State of California

THE RESOURCES AGENCY

Department of Water Resources

BULLETIN No. 126

FISH SLOUGH DAM AND RESERVOIR

Feasibility Investigation

OCTOBER 1964

HUGO FISHER
Administrator
The Resources Agency

EDMUND G. BROWN
Governor
State of California

WILLIAM E. WARNE
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PREFACE

This investigation of the feasibility of construction of a dam and reservoir at Fish Slough in Inyo and Mono Counties was made pursuant to legislative direction and was funded by appropriations during 1961-62, 1962-63, and 1963-64.

Because the enabling legislation directed that study be made of the Fish Slough site, all engineering, geologic, recreation, and economic studies were concentrated at this site.

Preliminary studies of various size reservoirs were made to determine an economic size for more detailed analysis. On the basis of these studies, a reservoir of 50,000 acre-feet capacity was selected for detailed engineering and economic evaluation. Upon completion of the seismologic, geologic, and engineering studies, it became apparent that it would be infeasible to construct a safe dam at the Fish Slough site, and that the facilities which had been postulated for construction could not perform their intended functions with an adequate degree of safety.

This report describes the investigation and the factors considered in analyzing the project feasibility. Although the project was found to be infeasible, information on the geology of the Fish Slough area and on the recreational potential of the Inyo-Mono area is being published in this bulletin. This information should be of value in future recreational planning and development in the two counties.

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TE OF CALIFORNIA—RESOURCES AGENCY
EDMUND G. BROWN, Governor
PARTMENT OF WATER RESOURCES
. BOX 388
RAMENTO

August 12, 1964

Honorable Edmund G. Brown, Governor,
and Members of the Legislature of
the State of California

Gentlemen:

I am transmitting herewith Bulletin No. 126, "Fish Slough Dam and Reservoir Feasibility Investigation," preparation of which was made possible by an initial expenditure of $20,000 from the Contingency Reserve Fund for fiscal year 1961-62, and from subsequent budget appropriations totaling $68,000 for fiscal years 1962-63 and 1963-64.

This investigation was limited to the determination of the feasibility of construction of a dam and reservoir at Fish Slough near Bishop for recreational purposes. After an intensive investigation of all engineering, geologic, and seismic factors involved, it was found that construction of a dam at the Fish Slough site is not feasible due to conditions which would make such a dam unsafe. The services of an eminent seismologist, Dr. Hugo Benioff of the California Institute of Technology, were obtained to evaluate the seismic hazards of the site.

The report contains a description of the seismic and related studies which led to the conclusion that the site was infeasible. A discussion of the recreational potential of the Inyo-Mono area is also included in the report. It is concluded that a definite demand exists in the area for water-associated recreation.

It is unfortunate that the Fish Slough damsite is not adequate and that a reservoir cannot be developed at this site to meet the recreational demand in this portion of California. I believe that it would be proper that additional appropriations be made for further studies. Such appropriations, however, should not be limited to investigating or evaluating a single project. I recommend that any enabling legislation permit us to examine several alternatives before a single plan is selected for detailed studies.

Sincerely yours,

B. Q. Goldberg

Acting Director

AUTHORIZATION

The California Water Code, in Division 6, Part 6, Chapter I, authorizes the Department of Water Resources to conduct investigations of the water resources of the State; to formulate plans for control, conservation, protection, and utilization of such water resources; and to prepare reports thereon.

In 1961, $20,000 was provided from the Contingency Reserve Fund for conducting an investigation as to the feasibility of a dam and reservoir for recreational purposes at Fish Slough. In the Budget Act of 1962, the State Legislature authorized an additional $58,000 from the General Fund to continue the investigation during the 1962-63 fiscal year. In the Budget Act of 1963, the Legislature authorized $10,000 to prepare this report with the conclusions and recommendations resulting from the investigation.

ACKNOWLEDGMENT

Valuable assistance and data used in this investigation were contributed by agencies of local, state, and federal governments and by private companies and individuals. This cooperation is gratefully acknowledged.

Special mention is made of the helpful cooperation of the following:

City of Los Angeles, Department of Water and Power

City of Los Angeles, Department of Recreation and Parks

California Department of Fish and Game

California Department of Parks and Recreation

California Department of Public Works, Division of Highways, District IX, Bishop

California Electric Power Company

Bureau of Land Management, United States Department of the Interior

Inyo National Forest, Forest Service, United States Department of Agriculture

Remstone Quarries

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

EDMUND G. BROWN, Governor
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This investigation and the preparation of this report
were conducted under the direction
of

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by

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by

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Charles A. Yelverton . . . . . Assistant Engineering Geologist

Recreation Studies were performed
by

J. Warren Gardner . . . . . Recreation Planner III

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*This investigation was under the direction of Vernon E. Valantine, Chief, Project Development Section, from July 1, 1961, to April 1, 1963.

CHAPTER I. INTRODUCTION

During the General Legislative Session of 1959, the Senate of the State of California adopted Senate Resolution No. 182 requesting the Department of Water Resources to formulate general or coordinated plans for the development of water projects within Mono and Inyo Counties and to file applications to appropriate water for use within the two counties. In response to this request the department made field and office reconnaissance studies of possible developments for additional conservation of water supplies in the Mono and Owens basins and for the enhancement of recreational opportunities. The results of these studies were presented in the Department of Water Resources report "Reconnaissance Investigation of Water Resources of Mono and Owens Basins, Mono and Inyo Counties," dated August 1960.

These reconnaissance studies revealed a number of possibilities for development of small reservoir projects which would be desirable for recreational purposes. Also, it was found that there were a number of natural lakes in the Mono and Owens basins where outlet control could be established for storage of small additional quantities of water on a seasonal basis, which could be released during summer months to make fishing conditions downstream more favorable. Therefore, water rights filings were made in October 1960, in accordance with Section 10500 of the California Water Code, at 16 potential reservoir projects for recreational purposes and at five existing lakes where additional storage could be used for streamflow maintenance and also for recreational purposes. Fish Slough Reservoir was one of these potential reservoir projects for which water rights filings were made.

In 1961, representatives of Inyo County requested the Legislature and the Governor's office to authorize the Department of Water Resources to study the feasibility of constructing a recreation project in Inyo County, with special consideration being given to the Fish Slough site near Bishop.

Objectives and Scope of Investigation and Report

This investigation was conducted to determine the engineering feasibility of, and economic justification for, constructing a dam and reservoir project for recreational purposes at Fish Slough.

In accomplishing these objectives it was necessary to: (1) study the water supply; (2) study the recreation demand, use, and benefits; (3) prepare topographic maps of the project area; (4) survey the geologic conditions and seismicity at the damsite and determine potential borrow areas; (5) undertake laboratory analyses of construction materials; (6) analyze the economic aspects of various sizes of reservoir; (7) formulate specific plans for facilities and make cost estimates; and (8) compare benefits with costs. As discussed subsequently, it was found that the damsite was not engineeringly feasible. Therefore, a complete presentation of the results of all of the studies enumerated above is not included herein.

Water supply studies included the compilation of precipitation, streamflow, and water quality records; a review of water rights filings; and an analysis of the flood characteristics of the area to determine dam spillway requirements. Topographic maps were made of the dam and reservoir site, alternative water supply conduit routes, and probable borrow areas. Geologic conditions at the damsite were determined by surface and

subsurface exploration, including drill holes and test pits, and the availability of construction materials was determined. A seismicity study was made of the area and comments of a seismologist were obtained regarding the seismic hazards of the damsite.

Recreation studies included: (1) evaluation of the present and potential recreation use in Inyo and Mono Counties and at the reservoir area; (2) prediction of projected benefits; (3) estimation of cost of recreation facilities; and (4) preparation of a recreation land-use plan. The California Department of Fish and Game conducted a preliminary evaluation of the potential of the reservoir for fish and wildlife enhancement opportunities.

The results of this investigation are presented in the chapters which follow. A description of the water supply available for the project, including discussions on sources, quantities, quality, and water rights, is presented in Chapter II. Chapter III presents a discussion of the present recreation facilities and present and potential recreation use of the Inyo-Mono area and Fish Slough. The project plan considered, including engineering, geologic, and seismic studies, is described in Chapter IV, and Chapter V presents the conclusions and recommendations resulting from this investigation.

Copies of correspondence pertinent to the investigation and a copy of the water rights filing for the Fish Slough Project are attached as appendixes at the end of the report.

Related Investigations and Reports

A number of reports containing information on recreation, hydrology, and geology applicable to the Fish Slough area were available

in the files of the Department of Water Resources. Reports of primary importance to this investigation were:

Bateman, P. C. "Geology of the Bishop Quadrangle, Mono-Inyo Counties." University of California at Los Angeles, PhD. Dissertation. 1951.

California Public Outdoor Recreation Plan Committee. "California Public Outdoor Recreation Plan." Part II. November 1960.

California State Department of Water Resources. "The California Water Plan." Bulletin No. 3. May 1957.

----. "Recreational Benefits from Upper Feather River Basin Development." Appendix A. Bulletin No. 59-2. July 1959.

----. "Reconnaissance Investigation of Water Resources of Mono and Owens Basins, Mono and Inyo Counties." August 1960.

Calloway, J. D. "Report on the Proposed Storage Reservoir at Fish Slough and the Supply Ditch from the Owens River near Bishop, Inyo County, California." Prepared for Owens Valley Water Protective Association. January 1906.

Conkling, H. "Report on Owens Valley Project, California." Department of the Interior, United States Reclamation Service. September 1921.

Outdoor Recreation Resources Review Commission. Study Report 21. "The Future of Outdoor Recreation in Metropolitan Regions of the United States." Volume III.

State Water Resources Board. "Water Resources of California." Bulletin No. 1. 1951.

----. "Water Utilization and Requirements of California." Bulletin No. 2. June 1955.

Additional studies made by these and other agencies relating to this project were reviewed and used where applicable.

Area of Investigation

The proposed dam and reservoir site in Fish Slough is located in the East central part of California in Inyo and Mono Counties, about

five miles north of Bishop as shown on Plate 1, "Vicinity Map." The slough is in the upper portions of a broad shallow depression in the volcanic tableland that lies north of the Owens River between the Sierra Nevada on the west and the White Mountains on the east. Both of these ranges have peaks attaining 14,000 feet in elevation. The valley ranges in elevation from about 4,170 feet at the damsite to 4,300 feet at the northern end; it is approximately six miles long and a maximum of two miles wide. On the east, the valley is rimmed by a steep uplifted portion of the volcanic tableland that reaches 4,650 feet in elevation and on the west merges into a gently sloping volcanic tableland which extends northwesterly towards Casa Diablo Mountain. The northern portions are relatively flat.

Fish Slough is marked by a spring-fed meandering stream which empties into the Owens River approximately two miles below and south of the damsite. The lowlands, particularly those areas adjacent to the water courses and springs, are abundantly covered with phreatophytes. Cottonwoods, willows, and other riparian vegetation are found growing near the springs.

The climate of the reservoir area is semiarid. Temperatures vary considerably during the year, with winter lows dropping below zero and summer highs exceeding 100° F. Weather bureau records for Bishop indicate that the average temperature for January is 38° F. and the average July temperature is 76° F. The average annual precipitation at Bishop is about five inches. Due to the relatively low elevation of the site and a comparatively mild spring and autumn climate, the recreation season would probably be six months long.

The reservoir site is accessible from the south over U. S. Highway No. 6 and connecting local routes, and from the north by way of a graded county road, which traverses the entire reservoir area.

CHAPTER II. WATER SUPPLY

The 23.5 square mile drainage area above the proposed damsite is characterized by sparse precipitation and highly absorptive terrain. Because of these conditions, the natural flow at the damsite is very small and originates almost entirely from springs and other seepage occurring within the reservoir area. The major portion of the water supply for the project considered at Fish Slough would be imported.

Precipitation

Precipitation in the drainage area was assumed to approximate that occurring at Bishop. Records for this station indicate the seasonal precipitation has varied from a maximum of 13.73 inches to a minimum of 1.11 inches. The average annual precipitation for the 78-year period, 1883-84 through 1960-61, was 5.36 inches. Estimated and recorded values of seasonal precipitation at Bishop for this period are presented in Table 1.

Runoff

Runoff from the Fish Slough area flows into the Owens River approximately two miles below and south of the proposed damsite. This supply would be insufficient to fill any but a very small reservoir at this site and an additional supply would have to be imported from the Owens River.

Fish Slough

Flow at the proposed damsite in Fish Slough consists primarily of rising ground water from three major springs and from the lower lying

TABLE 1

ESTIMATED AND RECORDED SEASONAL PRECIPITATION
AT BISHOP, FOR THE PERIOD
1883-84 TO 1960-61

In Inches

Season[a]	Precipitation	Season[a]	Precipitation	Season[a]	Precipitation
1883-84	2.63	1909-10	9.33[b]	1935-36	7.60[c]
84-85	1.81	10-11	12.59[b]	36-37	8.63[c]
85-86	2.03	11.12	3.29[b]	37-38	7.31[c]
86-87	3.83	12-13	4.24	38-39	6.56[c]
87-88	3.84	13-14	12.29	39-40	4.43[c]
1888-89	4.40	1914-15	7.20	1940-41	9.40[c]
89-90	7.46	15-16	11.53	41-42	5.19[c]
90-91	8.10	16-17	6.45[b]	42-43	7.44[c]
91-92	5.67	17-18	6.80[b]	43-44	3.38
92-93	6.20	18-19	3.97[b]	44-45	7.76
1893-94	2.36	1919-20	4.33[b]	1945-46	7.75
94-95	5.92	20-21	2.08[b]	46-47	4.12
95-96	4.11	21-22	5.22[c]	47-48	1.55
96-97	4.53	22-23	2.22[c]	48-49	3.07
97-98	2.01	23-24	1.11[c]	49-50	4.03
1898-99	2.68	1924-25	3.53[c]	1950-51	3.99
99-00	3.73	25-26	2.85[c]	51-52	13.73
00-01	11.51	26-27	9.52[c]	52-53	3.63
01-02	4.53	27-28	2.52[c]	53-54	6.02
02-03	2.63	28-29	1.67[c]	54-55	5.49
1903-04	7.08	1929-30	4.17[c]	1955-56	8.21
04-05	5.38	30-31	4.44[c]	56-57	3.70
05-06	8.67	31-32	6.29[c]	57-58	7.95
06-07	5.95	32-33	2.01[c]	58-59	4.17
07-08	7.65	33-34	2.67[c]	59-60	1.40
1908-09	6.35	1934-35	4.56[c]	1960-61	3.70
				78-year average -	5.36

a. Twelve-month period from October 1 through September 30.
b. Partially estimated.
c. Estimated.

portions of the reservoir area. These two sources produce an average flow of about nine second-feet. The flow is measured by a submerged rectangular orifice and an automatic water-stage recorder located approximately one-half mile downstream from the damsite.

