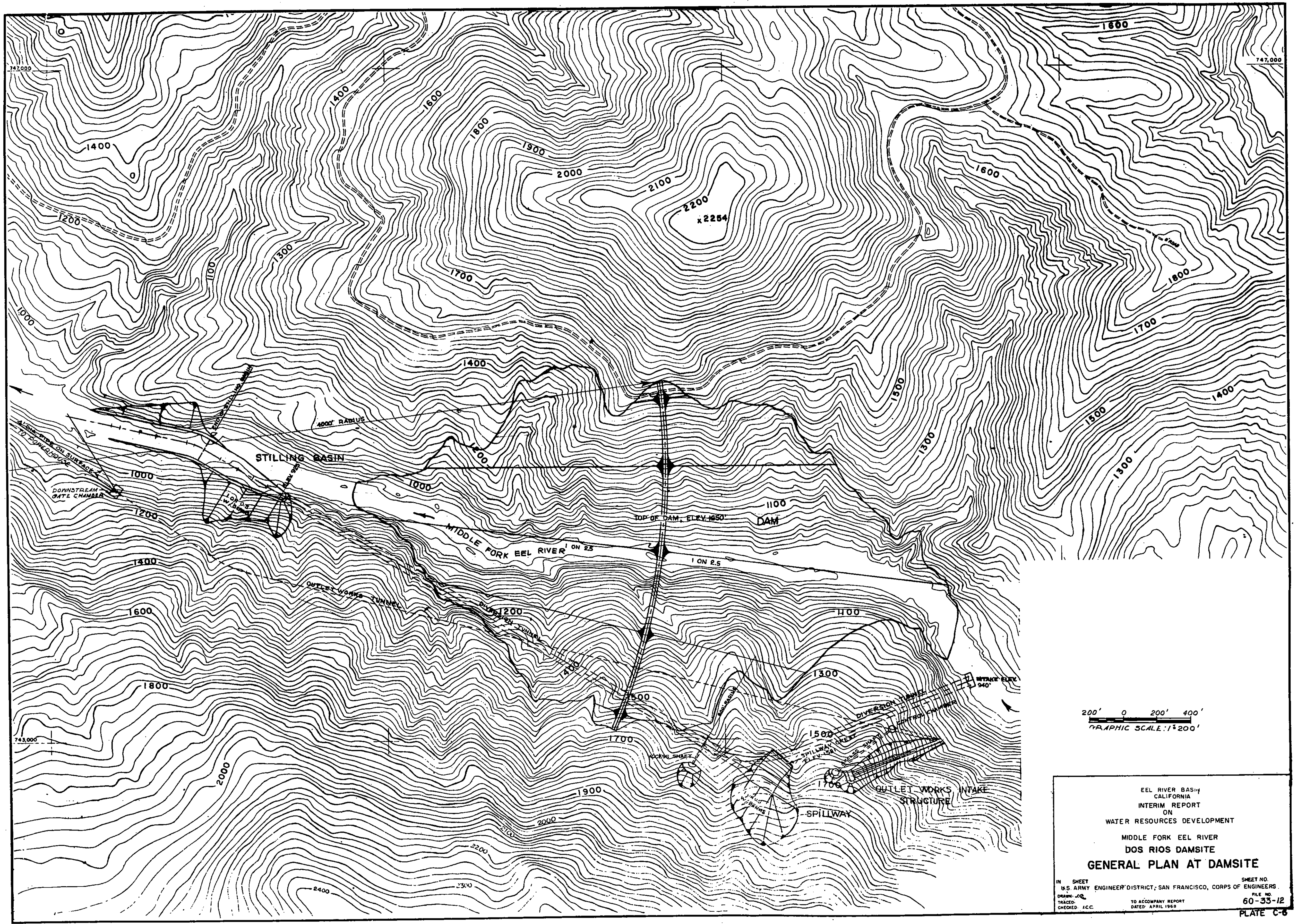
IN 5 SHEETS SHEET NO. 5
U.S. ARMY ENGINEER DIST., SAN FRANCISCO, C. OF E.
DRAWN: MJS FILE NO.
TRACED: TO ACCOMPANY REPORT
CHECKED: RHG DATED: APRIL 1968 60-36-9