Measured values of seasonal runoff for the 39-year period, 1922-23 to 1960-61, are presented in Table 2. The seasonal flow varied

TABLE 2

MEASURED SEASONAL RUNOFF
AT FISH SLOUGH DAMSITE

In Acre-Feet

Season*	Runoff	Season*	Runoff
1922-23	8,810	1942-43	6,670
23-24	9,000	43-44	6,390
24-25	8,860	44-45	6,200
25-26	8,880	45-46	6,380
26-27	8,610	46-47	6,310
1927-28	7,920	1947-48	6,130
28-29	7,670	48-49	6,070
29-30	7,620	49-50	6,110
30-31	7,100	50-51	6,410
31-32	6,120	51-52	6,580
1932-33	6,570	1952-53	6,020
33-34	5,660	53-54	6,020
34-35	6,130	54-55	5,710
35-36	5,680	55-56	6,200
36-37	5,610	56-57	6,070
1937-38	6,080	1957-58	6,400
38-39	5,730	58-59	5,890
39-40	5,820	59-60	5,410
40-41	6,400	60-61	5,390
41-42	6,560		
		39-year average -	6,590

*Twelve-month period from October 1 through September 30.

from a minimum of 5,390 acre-feet in 1960-61 to a maximum of 9,000 acre-feet in 1923-24. The 39-year average was 6,590 acre-feet per year.

Construction of a reservoir at this site in excess of about 10,000 acre-foot capacity would inundate the springs and general area of rising water. The effect which a full reservoir would have on this flow was not determined.

Owens River

Water to fill the reservoir initially and to replace annual evaporation and seepage losses and any releases would have to be diverted from the Owens River. The flow in the Owens River is regulated by Pleasant Valley Dam, completed in 1957 approximately six miles upstream from the point where Fish Slough discharges into the river, and by Long Valley Dam, completed in 1940 about 20 miles upstream from Pleasant Valley Dam. The estimated values of seasonal natural runoff of the Owens River below Pleasant Valley Dam for the period 1894-95 through 1960-61 are set forth in Table 3. The estimated average seasonal flow for this period was 197,510 acre-feet.

Water Rights

An overall determination of water rights in Mono and Inyo Counties has not been made. Most of the operations of the City of Los Angeles are carried out under water appropriations originating prior to the Water Commission Act of 1914. Water right permits or licenses for this exportation are not required and, therefore, are not on file with the State Water Rights Board. By acquisition of the majority of Owens Valley lands and/or water rights appurtenant thereto, the City of Los Angeles has minimized riparian claims and uses adverse to its exportation.

TABLE 3

ESTIMATED SEASONAL NATURAL RUNOFF OF
OWENS RIVER BELOW PLEASANT VALLEY DAM
1894-95 TO 1961-62

In Acre-Feet

Season*	Runoff	Season*	Runoff	Season*	Runoff
1894-95	296,000	1916-17	264,000	1938-39	167,000
95-96	250,000	17-18	201,000	39-40	175,000
96-97	254,000	18-19	197,000	40-41	214,000
97-98	174,000	19-20	167,000	41-42	224,000
98-99	176,000	20-21	170,000	42-43	208,000
1899-00	175,000	1921-22	234,000	1943-44	161,000
00-01	286,000	22-23	179,000	44-45	233,000
01-02	231,000	23-24	138,000	45-46	213,000
02-03	229,000	24-25	143,000	46-47	164,000
03-04	245,000	25-26	155,000	47-48	141,000
1904-05	205,000	1926-27	194,000	1948-49	128,000
05-06	325,000	27-28	152,000	49-50	137,000
06-07	359,000	28-29	116,000	50-51	160,000
07-08	229,000	29-30	107,000	51-52	245,000
08-09	277,000	30-31	88,000	52-53	157,000
1909-10	243,000	1931-32	173,000	1953-54	149,000
10-11	334,000	32-33	140,000	54-55	158,000
11-12	192,000	33-34	111,000	55-56	224,000
12-13	170,000	34-35	150,000	56-57	171,000
13-14	302,000	35-36	178,000	57-58	226,000
1914-15	226,000	1936-37	205,000	1958-59	144,000
15-16	246,000	37-38	325,000	59-60	121,000
				60-61	102,000
				67-year average -	197,510

*Twelve-month period from October 1 through September 30.

In the department's report "Reconnaissance Investigation of Water Resources of Mono and Owens Basins, Mono and Inyo Counties," it was concluded that water rights filings should be made by the Department of Water Resources at 21 sites, including Fish Slough, for water developments

for recreational purposes. On October 3, 1960, the department filed applications with the State Water Rights Board for the 21 sites, including Application 19778 to appropriate water from the Owens River and Fish Slough. The application provides that water will be diverted for recreational and domestic purposes from the Owens River to a 30,000 acre-foot capacity reservoir on Fish Slough at a maximum rate of 50 second-feet, not to exceed 30,000 acre-feet per year. A copy of this application is presented in Appendix A to this report.

Water Quality

The mineral quality of the water at the Fish Slough damsite and the Owens River is excellent. Analyses of water samples taken from the Fish Slough area and the Owens River near its confluence with Fish Slough indicate a total dissolved solids content of about 300 parts per million and 200 parts per million, respectively. The mineral concentrations in these waters are within the recommendations of the California State Department of Public Health for water for domestic use. In addition, the California State Department of Fish and Game states that the mineral concentrations in these waters are indicative of high aquatic fertility. Results of mineral analyses of samples taken from Fish Slough and the Owens River are listed in Table 4.

TABLE 4

MINERAL ANALYSES OF SURFACE WATER IN
FISH SLOUGH AND OWENS RIVER

Location of sampling point	Date sampled	EC x10^6 at 25°C	Constituents, in parts per million									Parts per million				
			Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl	NO_3	F	B	SiO_2	Total dissolved solids	Total hardness Ca CO_3	Percent Na
Fish Slough																	
at Spring No. 1 (NW¼ Sec. 18, T5S, R33E, MDB&M)	6-23-60	390	48	8	22	4.3	0	125	81	7	6.2	0.7	0.02	53	270	153	23
	4-22-62	319	37	1.3	22	1.7	0	134	33	6	1.0	0.56	0.05	62	214	98	32
at Springs Nos. 2 and 3 (NW¼ Sec.24, T5S, R32E, MDB&M)	4-22-62	552	49	7.7	59	6.2	0	220	75	13	0.1	1.2	0.21	60	373	154	44
1,000 feet above gaging station (NW¼ Sec. 7, T6S, R33E, MDB&M)	10-15-62	420	12	1	88	2.5	0	146	79	21	0	1.6	0.26	69	302	34	84
Owens River																	
at outlet from Long Valley Reservoir (NE¼ Sec. 19, T4S, R30E, MDB&M)	1940-41[a]	345	22	8	46	6	-	148[c]	18	21	-	0.79	-	35	195[b]	87	51

MINERAL ANALYSES OF SURFACE WATER IN
FISH SLOUGH AND OWENS RIVER
(continued)

Location of sampling point	Date sampled	EC x10^6 at 25°C	Constituents, in parts per million									Parts per million				
			Ca	Mg	Na	K	CO_3	HCO_3	SO_4	Cl	NO_3	F	B	SiO_2	Total dissolved solids	Total hardness Ca CO_3	Percent Na
Owens River (continued)																	
	1958-59[a]	339	21	5	44	5	-	154[c]	11	21	-	0.69	0.77	16.7	184[b]	73	53
at U. S. Hwy. No. 6 Bridge near Laws (NW¼ Sec. 28, T6S, R33E, MDB&M)	7-14-55	270	20	4	32	3.5	0.0	117	16	16	5.5	-	0.78	-	205	66	49
at outlet from Tinemaha Reservoir (NW¼ Sec. 26, T10S, R34E, MDB&M)	1934-35[a]	228	19	6	4	-	0.0	145	18	23	-	-	0.85	-	143[b]	71	11
	1954-55[a]	319	24	5	37	4	0.0	139	20	16	-	0.63	0.53	27	176[b]	80	50
	12-17-63	292	22	4.4	32	3.3	-	124[c]	28	13	0.6	0.70	-	19	166[b]	72	48
	3-17-64	306	24	5	40	3.8	-	124[c]	25	18	0.7	0.61	-	24	179[b]	84	51

a. Mean of 12 samples obtained at intervals of approximately one month.
b. Determined by addition of analyzed constituents.
c. Computed from total alkalinity.

CHAPTER III. RECREATION

The investigation of the feasibility of construction of a dam at Fish Slough was originally intended to be concerned not only with engineering feasibility but with economic justification as well. As the reservoir at Fish Slough was to be used only for recreation, its economic justification would dictate that the benefits to be derived from recreational use must exceed the cost of the development. However, it was subsequently found that the damsite was not suitable from an engineering standpoint, therefore, it is not necessary to present a benefit-cost analysis in this report. Nonetheless, valuable information has been developed on the present use and potential recreational demand of the Inyo-Mono area and is presented in the first part of this chapter with the aim of adding to the general subject of recreation, and in particular, water-oriented recreation.

Prior to the time it was found infeasible to construct a safe dam at the Fish Slough site, useful techniques were developed to predict total recreation demand and use, types of recreation use, and number of recreation facilities required to accommodate this use at a reservoir at Fish Slough. The methodology employed is described in the last portions of this chapter because of its applicability to other potential recreation reservoirs in the Inyo-Mono area.

Present Potential Recreational Use of the Inyo-Mono Area

The Inyo-Mono area (Inyo and Mono Counties) cover about 13,000 square miles along the central eastern portion of California. It is located about midway between the northern and southern extremities of the

State, and approximately equidistant from the large population centers of Southern California, the San Joaquin Valley and the San Francisco Bay area. Elevations vary from 280 feet below sea level at Death Valley to a maximum of 14,495 feet at Mt. Whitney. The region is easily accessible to residents of Southern California from U. S. Highway 395, the primary north-south artery in the eastern part of the State, and U. S. Highway 6 that provides access to and from the east. Access from areas lying to the west of the Sierra Nevada is more difficult. The population of Inyo and Mono Counties was only about 14,800 in 1960.

Previous studies by the Department of Water Resources and those described in this report, indicated that the Inyo-Mono area contains extensive opportunities for recreation. The natural surroundings provide an ideal environment for recreationists. Water-oriented sports, such as fishing, boating, and swimming, are popular during the summer months along the numerous streams and lakes, particularly at Mammoth Lakes, Convict, Silver, June, Grant, and South Lakes, Lake Sabrina, and Long Valley Reservoir (Lake Crowley).

Public agencies and private parties have enhanced the opportunity for water-associated sports by constructing recreation facilities adjoining natural lakes, reservoirs, and streams. The general order of magnitude of existing recreation developments in Inyo and Mono Counties is indicated in the following tabulation:

Agency administering recreation facility	Water-oriented Camp sites	Water-oriented Picnic areas	Boat launching facilities	Feet of shoreline devoted to swimming beaches	Lakes and reservoirs No.	Lakes and reservoirs Acres of water surface area
City of Los Angeles	---	---	6	150	6	6,650
Inyo and Mono Counties	800	---	---	---	---	
Inyo and Toiyabe National Forests	1,900	75	22	2,800	293	11,900
Private	3	---	20	---	14	5,250
Totals	2,703	75	48	2,950	313	23,800

Despite the efforts of public and private entities, the existing recreation facilities are not sufficient to satisfy the present demand for camping and water sports, especially fishing. During the summer months, more and more California outdoor enthusiasts are compelled to journey longer distances, often to other states, to obtain the recreation outlet they seek.

The demand for outdoor recreational facilities is being felt at all levels - local, state, and national. Since the end of World War II, visits to all recreational areas have increased markedly. Experts in the field believe that the demand for recreation will triple by the year 2000 while the population of the United States is forecast to double.

An analysis of the historical use of outdoor recreational areas can be used as an indicator of what might be expected in the future. An example of the recent and increasing emphasis that is being placed by the public and the state and federal governments on the importance of outdoor recreation is illustrated in Table 5.

TABLE 5

RECREATION USE TRENDS IN CALIFORNIA AND THE UNITED STATES IN COMPARISON WITH POPULATION TREND

Areas	Annual recreation use, in visitor-days		Percent increase
	1950	1960	
California State Parks	6,608,000	24,476,000	271
National Parks	114,291,000	254,772,000	123
National Forests	27,368,000	92,592,000	238
U. S. Bureau of Reclamation reservoirs	6,600,000	24,300,000	268
U. S. Army Corps of Engineers reservoirs	16,000,000	109,000,000	581
California population	10,586,000	15,717,000	48
United States population	150,700,000	179,300,000	19

It will be noted that the greatest percent increases in use occurred at water-oriented recreational areas, i.e., Bureau of Reclamation and Corps of Engineers reservoirs, and that recreational use for all areas is increasing at a much faster rate than is the population.

In addition to national and state trends, local trends of recreational use are even more valuable in determining future recreational demands of a specific area. Therefore, to determine the recreational demand of the Inyo-Mono area, an analysis was made of the past recreational use figures for the Inyo National Forest, Lake Crowley in Mono County, Lake Isabella in Kern County, and information contained in the "California Public Outdoor Recreation Plan," published in November 1960, by the California Public Outdoor Recreation Plan Committee.

The total recreation use for the Inyo National Forest, which surrounds the Fish Slough area to the north, east, and west, increased from 1,930,100 man-days in 1953 to 2,593,800 man-days in 1963, an increase of 34 percent. According to the City of Los Angeles Department of Recreation and Parks, angling use at Lake Crowley on the Owens River increased from 27,100 angler-days in 1953 to 60,500 angler-days in 1963 or an increase of 123 percent. At Lake Isabella on the Kern River, there were 724,800 visitor-days of use registered in 1963, an increase of 159 percent over the 1954 (earliest year attendance data available) figure of 280,000 visitor-days. For purposes of this report, the terms "man-days," "angler-days," and "visitor-days" are considered to be equivalent.

During the period 1953 to 1963, the population of the State increased only 46 percent, according to the State Department of Finance, indicating that recreational use, particularly water-associated recreation at reservoirs, is increasing at a much faster rate than the population.

Information published in the "California Public Outdoor Recreation Plan" indicates that the 1980 recreation demand for developed facilities in Inyo and Mono Counties will increase 5.3 times over the 1958 level of use. These estimates were based upon increased disposable income, leisure time, and mobility, in addition to the most basic factor, population increases.

The recreation demand in the Inyo-Mono area was projected to the year 2020 in order to estimate the magnitude of possible future use which could occur at potential recreational areas in this region if they are developed. This was accomplished by plotting the 1958 recreation use considered applicable to Fish Slough Reservoir, 3.2 million

activity-days*, and the 1980 forecasted use, 17 million activity-days, derived from information in "California Public Outdoor Recreation Plan," and extrapolating the demand as a straight line to the year 2020. This projection of outdoor recreation demand resulted in 42 million activity-days by the year 2020, or more than 13 times the 1958 level of use. The projected index of demand for each decade for the Inyo-Mono area based on these predicted activity-days is shown in Table 6.

TABLE 6

PROJECTED INDICES OF RECREATION DEMAND IN THE INYO-MONO AREA FOR SELECTED YEARS DURING THE PERIOD 1958 THROUGH 2020

Year	Index of demand
1958	1.0
1960	1.4
1970	3.3
1980	5.3
1990	7
2000	9
2010	11
2020	13

A check was made of the reasonableness of the projections beyond the year 1980 by comparison with projections made by federal agencies. In Table 6, it is indicated that the year 2000 demand would be nine times greater than the 1958 level of use, or about 6.5 times greater than the

*The term "activity-day" is defined as one person conducting one activity in one day, i.e., one person fishing, camping, and swimming in one day would be equivalent to three "activity-days."

1960 estimated use. This is reasonably close to estimates made by the United States Army Corps of Engineers in "Recreation As a Purpose of Water Resources Development," May 1962, that indicate that, by the year 2000, the recreational use of federal reservoirs may be seven times greater than it was in 1960. According to the "California Public Outdoor Recreation Plan," the United States Forest Service estimates that recreation use in national forests in California will increase from 16 million visitor-days in 1958 to about 123 million visitor-days in the year 2000, or about eight times. Because the projected increase in recreational demand for the Inyo-Mono area between 1960 and 2000 closely approximates the increases stated by the federal agencies mentioned, the year 2020 figure was assumed to be reasonable. Therefore, for the purposes of this study, the index of demand for recreational facilities in the Inyo-Mono area for each decade, as shown in Table 6, was adopted.

A comparison of the present recreation use and predicted large recreation demand in the Inyo-Mono area with the existing recreation facilities and opportunities, which are generally limited by size and climatic factors, portends the urgent need for additional reservoirs for recreation purposes, including maintenance of streamflows to enhance the fish resources. The 19 recreation lake sites reviewed in the Department of Water Resources' 1960 reconnaissance report were located on Lee Vining, Walker, Yost, Deadman, Dry, Little Hot, Convict, McGee, Crooked, Chidago Canyon, Rawson, Coyote, Cow, Baker, Independence, Lone Pine, and Summit Creeks, Lower Horse Meadows, and Fish Slough. Increased storage at existing lakes to maintain streamflow was considered on Convict, Rock, Bishop, and Big Pine Creeks. Because of the local interest and in

recognition of the intent of the legislative authorization, the investigation of developing additional recreation lakes discussed in this report was restricted to Fish Slough.

Present and Potential Recreational Use of Fish Slough

The present recreational uses at Fish Slough are limited to some fishing in the slough proper, occasional picnicking near the springs, hunting, and sightseeing. The California Department of Fish and Game estimates that about 500 angler-days of use occur annually in the slough. The principal species sought by anglers is largemouth bass, with most of the use originating locally. That department also estimates that about 200 hunter-days of use occur in the area annually. Most of the hunting effort is directed toward waterfowl with a smaller amount spent for hunting quail and rabbits.

The Petroglyph Loop Trip, a 50-mile circular route originating in Bishop and promoted by the local Chamber of Commerce, passes through the reservoir area. The southernmost of four petroglyphs is located in the reservoir area immediately west of the Fish Slough Road about five miles north of the damsite. The remaining petroglyphs are located to the north, outside of the reservoir area. The Fish Slough Petroglyphs, as well as the others, are believed to have been inscribed on the rocks by the ancestors of the local Paiute Indians.

Because there are no reservoirs at a relatively low elevation which provide a longer recreation season open to the public in the Inyo-Mono area, and because the water surface in the Fish Slough Reservoir would be held at a fairly constant level, water skiing, boating, and

swimming would be popular activities at the reservoir. However, fishing would be the principal attraction.

Fishing

At the request of the Department of Water Resources, the California State Department of Fish and Game evaluated the fishery potential of a reservoir at Fish Slough. The investigation indicated that a reservoir at this site could provide a high yield of warmwater game fishes, such as largemouth bass and sunfish. The concentration of minerals in the Owens River near the point where water would be diverted to the reservoir is such that a condition of high aquatic fertility would be achieved. In addition, the shallow portions of the reservoir would yield a high production of bottom organisms, resulting in a favorable food supply.

Based upon these and other factors it was estimated that the reservoir could support a standing crop of 400 pounds of warmwater game fishes per surface acre, assuming an absence of nongame species and fairly intensive management. The Department of Fish and Game further estimated that about 75 percent of the standing crop would be of harvestable size, resulting in harvestable crop of 300 pounds per surface acre. Based on the assumption that one-third of the harvestable crop would be caught annually, a reservoir at Fish Slough could yield 100 pounds of warmwater game fishes per surface acre per year. On the basis of a satisfactory level of angling quality of one pound per angler-day, a yield of 100 pounds per surface acre per year would support 100 angler-days per acre per year. A copy of the comments of the Department of Fish and Game is included in Appendix B to this report.

The addition of a warmwater fishery to a reservoir at Fish Slough would offer a much needed recreational opportunity to the present recreational resources of the region. While there are many lakes and streams providing trout fishing, warmwater fishing in the Inyo-Mono area is quite limited.

Hunting

A reservoir at Fish Slough would also provide a valuable resting and feeding area for waterfowl. This would be particularly beneficial late in the winter when Bridgeport Reservoir, Lake Crowley, and other waters used by these birds are frozen and the area of open water for resting is at a minimum in the Inyo-Mono area.

Camping

Because of the rather distant location of Fish Slough from the heavily populated regions from which most of the visitation would originate, much of the postulated use of a reservoir at the site would be of the week-end and holiday type. There would be heavy use by visitors with vacation trailers and campers because of the reservoir's proximity and easy access to U. S. Highways 6 and 395.

Boating, Water Skiing, and Other Uses

As stated, fishing would be the most popular use of a reservoir at Fish Slough. In addition, boating, water skiing, and swimming would also be in demand due to the limited opportunities for water contact sports in this portion of the State. The nearest water skiing areas available to the local population are Lake Isabella, 170 miles to the south in Kern County, and Mono Lake, 70 miles to the north in Mono County.

However, the high mineral content in the water of Mono Lake has resulted in very little local use for swimming or water skiing.

Recreational Demand at Fish Slough

An initial objective of the investigation was to prepare preliminary estimates of the recreational use for various sizes of reservoir at the Fish Slough site for the purpose of determining an economic size for more detailed studies. Estimates were made of the future recreational use of reservoirs of 30,000, 42,000, 60,000, and 100,000 acre-foot storage capacities. The recreational use both with and without a reservoir at the site was considered and the difference or net recreational use attributable to the reservoir was determined.

The future recreational use for a reservoir was projected for each decade until 2020 by applying the indices of demand determined for the Inyo-Mono area and presented in Table 6 to the 1958 level of use of a project area similar to the Fish Slough development. Ideally, such a comparable area should be selected on the basis of similar terrain features, elevation, recreation season, facilities and uses provided, access, and proximity to population centers. Unfortunately, there are no existing recreational reservoirs located in the immediate vicinity of Fish Slough that would satisfy all of these conditions. Those reservoirs that are located at comparable elevations and are similar in size to the Fish Slough site are closed to recreational use. The reservoirs and lakes in the area that are open are located at higher elevations, are smaller in size, and offer a smaller number of recreational activities or less overall recreational potential.

However, there are two heavily used reservoirs located somewhat near Fish Slough. One is Lake Isabella, located on the Kern River in northeastern Kern County, 170 miles south of Bishop, 60 miles northeast of Bakersfield, and 180 miles north of Los Angeles. The approximate elevation of this reservoir is 2,600 feet. It was constructed by the U. S. Army Corps of Engineers for flood control purposes and the development and management of the recreational development is administered by the Kern County Parks and Recreation Department under license agreement. The recreational development includes camping and trailer areas, picnic facilities, swimming beaches, boat launching ramps, and boating marinas. The recreational use of Lake Isabella has averaged about 750,000 visitor-days annually over the past ten years. It is estimated that about 80 percent of the users live in the Los Angeles metropolitan area. Although the reservoir is somewhat nearer to Los Angeles than Fish Slough and has a larger water surface area, data concerning the recreational use patterns at Lake Isabella were analyzed and applied, where appropriate, to the Fish Slough Reservoir investigation.

The other reservoir located near Fish Slough that offers some comparison is Lake Crowley. Located 30 miles northwest of Fish Slough at an elevation of 6,780 feet, which is about 2,500 feet higher than the Fish Slough site, Lake Crowley is one of the most popular trout fishing lakes in the State. Long Valley Dam, which creates the 5,300-acre reservoir, was built by the Los Angeles Department of Water and Power as a facility of the City of Los Angeles water supply system. The Los Angeles City Department of Recreation and Parks operates the recreational facilities at Lake Crowley for fishing only. Each year, hundreds of thousands

of trout are planted in the lake by the Department of Fish and Game. The reservoir is opened to fishing for a 90-day period each year, approximately May 1 through July 31. No camping is allowed at the lake and water contact sports are prohibited, but because of the highly successful efforts of the Department of Fish and Game and the phenomenal productivity of its waters, the lake has become famous for its excellent yield of trophy-sized trout and consequently receives exceptionally high use. It is not uncommon for 10,000 to 15,000 fishermen to travel to Lake Crowley for the opening weekend of fishing season. Recreation user-surveys indicate that over 90 percent of these anglers are from the Los Angeles metropolitan area, a round trip distance of about 600 miles.

Although a reservoir at Fish Slough would have only about one-half of the surface area of Lake Crowley, the magnitude of the recreational use would be similar. At Fish Slough the recreation season would be almost twice as long and there would be many additional attractions, such as camping and water contact sports. According to the Department of Fish and Game, a properly managed, productive warmwater fishery in this part of the State, where warmwater fishing is quite limited, would offer as great a recreational opportunity as a trout fishery. The demand for warmwater fish, which perpetuate themselves, is as great as the demand for trout which have been reared in hatcheries and planted in lakes. In view of this demand for good warmwater angling and the long recreation season and many other attractions at Fish Slough, it was estimated that the total recreational use for all purposes at Fish Slough would be at least equal to the fishing use at Lake Crowley.

The 1958 annual use at Lake Crowley of 60,000 visitor-days for fishing only was selected as the base for projecting the future recreation demand for all purposes for a reservoir at Fish Slough. The indices in Table 6 were used to project the demand shown in Table 7. The projection reveals that the recreation demand at Fish Slough would be about 200,000 visitor-days in 1970 and would increase 120,000 visitor-days each ten years thereafter, reaching 780,000 visitor-days in 2020.

TABLE 7

ESTIMATED ANNUAL RECREATIONAL DEMAND
FOR A RESERVOIR AT FISH SLOUGH

Year	Index of demand (times 1958 level of use)	Annual recreation demand, in visitor-days
1958	1.0	60,000
1960	1.4	84,000
1970	3.3	200,000
1980	5.3	320,000
1990	7	420,000
2000	9	540,000
2010	11	660,000
2020	13	780,000

Recreational Use for Alternative Sizes of Reservoir at Fish Slough

The future recreational use at Fish Slough would depend upon the size of reservoir actually selected, or more specifically, upon the extent of open water surface area available for recreational pursuits. In other words, the projected use at the reservoir would be limited by

the recreation-user capacity of the reservoir, and would be less than shown in Table 7 for those years after capacity is reached.

In estimating the recreational use of reservoirs of various sizes, consideration was given to the extent of usable water surface, the water-shoreline transition relationship, and the resulting shoreline gradient. For the smaller reservoirs considered, it was found that as much as 25 percent of the total surface area would be rendered useless for most recreational purposes because of the marsh-like conditions created by shallow water. Such areas were deducted from the gross water surface area of the reservoir in determining the potential recreational use. The gross and usable water surface areas of the four sizes of reservoir considered are set forth in Table 8.

TABLE 8

COMPARISON OF TOTAL AND USABLE WATER SURFACE AREAS FOR ALTERNATIVE SIZES OF RESERVOIR AT FISH SLOUGH

Reservoir capacity in acre-feet	Water surface area, in acres	
	Total	Usable
30,000	2,000	1,500
42,000	2,240	1,900
60,000	2,460	2,240
100,000	2,790	2,640

As stated previously, preliminary appraisals by the Department of Fish and Game indicated that a desirable fishery could be established and maintained at the reservoir and that an angling use of 100 angler-days per surface acre per year could be supported. Experience at other

reservoirs in California where a variety of recreational pursuits are offered has shown that angling use does not represent the total recreational use at a reservoir. Therefore, it is felt that a conservative estimate is that the angling use would represent only 50 percent of the total recreational use at Fish Slough.

Based upon the estimated angling use per acre of water surface, the net usable water surface areas shown in Table 8, and the ratio of angling use to total recreational use, the future recreational use for four different sizes of reservoir at the Fish Slough site was estimated and is shown in Table 9.

TABLE 9

ESTIMATED RECREATIONAL USE FOR ALTERNATIVE SIZES OF RESERVOIR AT FISH SLOUGH

Year	Annual recreation demand, in visitor-days	Annual recreation use, in visitor-days			
		Reservoir storage capacity, in acre-feet			
		30,000	42,000	60,000	100,000
1970	200,000	200,000	200,000	200,000	200,000
1980	320,000	300,000	320,000	320,000	320,000
1990	420,000	300,000	380,000	420,000	420,000
2000	540,000	300,000	380,000	450,000	520,000
2010	660,000	300,000	380,000	450,000	520,000
2020	780,000	300,000	380,000	450,000	520,000

It will be noted that for the smallest size reservoir considered, 30,000 acre-feet, recreation-user capacity is reached before the end of the first decade of use, or before 1980. For the largest size considered,

100,000 acre-feet, capacity was not reached until the third decade, or almost to the year 2000.