PLATE C-5

LOCATION Right Abutment
DRILLED BY Diamond Drill Contracting Co.
Drill Rig Longyear 34
Sampler 4-inch double wall core barrel
Depth of Hole 46.5 Core Recovery 95.2
Angle 45° from Vert. Bearing N 3° W
Started 9 Nov 66 Completed 12 Nov 66
Inspector JBT, MJS Cons'd Log by MJS
Elev. Orig. Ground 1134 Elev. Top Hole 1131
Depth Top Weathered Rock -
Depth Top Fresh Rock 0.0
Depth Water Table - Date

## REMARKS

1. Hole cored with water; 75% return to 27.0; no return below 27.0.
2. Hole cased to 11.0.
3. Bedding planes measured from plane normal to long axis to core.



EEL RIVER BASIN
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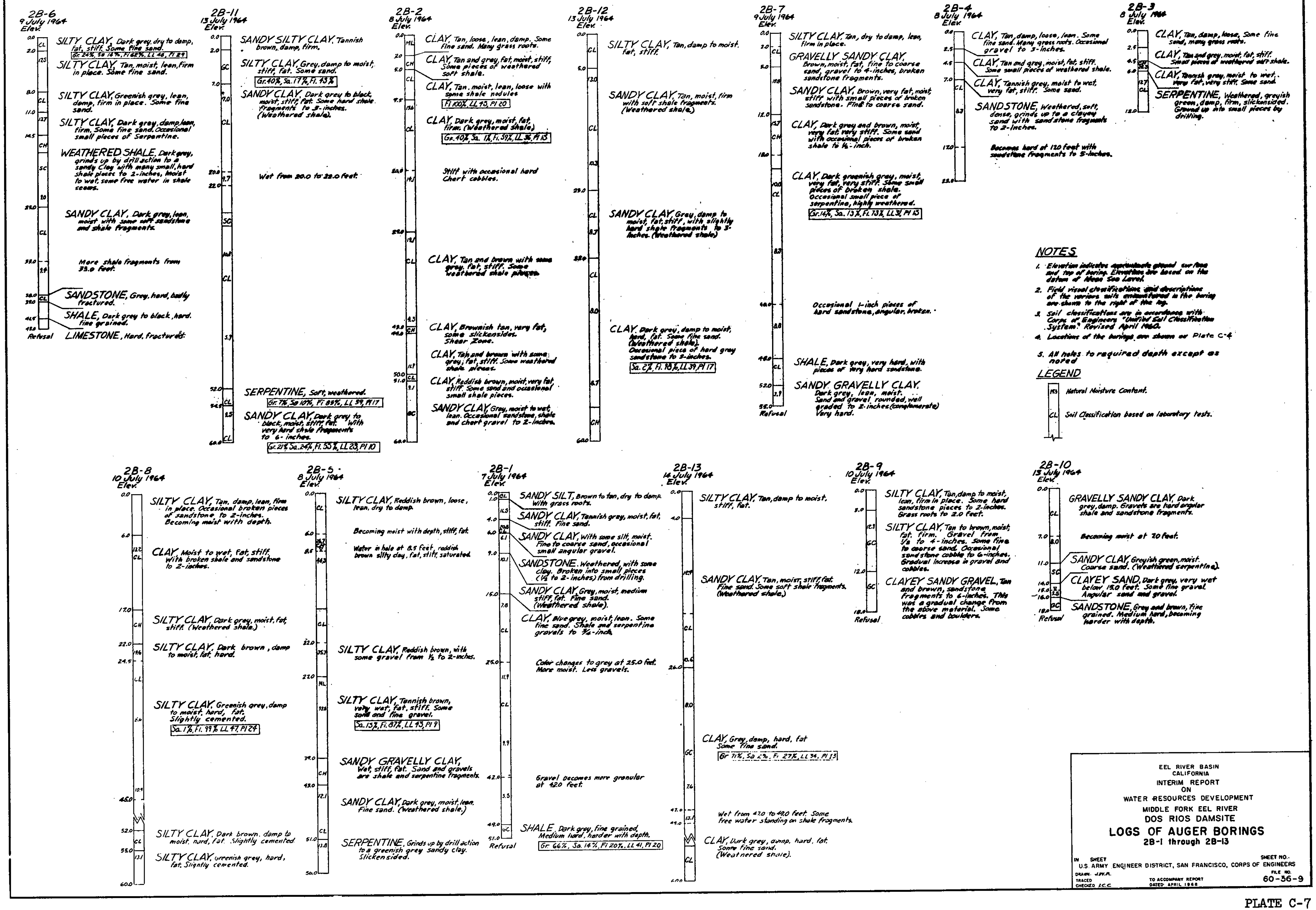
MIDDLE FORK EEL RIVER