Preliminary estimates were made of recreation benefits associated with the projected recreation use for reservoirs of various sizes. This was accomplished by assigning a monetary value to each visitor day of recreation use. The monetary value was derived by considering round trip distance traveled from residence to Fish Slough, number of persons in the party (automobile), duration of the trip including time spent at Fish Slough, and a transportation cost per mile. The benefits thus estimated were compared with approximate costs estimated for various size reservoirs, without regard to the severe construction and operational hazards as subsequently defined. It was found that the largest net benefits (gross benefits less costs) resulted from a reservoir having a storage capacity of about 50,000 acre-feet.

The estimated gross recreational use was determined for a reservoir of 50,000 acre-foot capacity in the same manner as for the alternative size reservoirs previously described. The future recreational use of the Fish Slough area without a reservoir was also evaluated using the 700 visitor-days of fishing and hunting in 1958 estimated by the Department of Fish and Game and projecting use to the year 2020 using growth rates for these two recreation activities as presented in "California Public Outdoor Recreation Plan." The predicted use without the project was found to be only 3,000 visitor-days in the year 2020, less than one percent of the total projected recreational use of 420,000 visitor-days in that year with the project. Therefore, the future recreational use without a reservoir was not significant. The estimated recreational use

by decades for a 50,000 acre-foot capacity reservoir are presented in Table 10.

TABLE 10

ESTIMATED ANNUAL RECREATIONAL USE FOR A RESERVOIR OF 50,000 ACRE-FEET STORAGE CAPACITY AT FISH SLOUGH

Year	Annual recreation use with reservoir, in visitor-days
1970	200,000
1980	320,000
1990	420,000
2000	420,000
2010	420,000
2020	420,000

Recreational Facilities Required for a 50,000 Acre-Foot Capacity Reservoir

As the total recreation use contemplated for a reservoir at Fish Slough would consist primarily of nonlocal users, most of the recreational facilities would be geared toward overnight camping use. The high ratio of nonlocal users to local users is due to the relatively small local population (14,800 in Inyo and Mono Counties in 1960) and the anticipation that recreationists would come to the area from long distances, as has been demonstrated at Lake Crowley, Inyo National Forest, and Lake Isabella. This assumption is further supported by information contained in "The Future of Outdoor Recreation in Metropolitan Regions of the United States," Outdoor Recreation Resources Review Commission

Study Report 21, Volume III, dated 1962. Studies made in conjunction with this report emphasize the extent of the mobility of Southern Californians. Analyses presented in Study Report 21 of the origins of California state park users indicate that residents of Southern California do not hesitate to drive hundreds of miles for a weekend of outdoor recreation, and there is every indication that this pattern will be continued in the future. The report concludes that the major part of the demand for outdoor recreation facilities for vacation and weekend use is for facilities at a moderate distance from the user's home (500 miles or less).

The ratio of nonlocal users to total users at existing reservoirs located about the same distance from Los Angeles as Fish Slough was analyzed to determine what this ratio would be for a reservoir at Fish Slough. A recreation user survey taken at Lake Crowley on opening day of the fishing season in 1962 revealed that 94 percent of the visitors came from more than 100 miles away. In July of the same year, another survey at Lake Crowley indicated that 95 percent of the visitors traveled more than 100 miles. Data obtained from the Kern County Department of Parks and Recreation indicate that the nonlocal users represent about 80 percent of the total use at Lake Isabella. Data from the "California Public Outdoor Recreation Plan" indicate that the 1980 overnight use demand for recreational facilities in the Inyo-Mono area (which reflects long distance travelers) will be 96 percent of the total demand.

Because it was believed that a reservoir at Fish Slough would be particularly appealing to the local residents, or day-users, in view of the potential for water sports and the proximity of Bishop, it was estimated that the local users would contribute at least 10 percent of

the total use of the Fish Slough area. It was assumed that local use would be day use and nonlocal use would be overnight use requiring camping facilities.

By applying these percentages to the estimated total future use, as presented in Table 10, the annual overnight use and day use for a reservoir at Fish Slough was projected, by decade, as shown in Table 11.

TABLE 11

ESTIMATED OVERNIGHT AND DAY USE FOR A RESERVOIR
OF 50,000 ACRE-FOOT STORAGE CAPACITY AT FISH SLOUGH

In Visitor-Days

Year	Total annual use	Annual overnight use	Annual day use
1970	200,000	180,000	20,000
1980	320,000	288,000	32,000
1990	420,000	378,000	42,000
2000	420,000	378,000	42,000
2010	420,000	378,000	42,000
2020	420,000	378,000	42,000

The number of camping and day-use units required to accommodate the projected use at Fish Slough was determined using the following criteria:

Camping Units

- The average camping party equals four people.
- One camping party occupies one camp unit for one day and one night.
- Twenty-five percent of the total annual camping use occurs during the peak month of use.

The number of camp units should be sufficient to accommodate the average daily demand during the peak month of use. (Total annual visitors x $\frac{1}{4}$ x $\frac{1}{4}$ x $\frac{1}{30}$)

Day-Use Units

- The average day-use party equals four people.
- Each unit accommodates 1.5 day-use parties per day during peak month of use.
- Twenty-five percent of the total annual day use occurs during the peak month of use.
- Day-use units should accommodate the average daily demand during the peak month of use. (Total annual visitors x $\frac{1}{4}$ x $\frac{1}{4}$ x $\frac{1}{30}$ x $\frac{1}{1.5}$)

By applying these criteria, to the projected use values presented in Table 11, the number of overnight units and day-use units required for each decade to 2020 was determined as shown in Table 12.

Following determination of the number of camp and day-use units required to accommodate the expected recreation use for a 50,000 acre-foot capacity reservoir at Fish Slough, a recreation land use plan was developed. The plan allocated certain areas for camping, picnicking, swimming, concessions, administration facilities, boat launching, and petroglyph viewing. As this plan is applicable to only the Fish Slough site, where it is now recommended that no dam be built, further discussion of the recreation land use plan does not appear warranted. The salient features of the plan, however, are illustrated on Plate 2, "Fish Slough Reservoir Recreation Land Use Plan," together with the topography of the reservoir area.

TABLE 12

ESTIMATED NUMBER OF CAMP AND DAY-USE UNITS REQUIRED FOR A RESERVOIR OF 50,000 ACRE-FOOT STORAGE CAPACITY AT FISH SLOUGH

Period	Camp units		Day-use units	
	Number installed* during period	Total number of units	Number installed* during period	Total number of units
1970-79	485	485	35	35
1980-89	205	690	15	50
1990-99	95	785	10	60
2000-09	0	785	0	60
2010-19	0	785	0	60

*Based on mid-decade demand.

CHAPTER IV. FISH SLOUGH PROJECT PLAN CONSIDERED

The purpose of this investigation was to determine the feasibility of construction of a dam and reservoir at Fish Slough for recreational purposes. During the course of the investigation, certain facilities were considered for construction and preliminary designs and cost estimates were prepared. However, as the studies of the damsite and surrounding area progressed, and seismic hazards were evaluated, it became apparent that a safe dam could not be built at the site. The geologic studies, the physical facilities considered for construction, and a discussion of the seismic activity of the project area are presented in this chapter.

Geology

In order that a dam and reservoir such as that suggested for Fish Slough could be considered to be feasible of construction, the following conditions would have to be met:

1. The dam and reservoir site must be geologically suitable for the proposed structure and the uses to which it would be subjected.
2. Construction must be possible with available materials and present construction techniques at a reasonable cost.
3. There must be no doubt as to the safety of the proposed structures.

Areal Geology

Fish Slough is in an area which is characterized by fault block ranges and intervening basins. The Owens Valley trough, a structural

graben with the Sierra Nevada on the west and the White Mountains on the east, forms a typical unit of this area.

The proposed dam and reservoir site is underlain by rocks comprising the Bishop Tuff, an early Pleistocene accumulation of rhyolitic pyroclastic rocks. These rocks form a somewhat flat-lying and gently eastward-dipping topographic feature known as the Volcanic Tableland. The geology of the damsite and reservoir area is shown on Plate 3, "Geology of Fish Slough Dam and Reservoir Site."

The tuffs, pumice, and ash comprising the Bishop Tuff unconformably overlie rocks which range in age and type from the oldest, the Upper Palezoic metamorphic limestones, schists, and gneisses; through the Mesozoic granitic rocks; Late Tertiary basalt and andesite flows; to the youngest, the early Pleistocene glacial outwash debris of Sherwin age. These older rocks are not exposed at the damsite and were not encountered in core holes drilled during the subsurface exploration. Gravimetric studies conducted in this area by the United States Geological Survey indicate that the depth to the older crystalline rocks is probably not more than 1,000 feet beneath the Volcanic Tableland at Fish Slough.

The materials encountered during the subsurface exploratory program at the damsite consist of two general rock types: Bishop Tuff and alluvium.

The Bishop Tuff in the vicinity of the damsite consists of five units that can be classified on the basis of color, grain size, degree of jointing, degree of consolidation, and ash content.

Unit One consists of a hard, consolidated, welded tuff, displaying colors of orange, gray, tan, and pale olive brown. It is

characteristically massive and highly jointed. Joints are mostly open, but many are partially to completely filled with silt, fine sand, and debris.

A pink to orange, poorly consolidated pumiceous tuff constitutes Unit Two. This unit is soft, ranging from fine to coarse grained. The upper portion of the unit is jointed, but joints pinch out at depth. Therefore, the uppermost portion of this unit is moderately permeable.

Unit Three consists of fine-grain ash, dust, and pumice. Generally white in color, but ranging from light gray to light pink, the ash is unconsolidated, very soft, generally massive, and possesses little jointing.

Unit Four, encountered only in core drill holes, consists of light gray to white, hard welded tuff and, except for color, is very similar to Unit One. The tuff is lightweight, porous, and highly jointed. Most joints are open and some have infillings of pyrite.

Unit Five was also encountered only in core drill holes. This unit consists of an unconsolidated white to grayish pink ash which varies from very fine to coarse grained. The unit is generally massive with a few pumice layers.

The alluvium at the damsite and within the reservoir area overlies the Bishop Tuff and consists predominantly of fine-grained sandy silt derived from the surrounding Bishop Tuff.

The dominant structural feature in the area is the Fish Slough fault, which traverses the entire length of the reservoir area and extends through the damsite. This fault is traceable for a distance of at least 5-1/2 miles from the mouth of the slough northward past the springs at the

upper end of the valley. Vertical displacement along this fault is at least 300 feet and may exceed 500 feet. In addition, a complex system of faults and major joints transects the entire Volcanic Tableland, formed as a result of deformation of the tuff by the warping of the tableland during movements of the many fault blocks occurring throughout the area.

Near the lower end of Fish Slough in the vicinity of the damsite, three tilted slump blocks lie along the Fish Slough fault. As shown on Figure 1 and Plate 3, all of these blocks have been rotated or slipped so that the south ends are lower and closer to the fault than the north ends. The present position of the three blocks is due to large-scale, rotational slumping, triggered by sharp earthquake-producing movements along the Fish Slough fault. Further possible slumping and rotational movement of the blocks may occur during such seismic activity. There is also a possibility of additional slumping activity all along the eastern escarpment of the reservoir.

Water flowing from springs in the upper portion of the reservoir area is attributed to ground water originating from the northwest being forced to the surface along the west side of the Fish Slough fault escarpment, which is an effective ground water barrier. The ground water originates as precipitation on the area in the vicinity of Casa Diablo Mountain where the existence of extensive alluvial fan deposits facilitates infiltration into the ground water body within the Bishop Tuff underlying the Volcanic Tableland.

Damsite Geology

The damsite selected for detailed study is upstream from the three tilted slump blocks, as depicted on Plate 3. Two sites, located

FIGURE 1

AERIAL VIEW OF DAMSITE SHOWING SLUMP BLOCKS
ON LEFT ABUTMENT

4,500 feet and 6,500 feet downstream from the selected site, were given cursory examination and rejected because of the location of the slump blocks in the immediate vicinity of the axis and the probability of renewed slumping due to saturation of the lower portion of the slump area by the creation of a reservoir behind the dam.

Six vertical 3-inch diameter core holes were drilled and water pressure tested, two on each abutment and two in the channel section, along a line designated as section A-A' on Plate 3. After the holes were drilled, however, it was found that this line was located too close to the northernmost slump block to be considered as the axis of the proposed dam structure; therefore, the final dam axis selected for detailed study is approximately 700 feet upstream from section A-A'.

In addition to the 3-inch diameter core holes, four trenches were excavated by bulldozer in order to explore the depth to bedrock and the character of bedrock near the dam axis. Two 18-inch diameter auger holes were drilled in the windblown material on the left abutment for field permeability tests. A geologic section along the line of diamond core holes, and logs of the holes are shown on Plate 4, "Damsite Geologic Section and Core Hole Data."

The selected damsite is underlaid with alluvium and Bishop Tuff. The alluvial materials consist predominantly of fine-grained sandy silt derived from the surrounding Bishop Tuff; these materials overlie the Bishop Tuff on the eastern and central portions of the damsite. The alluvium is approximately 25 feet thick in the channel and tapers out on the right abutment. The left abutment, however, is covered with from 40 to 60 feet of loose, windblown silty sand. The Bishop Tuff varies from

a hard, massive, highly jointed tuff in its upper portion to a soft, massive unconsolidated pumiceous ash in its lower portion. The following discussion describes the damsite in more detail.

Right (West) Abutment. The right abutment is of uniform configuration, with a very gentle, westerly-rising slope of about 8 percent. The abutment, for the most part, is devoid of vegetation and overburden and where soils do occur they consist entirely of windblown silt and fine sand in small declivities in the rock. Exposed rock consists entirely of the Bishop Tuff. The rock is fresh with little or no weathering, and the joints are in varying states of being filled with silt debris.

Water pressure tests conducted during the foundation drilling indicated a permeability varying from approximately 3,000 feet per year* in the upper portion of the foundation (Unit One of the Bishop Tuff), to approximately 80 feet per year in the lower portion (Unit Two of the Bishop Tuff). The high permeability is due to the presence of interconnected open joints which extend to a depth of at least 60 to 70 feet beneath the surface. It would be extremely difficult to seal the foundation because of the open fractures in the rock and the presence of silt and debris which would interfere with grouting.

The upper portion of the abutment would require considerable shaping, dental work, and slush grouting in preparation for a cutoff. The lower portion of the abutment would require the stripping of four to six feet of loose soil and five feet of rock. Excavating a cutoff trench

*A permeability of one foot per year is equivalent to 0.0205 gallon per day per square foot of cross section under a unit hydraulic gradient.

for an impervious core section of a dam embankment would probably require some light blasting with a low intensity explosive.

Channel Section. The width of the channel section between abutments is about 500 feet and, except for a narrow section through which the stream flows, is relatively flat. Rock outcrops in the channel section are nonexistent on the east side of the slough. On the west side of the slough the hard, welded tuff is near the surface.

The channel section is filled with unconsolidated alluvial materials consisting of peat, fine silty sand, and fine gravel. As shown on Plate 4, core hole C-1 penetrated about 22 feet of alluvial material before encountering the Bishop Tuff. Core hole C-2 encountered about 13 feet of overburden before entering an inclined shear zone containing a very hard, brown volcanic breccia, which extends to a depth of about 34 feet. In the interval from 34 to 45 feet, a weathered or decomposed breccia was penetrated before entering the tuff.

Water pressure testing of the drill holes indicated that the permeability of the foundation materials in the channel section ranges from about 3,000 feet per year in the upper 60 feet to about 60 feet per year in the portion between 60 and 100 feet below the surface. The high permeability of the foundation indicates that the rock materials are highly fractured. As in the case of the right abutment, it would be extremely difficult to seal the foundation.

Average depth of stripping of the channel section would be approximately 25 feet. As stripping proceeded across the channel section from right to left, the stripping and cutoff would deepen toward the left

abutment, as shown on Plate 4. In addition to the removal of the overburden, it is probable that some dental work would be required to remove the weathered breccia to a depth of 45 feet.

Dewatering of the channel section would require the diversion of the surface flow, which rarely exceeds 15 second-feet at the damsite. Suballuvial springs which appeared during the foundation exploration will also add to the dewatering problem. Some "overexcavation" and flattened cutslopes would be required in channel stripping in order to prevent slumping.

Left (East) Abutment. The left abutment at the Fish Slough damsite is regular in configuration, with a slope of about 45 percent, and is covered by loose, windblown, silty sand and a small number of large angular blocks of talus debris from the cliff above the abutment.

The stratigraphic section on the left abutment is the same as that on the right and in the channel section, however, the Bishop Tuff comprising the rocks of the left abutment has been vertically uplifted along the Fish Slough fault about 350 feet. Geologic cross section A-A' on Plate 4 shows this relationship of the rock units of the Bishop Tuff.

The depth to firm rock is much greater on the left abutment than on the right abutment or in the channel section. Core holes LA-1 and LA-2, shown on Plate 4, were drilled to depths of 185 feet and 138 feet, respectively. Data from hole LA-1 indicated 38 feet of overburden overlies the pink tuff. White ash was encountered from a depth of about 60 feet to about 125 feet where white tuff was encountered. Drill hole LA-2 indicates the existence of 65 feet of overburden which overlies

50 feet of pale brown to pink fine-grained, consolidated tuff. Pumice and ash were encountered at a depth of about 115 feet. The ash and pumice in the left abutment are similar to the ash beds exposed along Chalk Bluffs Road and to that encountered during construction of Pleasant Valley Dam.

On the basis of the core hole data, it appears that the left abutment is cut by at least three faults, and that the Fish Slough fault is not a single plane of disruption but one of a series of near vertical uplifts along these fractures. Water pressure tests in the welded tuff indicate permeabilities similar to those in the right abutment. Water pressure tests were unsuccessful in the soft, unconsolidated ash. Two field permeameter tests were made in the windblown sand, showing an average permeability of 2,500 feet per year. The ash would probably have a permeability of about 3,500 feet per year, based upon tests of similar material by the City of Los Angeles at Pleasant Valley damsite.

The stripping depth on the left abutment would range from 43 to 70 feet including about five feet of rock. The removal of the overburden from the dam foundation would involve the excavation of a large volume of material which would have to be wasted. In addition, a large volume of windblown material would have to be removed from the upper portion of the left abutment and wasted in order to stabilize the slope. The ash beds would have to be blanketed with impervious material to reduce leakage.

Spillway and Outlet Works. The spillway considered for the dam was located on the right abutment. No subsurface exploration was made of the spillway alignment; however, the rock exposed throughout the extent

of the spillway and discharge channel consists of the hard, welded tuff of Unit One, and is the same as that underlying the right abutment. The tuff would provide a suitable foundation for the spillway. Excavation for the spillway would consist of shaping the channel and some light blasting. Except for the short transition section near the dam, lining would not be required because of the nature of the foundation material. Although some spalling could occur if the spillway were subjected to repetitive use, the rarity of a large spillway flow occurring precludes the necessity for lining. The location of the spillway is shown on Plate 2.

The outlet works considered for the dam would include a cast-in-place reinforced concrete steel-lined pressure conduit located to the right of the channel section of the foundation and extending from the heel to the toe of the embankment. The conduit would be constructed in an open trench excavated entirely in Unit One of the Tuff.

Construction Materials

The construction materials investigation consisted of sampling, testing, and delineating potential source areas for semipervious and impervious soils and concrete aggregate, rockfill, and riprap materials. Plate 5, "Location of Construction Materials," shows the location of the principal borrow areas within the reservoir area and in close proximity to the damsite. Borrow Area 1, located in the extreme upper portion of the reservoir area about five miles from the damsite, was considered as a source for impervious fill material. Borrow Areas 2 and 2A, located outside the reservoir area near the mouth of Fish Slough, were considered

as sources of semipervious fill and aggregate. Borrow Area 3, located just south of the damsite above the left abutment, was considered as a potential source of rockfill and riprap materials.

Impervious Material. The impervious soil from Borrow Area 1 near the northern limit of the proposed reservoir site consists predominantly of fine-to-medium-grained silty sands of low density and low permeability. The water table is about four feet below ground surface at the south margin of the area, but increases in depth to about 16 feet near the upper end. The average depth to water is about seven feet.

The upper three feet of soil contains organic matter and surface deposits of sodium bicarbonate evaporites and would have to be stripped and wasted. The volume of material available from Borrow Area 1 is estimated to be at least 800,000 cubic yards.

Semipervious Material. Semipervious materials obtained from Borrow Area 2 and tested in the laboratory are classified as poorly-graded to well-graded gravels and silty gravels. The dry density of the tested materials varies from 102 pounds per cubic foot to about 121 pounds per cubic foot. Optimum moisture content of these materials is about 13 percent. Slow direct shear tests reveal shear angles of about 43 degrees. Average permeability of the material is about 45 feet per year. At least 800,000 cubic yards of pervious material is available from Borrow Areas 2 and 2A.

Concrete Aggregate. The granular materials presently being processed at the gravel pit at the mouth of Fish Slough consist of fresh to moderately weathered igneous and metamorphic rock fragments ranging

from six to eight-inch cobbles to fine sand. About 25 percent of the material passes through the No. 50 sieve. Very small percentages of clay-size particles are present.

The gravels are derived predominantly from the Sierra Nevada igneous and metamorphic complex although a small percentage of the aggregate materials is derived from the Bishop Tuff. The aggregate constituents derived from this latter source contain very high percentages of volcanic glass and pumice. Because of the volcanic constituents the aggregate would be highly reactive in concrete mixes, and low alkali cement would have to be used in all concrete made with aggregates from this source.

Riprap and Rockfill. At least 450,000 cubic yards of rock for riprap and rockfill is readily available from Borrow Area 3, shown on Plate 5. The rock in this area is the upper unit of the Bishop Tuff, which occurs as the cap rock of the large slump block lying immediately downstream of the left abutment of the dam.

Large blocks of the consolidated welded tuff, ranging in size from 4 to 20 feet are readily available. Rock of this same type was utilized as riprap at Pleasant Valley Dam on the Owens River.

General Plan of Project Facilities Considered

Considered in this investigation were all of those facilities that would be required to provide a recreational area to support the recreational use estimated in Chapter III. Included were the dam and appurtenant structures, a water supply conduit to convey water from the Owens River to the reservoir, the recreation facilities, the relocation of Fish Slough Road around the reservoir area, and the acquisition of lands and easements required for the project.

Dam, Reservoir, and Appurtenant Structures

The dam considered for construction would have been located on Fish Slough, approximately two and one-half miles above its confluence with the Owens River, one mile south of the Inyo-Mono County line, and five miles north of Bishop. Streambed elevation at the proposed damsite is 4,168 feet above mean sea level.

The entire reservoir area was mapped in 1962 by stereoscopic methods at a scale of one inch equals 400 feet with a contour interval of 10 feet. In addition, the area near the proposed damsite was mapped at a scale of one inch equals 200 feet with a five-foot contour interval. Table 13 indicates the water surface area and storage capacity of the

TABLE 13

AREAS AND CAPACITIES OF A RESERVOIR AT FISH SLOUGH

Depth of water at damsite, in feet	Water surface elevation, in feet	Water surface area, in acres	Storage capacity, in acre-feet	Average depth of water in reservoir, in feet
0	4,168	0	0	0
2	4,170	3	3	1
12	4,180	262	1,326	5
22	4,190	1,175	8,513	7
32	4,200	1,857	23,674	13
42	4,210	2,267	44,295	20
52	4,220	2,531	68,285	27
62	4,230	2,743	94,656	34
72	4,240	2,942	123,083	42
82	4,250	3,148	153,534	49

reservoir site at ten-foot increments determined by planimetering the contour map. It will be noted that a large water surface area and storage capacity can be attained with a relatively shallow depth of water.

The zoned earth and rockfill dam considered in this investigation would have risen 69 feet above streambed to an elevation of 4,237 feet, requiring 980,000 cubic yards of embankment material. The normal water surface elevation would be 4,212, creating a storage capacity of 50,000 acre-feet of water. The large freeboard (distance from normal water surface to crest of dam), 25 feet, was an attempt to provide suitable allowance for possible offset in recognition of the active fault extending through the damsite. The reservoir would inundate practically all of the valley area adjacent to Fish Slough and would extend about five miles upstream from the dam into southern Mono County. The pertinent features of the dam and reservoir selected for detailed analysis are as follows:

FEATURES OF FISH SLOUGH DAM AND RESERVOIR
SELECTED FOR PRELIMINARY DESIGN

RESERVOIR

Drainage area, in square miles	23.5
Normal water surface elevation, in feet above mean sea level	4,212
Maximum pool storage capacity, in acre-feet	50,000
Normal pool surface area, in acres	2,330

DAM STRUCTURE

Type	zoned earth and rockfill
Crest elevation, in feet above mean sea level	4,237
Crest height, in feet above streambed	69
Crest length, in feet	2,000
Total embankment, in cubic yards	980,000

Embankment. The 980,000 cubic yard embankment section considered would contain a moderately thick core section of impervious material, obtained from a borrow area located in the upper portion of the reservoir area approximately five and one-half miles from the damsite. The core would be flanked on the downstream side by a transition zone of selected material. Overlying the transition zone would be a rockfill zone. Overlying the core on the upstream side would be a semipervious embankment zone of silty gravel obtained from a borrow area located about two and one-half miles from the damsite near the mouth of Fish Slough. The upstream semipervious zone would be covered with a layer of riprap. Upstream and downstream slopes would be 3-1/2:1 and 1-3/4:1, respectively.

Spillway. The uncontrolled spillway considered for the dam would be located in the right abutment and would include an unlined approach channel, a reinforced-concrete lined ogee-type weir section, and an unlined chute. The crest of the weir would be at elevation 4,212 feet, and the approach channel to the spillway would be excavated to elevation 4,207 feet. The spillway chute would be a trapezoidal section and would discharge flood flows into Fish Slough downstream from the toe of the dam. A nominal weir crest length of eight feet was used and would be more than adequate to discharge the routed spillway outflow of 40 second-feet resulting from the maximum probable storm on the reservoir drainage area.

Outlet Works. The outlet works considered for the dam would be located on the right side of the slough and would be used for both diversion of the slough waters during construction of the embankment and for release of water in storage after construction. The outlet works

would have a maximum capacity of 1,300 second-feet under a maximum head of 44 feet and would be capable of emptying the reservoir within three weeks. The outlet works would include an intake structure, pressure conduit, and outlet structure. The intake structure would be a submerged, drop inlet type with a hydraulically operated pressure slide gate and a trashrack. A cast-in-place reinforced concrete steel-lined pressure conduit with cutoff collars would carry the releases through the dam to an outlet structure consisting of a deflector and plunge basin to dissipate the energy.

Water Supply Conduit

The reservoir contemplated for Fish Slough would be filled and maintained with water diverted from the Owens River. Three diversion and supply systems with a conveyance capacity of 50 second-feet were studied and a cost comparison was made to aid in the selection of the system. The 50 second-foot capacity was selected because this was the diversion capacity included in Application 19778, filed by the State Department of Water Resources with the State Water Rights Board on October 3, 1960. This diversion rate would permit initial filling of the reservoir in about 16 months and annual replenishment to offset evaporation and seepage losses in about 16 weeks. Smaller capacities were considered and found to be less costly but would of necessity extend the initial and annual filling periods.

A brief discussion of each of the three systems studied follows:

Gravity Diversion from Owens River. A 5.7 mile-long gravity water supply conduit to divert water from the Owens River approximately

three miles upstream from the existing McNally Canal diversion of the City of Los Angeles located near the mouth of Fish Slough and shown on Plates 3 and 5. The diverted water would flow by gravity in an open concrete-lined, trapezoidal section canal easterly along the north bank of the river and thence northerly to the damsite. For about three miles, the canal would be located in the side of a steep bluff along the river. Siphons would be necessary to conduct the flow of water across canyons. No foundation exploration was conducted along the conduit route, however, the foundation is primarily Bishop Tuff material and should be satisfactory after the removal of loose debris. Large blocks of rock perched above the canal alignment along the base of the steep cliffs would have to be stabilized or removed. Slopes above the canal in alluvial material would be 2:1 and in the rock would be 1:1.

Pumping Diversion from Owens River. A pumping diversion scheme to divert water from the Owens River at a point just upstream from the existing McNally Canal diversion, thus eliminating about three miles of conduit required with the gravity scheme just described. A pumping plant located just north of Chalk Bluff Road would be needed to lift the diverted water through a pressure conduit to an open, concrete-lined, trapezoidal section canal, where it would flow by gravity to the damsite, following the same route as in the gravity scheme. The pumping plant would operate under a head of about 50 feet. As in the gravity scheme, siphons would be necessary to conduct the flow of water across canyons.

Diversion from Existing Upper McNally Canal. The third diversion scheme considered was to divert Owens River water from the City of

Los Angeles' existing Upper McNally Canal at its northernmost point in Fish Slough. This existing canal has a maximum conveyance capacity of about 75 second-feet, compared to the contemplated capacity of the conduit of 50 second-feet. The diverted water would be pumped through a pressure conduit to an open concrete-lined, trapezoidal section canal, where it would flow by gravity to the damsite following the same route as in the two previous schemes. Here again, siphons would be necessary to conduct the flow of water across canyons. This scheme would eliminate about 1.6 miles of conduit over that in the pumping diversion scheme and about 4.6 miles over that in the gravity scheme. However, diversion operations to Fish Slough Reservoir would be much less flexible and reliable in this scheme because of possible interference from existing water spreading and irrigation operations which utilize the Upper McNally Canal.