DOS RIOS DAMSITE

## GENERAL PLAN AT DAMSITE

IN SHEET
SHEET NO.
U.S. ARMY ENGINEER DISTRICT, SAN FRANCISCO, CORPS OF ENGINEERS
DRAWN: J.C.
TRACED:
CHECKED: J.C.C.
TO ACCOMPANY REPORT
DATED APRIL 1968
FILE NO.
60-33-12

PLATE C-6



2B-6

SILTY CLAY, Dark grey, dry to damp, fat, stiff. Some fine sand.
Gr. 24%, Sa 14%, Fi 62%, LL 46, PI 29

SILTY CLAY, Tan, moist, lean, firm in place. Some fine sand.

SILTY CLAY, Greenish grey, lean, damp, firm in place. Some fine sand.

SILTY CLAY, Dark grey, damp, lean, firm. Some fine sand. Occasional small pieces of Serpentine.

WEATHERED SHALE, Dark grey, grinds up by drill action to a sandy Clay with many small, hard shale pieces to 2-inches, moist to wet, some free water in shale seams.

SANDY CLAY, Dark grey, lean, moist with some soft sandstone and shale fragments.

More shale fragments from 33.0 feet.

SANDSTONE, Grey, hard, badly fractured.

SHALE, Dark grey to black, hard. fine grained.

LIMESTONE, Hard, fractured.

2B-11

SANDY SILTY CLAY, Tannish brown, damp, firm.

SILTY CLAY, Grey, damp to moist, stiff, fat. Some sand.
Gr. 40%, Sa. 17%, Fi. 43%

SANDY CLAY, Dark grey to black, moist, stiff, fat. Some hard shale fragments to 3-inches. (Weathered shale).

Wet from 20.0 to 22.0 feet.

SERPENTINE, Soft, weathered.
Gr. 7%, Sa 10%, Fi 83%, LL 39, PI 17

SANDY CLAY, Dark grey to black, moist, stiff, fat. With very hard shale fragments to 6-inches.
Gr. 21%, Sa. 24%, Fi. 55%, LL 23, PI 10

2B-2

CLAY, Tan, loose, lean, damp. Some fine sand. Many grass roots.

CLAY, Tan and grey, fat, moist, stiff, Some pieces of weathered soft shale.

CLAY, Tan, moist, lean, loose with some shale nodules
Fi 100%, LL 45, PI 20

CLAY, Dark grey, moist, fat, firm. (Weathered shale)
Gr. 40%, Sa. 1%, Fi. 59%, LL 36, PI 13

Stiff with occasional hard Chert cobbles.

CLAY, Tan and brown with some grey, fat, stiff. Some weathered shale pieces.

CLAY, Brownish tan, very fat, some slickensides. Shear Zone.

CLAY, Tan and brown with some grey, fat, stiff. Some weathered shale pieces.

CLAY, Reddish brown, moist, very fat, stiff. Some sand and occasional small shale pieces.