Comparison of Alternative Water Supply Schemes. A comparison of the three alternative water supply schemes indicated the gravity scheme to be more costly than either of the pumping schemes. The comparison also indicated that the scheme which made use of the Upper McNally Canal to divert water to the reservoir would be the least costly of the three schemes studied due to the shorter length of conduit required. Although this latter scheme was found to be superior from the standpoint of economics, the other pumping scheme was preferable because there would be no possibility of interference from operations of the City of Los Angeles which involve use of the existing Upper McNally Canal.

Recreation Facilities

The development of a water-oriented recreation area at Fish Slough would require the installation of camp units, picnic units, beach

area, boat launching ramps, and boat dock. In addition, water supply and sanitary facilities would be required, as well as access roads and other items required for the proper operation and maintenance of the recreation facilities. Recreation facilities required at Fish Slough for each decade until 2020 were listed previously in Table 12.

Land Requirements, Relocations, and Easements

Construction of a dam and reservoir at Fish Slough would require the acquisition of 5,520 acres of land and the relocation of 7.2 miles of Fish Slough Road around the reservoir area. The land requirements for the project and the relocated road are shown on Plate 2. In addition, approximately 70 acres below the reservoir would be leased to obtain semipervious embankment material for the dam and a permanent easement would be obtained for the water supply conduit and pumping plant.

Project Costs

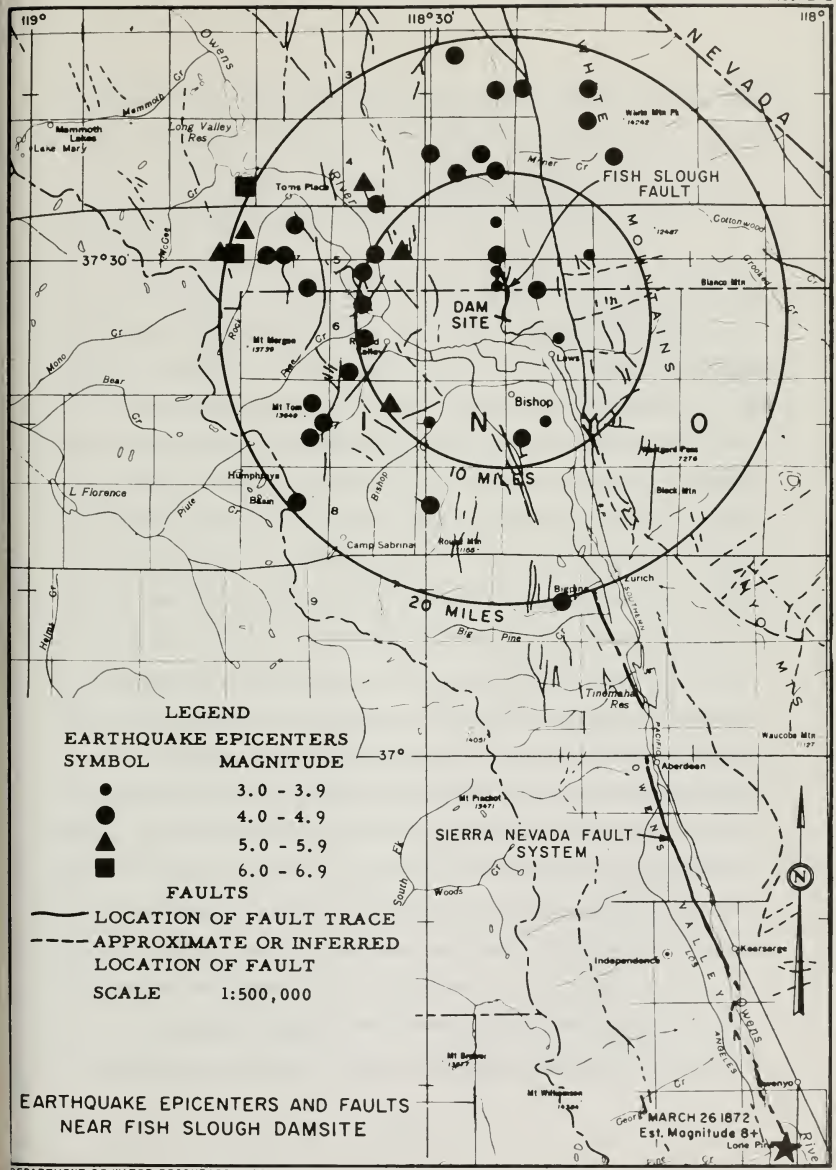
As previously stated, estimates of approximate costs were prepared for various sizes of recreation reservoirs and compared with anticipated benefits resulting from these reservoirs to determine the optimum structure producing the largest net benefits. Subsequently, as additional information became available on subsurface conditions and potential landslides at the damsite, the project costs were increased accordingly. Although it is now concluded that a safe dam cannot be constructed at Fish Slough, it is important to note that the capital cost of a 50,000 acre-foot capacity reservoir project, as previously described, and a water supply conduit, recreation facilities, and the required lands and easements was estimated to be in the general order of 13 million dollars.

However, project costs would exceed this value if subsurface conditions proved less suitable than those predicted from limited exploration. It is probable that project costs would exceed anticipated recreation benefits, and that the project would not have been economically justified.

Seismology

The presence of numerous faults in the Fish Slough area was revealed during the geologic phase of this investigation. The degree of seismic activity was reviewed in a reconnaissance survey by staff of the department. Subsequently, it was felt that consultation on the important question of seismic activity should be secured. The department then obtained an oral report and brief written statement of seismologic conditions at Fish Slough from Dr. Hugo Benioff, Professor at the California Institute of Technology. Dr. Benioff's letter report, dated September 2, 1963, is Appendix C to this report.

The magnitudes and the locations of instrumentally determined epicenters of earthquakes which have occurred in the vicinity of the damsite, were obtained from seismological data published since 1934 by the California Institute of Technology and by the University of California. From 1934 to December 1960, eighty-seven earthquakes of Richter magnitude 4.0 and greater occurred within a 20-mile radius of the damsite. Thirteen epicenters between magnitude 3.0 and 3.9 were plotted within 10 miles of the site. Not all of the epicenters have been plotted on Figure 2 because the locations of many of them were reported at the same point on the map. Only the epicenter of either the first or the largest earthquake reported at a given point has been plotted on the map. A separate table, which



LEGEND

EARTHQUAKE EPICENTERS

SYMBOL	MAGNITUDE
●	3.0 - 3.9
●	4.0 - 4.9
▲	5.0 - 5.9
■	6.0 - 6.9

FAULTS

——— LOCATION OF FAULT TRACE

- - - - APPROXIMATE OR INFERRED LOCATION OF FAULT

SCALE 1:500,000

EARTHQUAKE EPICENTERS AND FAULTS NEAR FISH SLOUGH DAMSITE

DEPARTMENT OF WATER RESOURCES, 1964

accompanied the original office report on earthquake hazards at Fish Slough damsite, listed all of the earthquakes and their magnitudes and epicentral locations. The presence of such a large number of earthquakes with a 20-mile radius of the damsite strongly suggests that the area is still seismically active.

Fish Slough fault falls along the possible northward extension of the Sierra Nevada fault system, the origin of the great Owens Valley earthquake of 1872. This earthquake was one of the three great earthquakes that have occurred in California in recorded history. The maximum vertical and horizontal fault displacements were approximately 23 feet and 18 feet, respectively. The break extended northward from Lone Pine for a distance of more than 45 miles, with cracks visible at Bishop. Farther north along the same alignment, another fault scarp is visible near the town of Genoa, Nevada. Although the earthquake associated with this latter scarp occurred in prehistoric times, it is clearly very recent, geologically speaking. The displacement of this fault was 47 feet vertically and is the largest single fault break observed anywhere on earth, according to Dr. Benioff.

Available evidence indicates that a large earthquake is possible at the damsite that could rupture the ground surface along the Fish Slough fault. A dam constructed at this site would need to withstand both vertical and horizontal offsets. In addition, the embankment and appurtenant structures would be required to withstand very large oscillatory accelerations in the foundation and large seiches generated either by seismic surface waves or earthquake-induced landslides.

Dr. Benioff reports that ground accelerations of 0.5 gravity and horizontal and vertical offsets of ten feet or greater are possible

at Fish Slough. To the department's knowledge, no dam in California has been designed to withstand accelerations in excess of 0.15 gravity.

Summary of Design and Construction Problems and Safety Hazards

A summary of the problems associated with the design and construction of a dam at Fish Slough indicates that the following are limiting factors: (1) Fish Slough fault with possible large vertical and horizontal offsets; (2) seismic shaking forces; (3) seiches, or earthquake-induced water waves; (4) landslides; and (5) foundation leakage.

Fish Slough fault intersects the dam and reservoir site. The fault is apparently still active and appears to be a northward extension of the Sierra Nevada fault system, which has experienced large vertical and horizontal movements in the past. It is possible that both horizontal and vertical offsets in excess of ten feet could occur here in the future. Any earth or rockfill embankment constructed at Fish Slough would most certainly be ruptured if an offset occurred. Even though a very large freeboard were provided, there is no assurance that the movements of the land masses on the opposite sides of the fault would be perpendicular to the axis of the dam embankment. A parting or pulling apart of the two sides would immediately cause a breach in the dam that would create a flood hazard at Bishop, located only five miles downstream.

Fish Slough is located in one of the two most active earthquake zones in California, and severe earthquakes could occur here in the future as they have in the past. Ground accelerations of 0.50 gravity, or greater, are possible at the damsite, and there is no precedent for designing a dam to withstand such great shaking forces. This problem is further accentuated

by the fact that the foundation consists of Bishop Tuff, portions of which are relatively weak and of low density.

Large earthquakes of the magnitude expected along the Sierra Nevada fault zone would propagate seismic surface waves, which could generate large water waves, or seiches in a reservoir at Fish Slough. The seiches could also be induced by a differential tilting or upheaval of the reservoir floor. Such large waves could cause damage to on-shore recreational facilities and overtop the dam, causing damage to the embankment and to downstream areas. The lives of persons in the reservoir area and in the vicinity of Bishop would be in danger.

The entire east side of the reservoir is rimmed by a steep ridge created by uplifting of the volcanic tableland 300 to 400 feet along the Fish Slough fault. At the southern margin of this uplift near the damsite, three large blocks have broken away from the ridge and slumped toward the slough. These slump blocks are indicative of the general instability of the east wall of the reservoir area. Should the lower portion of the ridge become saturated with water stored behind the dam, additional landslides could occur, causing large water waves, similar to those which occurred after the landslide at Vaiont Reservoir in Italy on October 9, 1963. A similar landslide at Fish Slough damsite would damage the dam embankment, possibly resulting in destruction of property and lives. This hazard would be even more critical during an earthquake.

The rock foundation at the damsite is highly fractured and highly permeable, even at depths of 60 to 70 feet. Joints are interconnected and open and are filled or partially filled with silt debris. It would be extremely difficult to seal the foundation because of the presence of silt

debris in the open fractures. This debris could not be effectively flushed out prior to the grouting operation. The inability to achieve an effective grout curtain would result in a leaky foundation and an additional safety problem.

The problems cited above are the principal ones encountered in this investigation and each is sufficient to create a safety hazard for potential users of the reservoir and for the residents of Bishop. In combination, the problems are insurmountable and are not possible of solution by any design or construction methods presently known.

CHAPTER V. CONCLUSIONS AND RECOMMENDATIONS

The following principal conclusions and recommendations result from the investigation of the feasibility of construction of a dam and reservoir at the Fish Slough site.

Conclusions

As a result of this investigation, it is concluded that:

1. Public agencies and private parties have enhanced the opportunity for water-associated sports in the Inyo-Mono area by constructing recreation facilities adjoining natural lakes, reservoirs, and streams.
2. The demand for water-oriented recreation in the Inyo-Mono area exceeds the recreation capacity of the natural environment and man-made facilities. Furthermore, the demand will increase at a rate much faster than California's population. It is estimated that in 1990, the demand will be seven times the demand in 1958, whereas in the year 2020, the demand is estimated to be about thirteen times the 1958 demand.
3. A large fresh water reservoir located at a relatively low elevation and offering unlimited recreational opportunities, such as that suggested for the Fish Slough site, would have a recreational demand of 200,000 visitor-days in 1970 and increasing to about 420,000 visitor-days in 1990. If the availability of water surface area was not a limiting factor, the demand would further increase to 780,000 visitor-days in 2020.

4. Construction of a dam and reservoir at the Fish Slough site is not feasible from an engineering standpoint for the following reasons:

   a. The dam and reservoir site is intersected by the Fish Slough fault, along which both horizontal and vertical offsets in excess of 10 feet could occur. An offset along the fault could rupture the earth's surface and embankment of a dam constructed at the site.

   b. Fish Slough is located in one of the two most active earthquake zones in California. Ground accelerations of 0.50 gravity, or greater, are possible, substantially exceeding 0.15 gravity, the maximum value heretofore used in the design of California dams.

   c. Earthquakes of the magnitude expected at this site could also generate large water waves in the reservoir that could overtop the dam.

   d. The steep ridge along the east side of the reservoir is unstable. Storage of water behind the dam would saturate the lower portion of the ridge and could cause landslides into the reservoir or onto the dam. This hazard would become even more critical during an earthquake.

   e. The rock foundation at the damsite is highly fractured and would be extremely difficult to seal by any construction methods presently known.

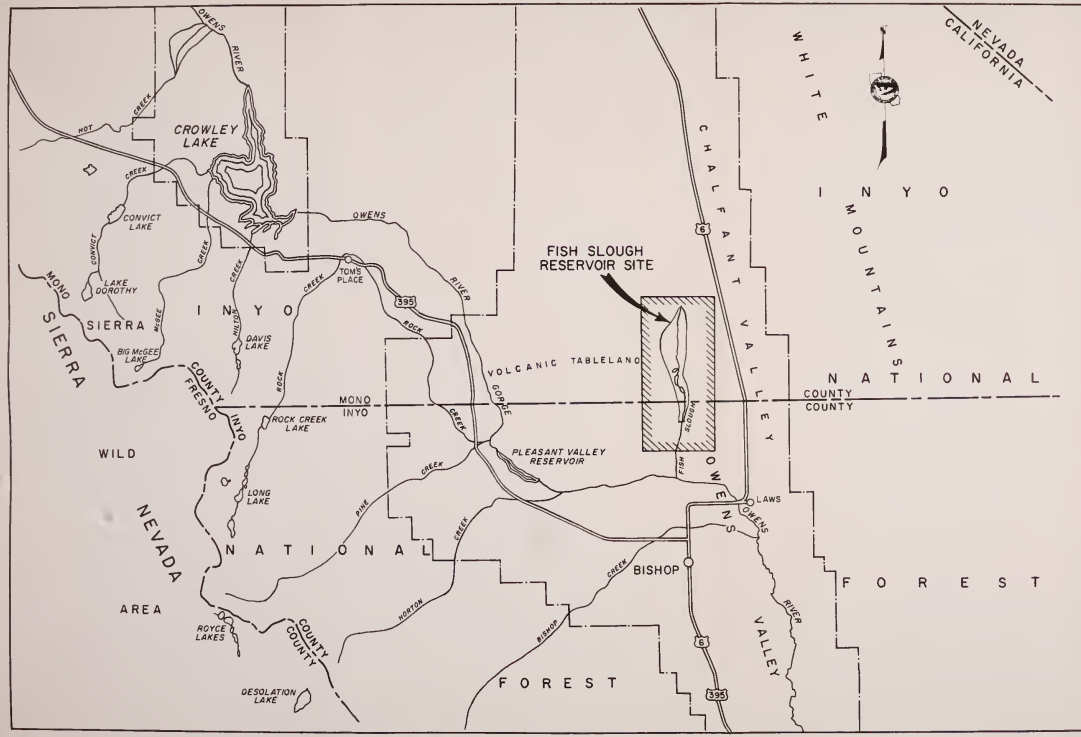
The combination of the above cited problems would create a safety hazard for potential recreational users of the reservoir and for the residents of Bishop and are considered insurmountable.

5. A portion of the demand for water-oriented recreation could be satisfied by a reservoir or reservoirs located at other potential sites in the Inyo-Mono area.

Recommendations

It is is recommended that:

1. No further consideration be given to the construction of a dam and reservoir at the Fish Slough site.
2. Should consideration be given in the future to a dam and reservoir for recreation, or other purposes, in the Inyo-Mono area, such studies not be confined to one site, but encompass a large area to assure the formulation of a feasible project.



LOCATION MAP

LEGEND

FISH SLOUGH DAM AND RESERVOIR AREA AS SHOWN ON PLATE 2

STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT

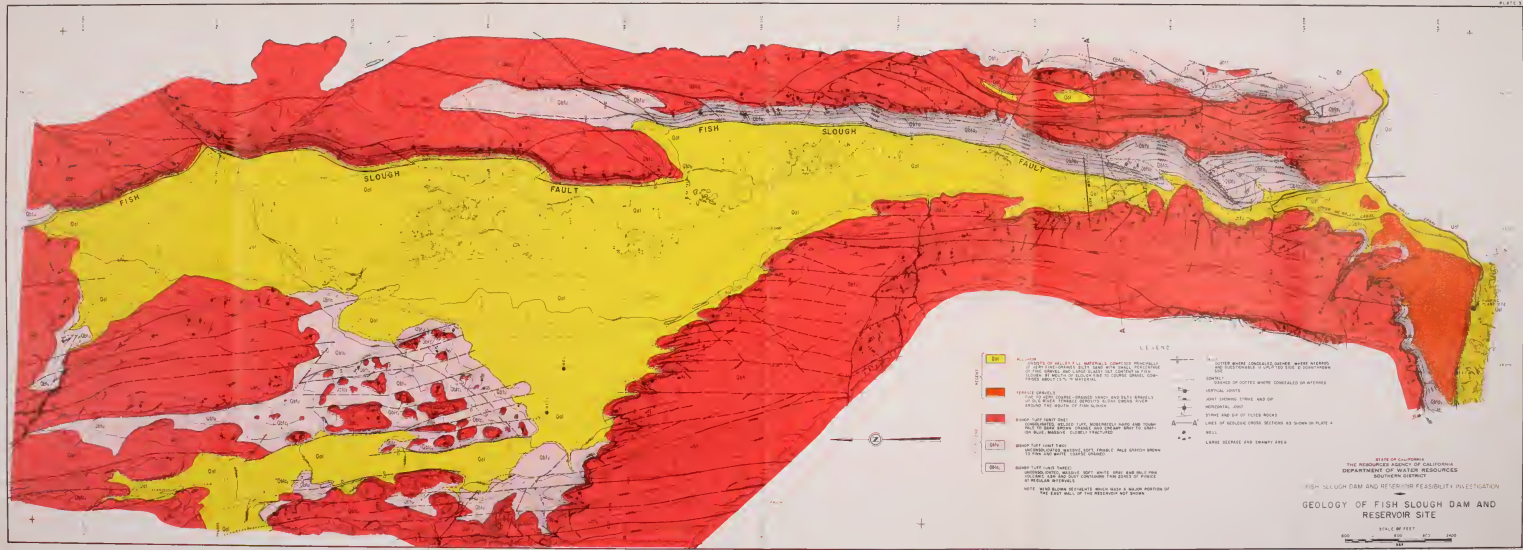
FISH SLOUGH DAM AND RESERVOIR FEASIBILITY INVESTIGATION

VICINITY MAP

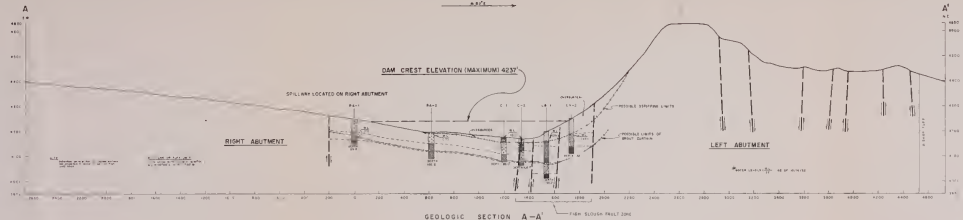
SCALE OF MILES
0 1 2 3 4 5 6

1964

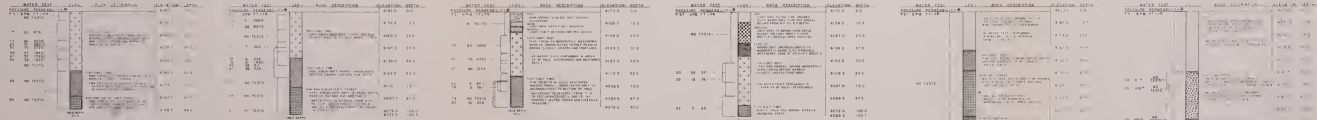

TO BENTON 20 MILES
FISH SLOUGH RESERVOIR
WATER SURFACE ELEVATION 4212'
T 5S
T 6S
R 33E
R 32E
TO BISHOP 5 MILES
OWENS RIVER
FISH SLOUGH PETROGLYPHS
PETROGLYPHS AREA
PANORAMA POINT AREA
COTTONWOOD FLATS AREA
MONO
INYO
LEGEND
CAMPING
PICNICKING
SWIMMING BEACH
CONCESSION AREA
ADMINISTRATION AREA
BOAT LAUNCHING AND PARKING
RELOCATED COUNTY ROAD
RECREATION ACCESS ROAD
PROJECT BOUNDARY LINE
STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
FISH SLOUGH DAM AND RESERVOIR FEASIBILITY INVESTIGATION
FISH SLOUGH RESERVOIR
RECREATION LAND USE PLAN
SCALE OF FEET


FISH SLOUGH FAULT
FISH SLOUGH FAULT
LEGEND
Qal
Qtg
Qbt1
Qbt2
Qbt3
N
STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
FISH SLOUGH DAM AND RESERVOIR FEASIBILITY INVESTIGATION
GEOLOGY OF FISH SLOUGH DAM AND RESERVOIR SITE
SCALE IN FEET

PLATE



GEOLOGIC SECTION A–A'
(LOOKING UPSTREAM)
SCALE IN FEET
HORIZONTAL - 1"=200'
VERTICAL - 1"=100'



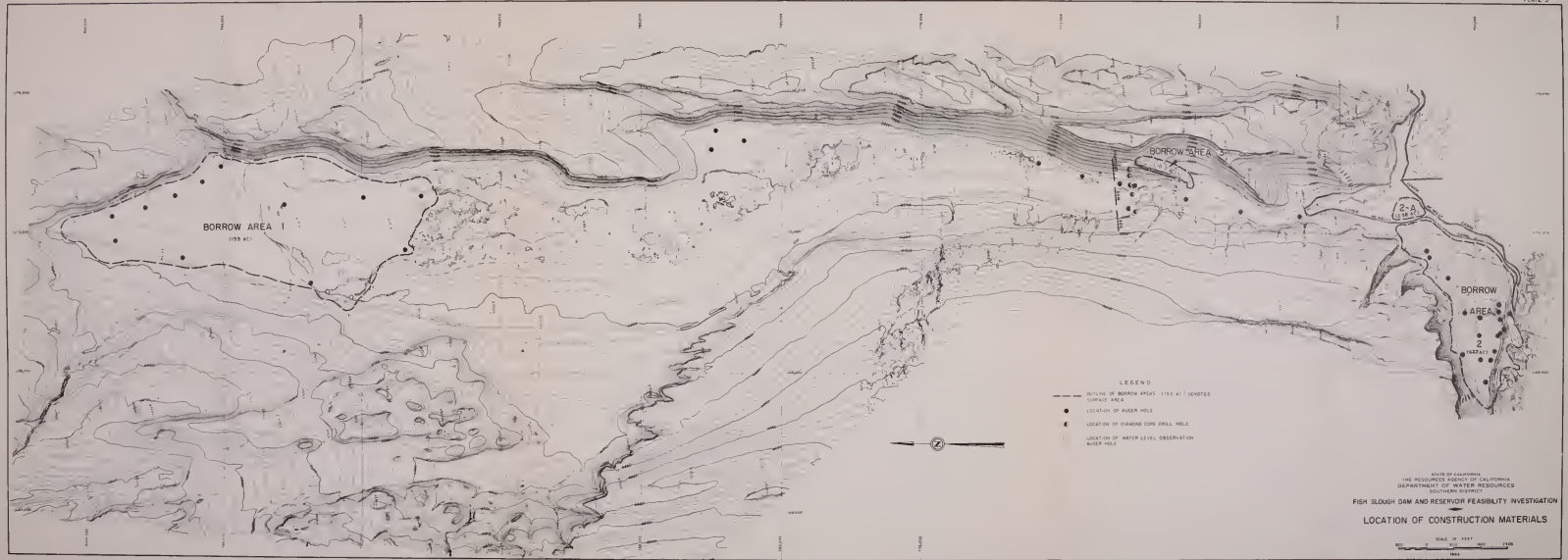
FOUNDATION CORE HOLE LOGS

STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT

SLOUGH DAM AND RESERVOIR FEASIBILITY INVESTIGATION

DAMSITE GEOLOGIC SECTION
AND CORE HOLE DATA

1964



STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT

FISH SLOUGH DAM AND RESERVOIR FEASIBILITY INVESTIGATION

LOCATION OF CONSTRUCTION MATERIALS

SCALE OF FEET
1964

APPENDIX A

WATER RIGHTS FILING FOR FISH SLOUGH PROJECT

APPLICATION NO. 19778

STATE OF CALIFORNIA

State Water Rights Board

1401 21ST STREET
P. O. BOX 1592
SACRAMENTO 7, CALIFORNIA

October 5, 1960

Application 19778

California Water Commission
P. O. Box 388
Sacramento, California

Gentlemen;

Your application to appropriate from Owens River and Fish Slough was received Oct. 3, 1960 and given the number 19778. It will be examined soon and you will then be informed of further requirements.

Very truly yours,

L. K. Hill
Executive Officer

Form 19
8/1/60

APPLICANT: Calif. Water Commission

ADDRESS: P. O. Box 368
Sacto., Calif.

Form No. 01

APPLICATION see index

APPLICANT ~~Calif. Dept. of Water Resources~~ See Below

RECEIVED 10/3/60 o.c. RECEIVED RECEIVED

MAPS FILED POCKET

FORMS SENT

FEE Exempt

PROTESTS	ANSWERED	DISMISSED OR WITHDRAWN	STIPULATION

REMARKS 10/3/60 Assigned to Calif. Water Commission, per Chap. 2101, Stat. of 1959

10/3/60 Investigation Report of Dept. of Water Resources dated 1960 (filed in library)

RECORD OF FOLDERS

MAIN FOLDER

2nd FOLDER

3rd FOLDER [illegible] 16719

4th FOLDER

5th FOLDER

[illegible]tion Schedule F - 1 year SWRB Files after cancellation prior to microfilming
[illegible] year CRD Files before destruction.

FILE IN DUPLICATE

[For full information concerning the filing out of this form refer to Article 4 of Rules and Regulations Pertaining to Appropriation of Water]

STATE OF CALIFORNIA—STATE WATER RIGHTS BOARD

Oct 3 3 07 PM '60

STATE WATER RIGHTS BOARD SACRAMENTO

Application No. [illegible] Filed Oct. 3, 1960 at 3:07 P. M.
(Applicant must not fill in the above blanks)

APPLICATION TO APPROPRIATE UNAPPROPRIATED WATER

I, State of California, Department of Water Resources Notice of Assignment (Over)
Name of applicant or applicants

of 1120 N Street, Sacramento County of Sacramento
Address

State of California, do hereby make application for a permit to appropriate the following described unappropriated waters of the State of California, *SUBJECT TO VESTED RIGHTS:*

Source, Amount, Use and Location of Diversion Works

1. The source of the proposed appropriation is (a) Owens River (b) Fish Slough
Give name of stream, lake, etc., if named; if unnamed state nature of source and that it is unnamed

located in Inyo County, tributary to (a) Owens Lake (b) Owens River

2. The amount of water which applicant desires to appropriate under this application is as follows:
See insert page 3a.

(a) For diversion to be directly applied to beneficial use ..... cubic feet per second
1 cubic foot per second equals 40 statute miner's inches or 646,317 gallons per day

to be diverted from ..... to ..... of each year.
Beginning date Closing date

(b) For diversion to be stored and later applied to beneficial use ..... acre-feet per annum
1 acre-foot equals 325,851 gallons

to be collected between ..... and ..... of each season.
Beginning date Closing date

NOTE.—Answer *(a)* or *(b)* or both *(a)* and *(b)* as may be necessary. If amount under *(a)* is less than .025 cubic foot per second, state in gallons per day. Neither the amount nor the season may be increased after application is filed. If underground storage is proposed a special supplemental form will be supplied by the State Water Rights Board upon request.