SANDY CLAY, Grey, moist to wet, lean. Occasional sandstone, shale and chert gravel to 2-inches.

2B-12

SILTY CLAY, Tan, damp to moist. fat, stiff.

SANDY CLAY, Tan, moist, firm with soft shale fragments. (Weathered shale.)

SANDY CLAY, Grey, damp to moist, fat, stiff, with slightly hard shale fragments to 3-inches. (Weathered shale)

CLAY, Dark grey, damp to moist, hard, fat. Some fine sand. (Weathered shale). Occasional piece of hard grey sandstone to 3-inches.
Sa. 2%, Fi. 98%, LL 39, PI 17

2B-7

SILTY CLAY, Tan, dry to damp, lean, firm in place.

GRAVELLY SANDY CLAY, Brown, moist, fat, fine to coarse sand, gravel to 4-inches, broken sandstone fragments.

SANDY CLAY, Brown, very fat, moist, stiff with small pieces of broken sandstone. Fine to coarse sand.

CLAY, Dark grey and brown, moist, very fat, very stiff. Some sand with occasional pieces of broken shale to ½-inch.

CLAY, Dark greenish grey, moist, very fat, very stiff. Some small pieces of broken shale. Occasional small piece of serpentine, highly weathered.
Gr. 14%, Sa. 13%, Fi. 73%, LL 31, PI 15

Occasional 1-inch pieces of hard sandstone, angular, broken.

SHALE, Dark grey, very hard, with pieces of very hard sandstone.

SANDY GRAVELLY CLAY, Dark grey, lean, moist. Sand and gravel rounded, well graded to 2-inches (conglomerate) Very hard.

2B-4

CLAY, Tan, damp, loose, lean. Some fine sand. Many grass roots. Occasional gravel to 3-inches.

CLAY, Tan and grey, moist, fat, stiff. Some small pieces of weathered shale.

CLAY, Tannish grey, moist to wet, very fat, stiff. Some sand.

SANDSTONE, Weathered, soft, dense, grinds up to a clayey sand with sandstone fragments to 2-inches.

Becomes hard at 12.0 feet with sandstone fragments to 5-inches.

2B-3

CLAY, Tan, damp, loose, Some fine sand, many grass roots.

CLAY, Tan and grey, moist, fat, stiff. Small pieces of weathered soft shale.

CLAY, Tannish grey, moist to wet, very fat, very stiff. Some sand.

SERPENTINE, Weathered, greyish green, damp, firm, slickensided. Ground up into small pieces by drilling.

2B-8

SILTY CLAY, Tan, damp, lean, firm in place. Occasional broken pieces of sandstone to 2-inches. Becoming moist with depth.

CLAY, Moist to wet, fat, stiff. With broken shale and sandstone to 2-inches.

SILTY CLAY, Dark grey, moist, fat, stiff. (Weathered shale.)

SILTY CLAY, Dark brown, damp to moist, fat, hard.

SILTY CLAY, Greenish grey, damp to moist, hard, fat. Slightly cemented.
Sa. 1%, Fi. 99% LL 47, PI 24

SILTY CLAY, Dark brown, damp to moist, hard, fat. Slightly cemented.

SILTY CLAY, Greenish grey, hard, fat. Slightly cemented.

2B-5

SILTY CLAY, Reddish brown, loose, lean, dry to damp.

Becoming moist with depth, stiff, fat.

Water in hole at 8.5 feet, reddish brown silty clay, fat, stiff, saturated.

SILTY CLAY, Reddish brown, with some gravel from ½ to 2-inches.

SILTY CLAY, Tannish brown, very wet, fat, stiff. Some sand and fine gravel.
Sa. 13%, Fi. 87%, LL 43, PI 9

SANDY GRAVELLY CLAY, Wet, stiff, fat. Sand and gravels are shale and serpentine fragments.

SANDY CLAY, Dark grey, moist, lean. Fine sand. (Weathered shale.)

SERPENTINE, Grinds up by drill action to a greenish grey sandy clay. Slickensided.

2B-1

SANDY SILT, Brown to tan, dry to damp. With grass roots.

SANDY CLAY, Tannish grey, moist, fat, stiff. Fine sand.

SANDY CLAY, With some silt, moist. Fine to coarse sand, occasional small angular gravel.

SANDSTONE, Weathered, with some clay. Broken into small pieces (½ to 2-inches) from drilling.

SANDY CLAY, Grey, moist, medium stiff, fat. Fine sand. (Weathered shale).

CLAY, Blue grey, moist, lean. Some fine sand. Shale and serpentine gravels to ¾-inch.

Color changes to grey at 25.0 feet. More moist. Less gravels.

Gravel becomes more granular at 42.0 feet.

SHALE, Dark grey, fine grained, Medium hard, harder with depth.
Gr. 66%, Sa. 14%, Fi 20%, LL 41, PI 20

2B-13

SILTY CLAY, Tan, damp to moist, stiff, fat.

SANDY CLAY, Tan, moist, stiff, fat. Fine sand. Some soft shale fragments. (Weathered shale.)

CLAY, Grey, damp, hard, fat Some fine sand.
Gr 71%, Sa 2%, Fi 27%, LL 34, PI 13

Wet from 47.0 to 49.0 feet. Some free water standing on shale fragments.

CLAY, Dark grey, damp, hard, fat. Some fine sand. (Weathered shale).

2B-9

SILTY CLAY, Tan, damp to moist, lean, firm in place. Some hard sandstone pieces to 2-inches. Grass roots to 2.0 feet.

SILTY CLAY, Tan to brown, moist, fat, firm. Gravel from ½ to 4-inches. Some fine to coarse sand. Occasional sandstone cobble to 6-inches. Gradual increase in gravel and cobbles.

CLAYEY SANDY GRAVEL, Tan and brown, sandstone fragments to 6-inches. This was a gradual change from the above material. Some cobbles and boulders.

2B-10

GRAVELLY SANDY CLAY, Dark grey, damp. Gravels are hard angular shale and sandstone fragments.

Becoming moist at 7.0 feet.

SANDY CLAY, Greyish green, moist. Coarse sand. (Weathered serpentine).

CLAYEY SAND, Dark grey, very wet below 15.0 feet. Some fine gravel. Angular sand and gravel.

SANDSTONE, Grey and brown, fine grained. Medium hard, becoming harder with depth.

NOTES

1. Elevation indicates approximate ground surface and top of boring. Elevations are based on the datum of Mean Sea Level.
2. Field visual classifications and descriptions of the various soils encountered in the boring are shown to the right of the log.
3. Soil classifications are in accordance with Corps of Engineers "Unified Soil Classification System." Revised April 1960.
4. Locations of the borings are shown on Plate C-4
5. All holes to required depth except as noted

LEGEND

| | |
|---|---|
| 19.3 | Natural Moisture Content. |
| CL | Soil Classification based on laboratory tests. |

EEL RIVER BASIN
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ON
WATER RESOURCES DEVELOPMENT
MIDDLE FORK EEL RIVER
DOS RIOS DAMSITE

## LOGS OF AUGER BORINGS
2B-1 through 2B-13

IN SHEET
SHEET NO.
U.S. ARMY ENGINEER DISTRICT, SAN FRANCISCO, CORPS OF ENGINEERS
DRAWN J.W.A.
TRACED
CHECKED J.C.C.
TO ACCOMPANY REPORT
DATED APRIL 1966
FILE NO.
60-36-9

# EEL RIVER BASIN, CALIFORNIA

# INTERIM REPORT
# ON
# WATER RESOURCES DEVELOPMENT
# FOR
# MIDDLE FORK EEL RIVER

APRIL 1968

## APPENDIX D

## RECREATION, FISH AND WILDLIFE

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## TABLE OF CONTENTS (Continued)

## TABLES