3. The use to which the water is to be applied is recreational and domestic
Domestic, irrigation, power, municipal, mining, industrial, recreational

purposes.

4. The point of diversion is to be located
State bearing and distance or coordinate distances from section or quarter section corner

being within the
State 40-acre subdivision of public land survey or projection thereof

of Section (a)24 (b)7, T. (a)6S (b)6S, R. (a)31E (b)33E, M.D. B. & M., in the County of Inyo

5. The main conduit terminates in ..... of Sec. 12, T. 6S, R. 32E, M.D. B. & M.
State 40-acre subdivision of U. S. Government survey or projection thereof

Description of Diversion Works

NOTE.—An application cannot be approved for an amount grossly in excess of the estimated capacity of the diversion works.

6. Intake or Headworks (fill only those blanks which apply)

(a) Diversion will be made by pumping from .....
Sump, offset well, unobstructed channel, etc.

(b) Diversion will be by gravity, the diverting dam being ..... feet in height (stream bed to level of overflow); ..... feet long on top; and constructed of earth
Concrete, earth, brush, etc.

(c) The storage dam will be 50 feet in height (stream bed to overflow level); 1,200 feet long on top; have a freeboard of 10 feet, and be constructed of earth
Concrete, earth, etc.

7. Storage Reservoir unnamed
Name

The storage reservoir will flood lands in See insert page 3a.
Indicate section or sections, also 40-acre subdivisions unless shown upon map

It will have a surface area of 1,900 acres, and a capacity of 30,000 acre-feet.

☞ In case of insufficient space for answers in form, attach extra sheets at top of page 3 and cross reference.

FORM 1

2. (a) For diversion from Owens River to offstream storage in a reservoir on Fish Slough, 18,000 acre-feet per year to be collected between January 1 and December 31 of each season. Maximum rate of diversion to storage to be 50 cubic feet per second. (b) For diversion to be stored and later applied to beneficial use 30,000 acre-feet per annum, to be collected between January 1 and December 31 of each season. The total water diverted under (a) and (b) shall not exceed 30,000 acre-feet per annum.

7. The storage reservoir will flood lands in Sections 1 and 12, T6S, R32E; Sections 6 and 7, T6S, R33E; Sections 13, 24, 25, and 36, T5S, R32E; Sections 18, 19, 30, and 31, T5S, R33E, M. D. B. & M.

8. Conduit System (describe main conduits only) canal dimensions not yet determined

(a) Canal, ditch, flume: Width on top (at water line) ____ feet; width at bottom ____ feet; depth of water ____ feet; length 8.5 miles ~~feet~~; grade ____ feet per 1,000 feet; materials of construction ____
(Cross out two not used) (Earth, rock, timber, etc.)

(b) Pipe line: Diameter ____ inches; length ____ feet; grade ____ feet per 1,000 feet; total fall / lift from intake to outlet ____ feet; kind ____
(Riveted steel, concrete, wood-stave, etc.)

NOTE.—If a combination of different sizes or kinds of conduit is to be used, attach extra sheets with complete description, also show location of each clearly on map.

9. The estimated capacity of the diversion conduit or pumping plant proposed is 50 cubic feet per second
(State cubic feet per second or gallons per minute)

The estimated cost of the diversion works proposed is ____
(Give only cost of intake, or headworks, pumps, storage reservoirs and main conduits described herein)

Completion Schedule

10. Construction work will begin on or before ____

Construction work will be completed on or before ____

The water will be completely applied to the proposed use on or before ____

Description of Proposed Use

11. Place of Use. At reservoir site and immediately adjacent thereto.
(State 40-acre subdivisions of the public land survey. If area is unsurveyed indicate the location as if lines of the public land survey were projected. In the case of irrigation use state the number of acres to be irrigated in each 40-acre tract, if space permits. If space does not permit listing of all 40-acre tracts, describe area in a general way and show detail upon map.)

Do(es) applicant(s) own the land whereon use of water will be made? ____ (Yes or No) Jointly? ____ (Yes or No)

If applicant does not own land whereon use of water will be made, give name and address of owner and state what arrangements have been made with him.

12. Other Rights. Describe all rights except those on file with the State Water Rights Board under which water is served to the above named lands.

Nature of Right (riparian, appropriative, purchased water, etc.)	Year of First Use	Use made in recent years including amount if known	Season of Use	Source of Other Supply
1.				
2.				
3.				
4.				

Attach supplement at top of page 3 if necessary.

13. Irrigation Use. The area to be irrigated is ____ acres.
(State net acreage to be irrigated)

The segregation of acreage as to crops is as follows: Rice ____ acres; alfalfa ____ acres; orchard ____ acres; general crops ____ acres; pasture ____ acres.

NOTE.—Care should be taken that the various statements as to acreage are consistent with each other, with the statement in Paragraph 11, and with the map.

The irrigation season will begin about ____ (Beginning date) and end about ____ (Closing date)
J

14. Power Use. The total fall to be utilized is ____ feet.
(Difference between nozzle or draft tube water level and first free water surface above)

The maximum amount of water to be used through the penstock is ____ cubic feet per second.

The maximum theoretical horsepower capable of being generated by the works is ____ horsepower.
(Second feet × fall ÷ 8.8)

The use to which the power is to be applied is ____
(For distribution and sale or private use, etc.)

The nature of the works by means of which power is to be developed is ____
(Turbine, Pelton wheel, etc.)

The size of the nozzle to be used is ____ inches.

The water will / will not be returned to ____ (Name stream) in ____ (State 40-acre subdivision) of Sec. ____, T. ____, R. ____, ____ B. & M.

DO NOT WRITE IN THIS SPACE
ATTACH EXTRA SHEETS HERE

15. **Municipal Use.** This application is made for the purpose of serving _____ (Name city or cities, town or towns. Urban areas only) having a present population of _____

The estimated average daily consumption during the month of maximum use at the end of each five-year period until the full amount applied for is put to beneficial use is as follows:

_____

_____

16. **Mining Use.** The name of the mining property to be served is _____ (Name of claim) and the nature of the mines is _____ (Gold placer, quartz, etc.)

The method of utilizing the water is _____

It is estimated that the ultimate water requirement for this project will be _____ (Cubic feet per second, gallons per minute. State basis of estimate)

The water will / will not be polluted by chemicals or otherwise _____ (Explain nature of pollution, if any)

and it will / will not be returned to _____ (Name stream) in _____ (State 40-acre subdivision) of Sec. _____, T. _____, R. _____, _____ B. & M.

17. **Other Uses.** The nature of the use proposed is recreational and domestic (Industrial, recreational, domestic, stockwatering, fish culture, etc.)

_____

State basis of determination of amount needed. While the amount of water herein applied for (Number of persons, residences, area of domestic lawns and gardens, number and kind of stock, type) is based upon the capacity of the reservoir, it is anticipated that once the (industrial use, and unit requirements) reservoir has been filled to capacity, the average annual amount of water used will be that required for evaporation and operational losses, including incidental domestic use. It is estimated that loss by evaporation will approximate 13,500 acre-feet per year. Data in this application are based on information presented in report entitled "Reconnaissance Investigation of Water Resources of Mono and Owens Basins, Mono and Inyo Counties", Department of Water Resources, August 1960.

_____

_____

_____

General

18. Are the maps as required by the Rules and Regulations filed with Application? Yes (Yes or No), If not, state specifically the time required for filing same. _____

19. Does the applicant own the land at the proposed point of diversion? _____ (Yes or No), If not, give name and address of owner and state what steps have been taken to secure right of access thereto. _____

_____

20. What is the name of the post office most used by those living near the proposed point of diversion?

_____

21. What are the names and addresses of claimants of water from the source of supply below the proposed point of diversion? City of Los Angeles, Department of Water and Power, P. O. Box 3669 Terminal Annex, Los Angeles 54, California

_____

_____

[SIGNATURE OF APPLICANT] _____

APPLICANT MUST NOT FILL IN BLANKS BELOW

PERMIT No._____

This is to certify that the application of which the foregoing is a true and correct copy has been considered and approved by the State Water Rights Board SUBJECT TO VESTED RIGHTS and the following limitations and conditions:

1. The amount of water appropriated shall be limited to the amount which can be beneficially used, and shall not exceed

2. The maximum amount herein stated may be reduced in the license if investigation so warrants.

3. Actual construction work shall begin on or before and shall thereafter be prosecuted with reasonable diligence, and if not so commenced and prosecuted this permit may be revoked.

4. Said construction work shall be completed on or before

5. Complete application of the water to the proposed use shall be made on or before

6. Progress reports shall be filed promptly by permittee on forms which will be provided annually by the State Water Rights Board until license is issued.

7. All rights and privileges under this permit including method of diversion, method of use and quantity of water diverted are subject to the continuing authority of the State Water Rights Board in accordance with law and in the interest of the public welfare to prevent waste, unreasonable use, unreasonable method of use or unreasonable method of diversion of said water.

This permit is issued and permittee takes it subject to the following provisions of the Water Code:

Section 1390. A permit shall be effective for such time as the water actually appropriated under it is used for a useful and beneficial purpose in conformity with this division (of the Water Code), but no longer.

Section 1391. Every permit shall include the enumeration of conditions therein which in substance shall include all of the provisions of this article and the statement that any appropriator of water to whom a permit is issued takes it subject to the conditions therein expressed.

Section 1392. Every permittee, if he accepts a permit, does so under the conditions precedent that no value whatsoever in excess of the actual amount paid to the State therefor shall at any time be assigned to or claimed for any permit granted or issued under the provisions of this division (of the Water Code), or for any rights granted or acquired under the provisions of this division (of the Water Code), in respect to the regulation by any competent public authority of the services or the price of the services to be rendered by any permittee or by the holder of any rights granted or acquired under the provisions of this division (of the Water Code) or in respect to any valuation for purposes of sale to or purchase, whether through condemnation proceedings or otherwise, by the State or any city, city and county, municipal water district, irrigation district, lighting district, or any political subdivision of the State, of the rights and property of any permittee, or the possessor of any rights granted, issued, or acquired under the provisions of this division (of the Water Code).

Dated: STATE WATER RIGHTS BOARD

10067 12 59 15M © SPO

APPENDIX B

COMMENTS OF THE STATE DEPARTMENT OF FISH AND GAME ON FISH AND WILDLIFE AT FISH SLOUGH

COMMENTS OF THE STATE DEPARTMENT OF FISH AND GAME
ON FISH AND WILDLIFE AT FISH SLOUGH

(Approved January 30, 1963, by Robert D. Montgomery, Deputy Director)

Estimate of Potential Annual Yield of Fish

Several factors point to a potentially high production of warmwater game fishes in the proposed reservoir, assuming that nongame fishes can be totally eradicated from the existing slough and can be effectively prevented from entering the reservoir via a pumped or gravity flow water supply. These factors are:

1. The relatively high concentration of total dissolved solids in the lower Owens River. TDS in Crowley Lake are 187 parts per million. Concentrations of that magnitude are indicative of high aquatic fertility.

2. The favorable morphometry of the proposed reservoir. The mean depth of a 30,000 acre-foot impoundment would be 15 feet, with a maximum depth of only 35 feet. Such shallowness would result in relatively high production of bottom organisms. An abundant crop of bottom organisms would be further enhanced by the anticipated minor degree of water level fluctuation. Even a 100,000 acre-foot reservoir would be sufficiently shallow to produce an abundant bottom fauna.

3. The geology of the reservoir basin. The area that would be occupied by Fish Slough Reservoir is obviously of volcanic origin. Although the specific geologic formation is unknown at this writing, it is the general rule that substrate materials of volcanic origin result in high aquatic production when inundated.

It is estimated that Fish Slough Reservoir could support a standing crop of 400 pounds of warmwater game fishes per surface acre, assuming an absence of nongame species and fairly intensive management. It is further estimated that about 75 percent of the standing crop would be of harvestable size, resulting in a harvestable crop of 300 pounds per surface acre.

It is anticipated that about one-third of the harvestable crop would be caught annually. Thus, a potential yield of 100 pounds of warmwater game fishes per surface acre is indicated.

Estimate of Angler-Capacity

Data from other warmwater reservoirs in California indicate that an average of one pound of game fish per angler-day is a satisfactory level of angling quality. An average daily catch of this magnitude is sufficient to attract substantial numbers of anglers in the southern one-half of the State when a reasonably balanced population of largemouth bass, sunfish, and catfish is present.

An estimated annual yield of 100 pounds of fish per surface acre would, therefore, support approximately 100 angler-days per acre. On this basis, a Fish Slough Reservoir with a normal pool of 2,000 surface acres would support 200,000 angler-days annually.

Standards of angling quality might drop appreciably in California in future years due to predicted population increases, just as they have apparently fallen during the past 20 years. A reduction in the angler success level from one pound/angler-day of warmwater game species to 0.67 pounds/angler-day, which is superficially a reasonable reduction, would increase the angler capacity of Fish Slough Reservoirs from 100 to 150 angler-days/acre/year.

Optimum Reservoir Size for Fish and Wildlife

Production of warmwater fishes is related to the surface area of aquatic environments rather than water volume. Therefore, on the basis of fish production alone, a reservoir capacity of 100,000 acre-feet would be relatively inefficient.

A reservoir with a capacity of 42,000 acre-feet and a surface area of 2,220 acres appears to be a satisfactory size, considering the multitude of factors that would influence recreational use of the reservoir, the availability of water, and capital costs of the dam. Greater capacities would not be particularly profitable.

Maximum water surface temperatures, with a reservoir of 2,220 acres, would probably reach the middle 80's during July. Maximum surface temperatures of this magnitude are not inimical to warmwater game species.

Present Hunting and Fishing Use of Fish Slough Basin

About 500 angler-days occur annually in the area to be inundated. The principal species sought by anglers is largemouth bass.

It is estimated that about 200 hunter-days of use occurs in the area each year. Most of the hunting effort is directed toward waterfowl. A minor amount of hunting for quail and rabbits occurs also.

Wildlife Benefits

The proposed reservoir would provide a valuable resting and feeding area for waterfowl. This would be particularly beneficial late in the winter when Bridgeport Reservoir, Crowley Lake, and other waters used by these birds have frozen, and open water for resting is at a premium in the Inyo-Mono area.

The proposed reservoir would also provide waterfowl hunting opportunities that far exceed the present potential of the area. We strongly recommend that waterfowl hunting be included as a purpose of the project and that provisions for this activity be made in a recreational development plan, should the project be authorized for construction at some future date.

The number of hunter-days that could be supported by a Fish Slough Reservoir is roughly 4,000 per annum.

Costs of Initial Eradication of Rough Fish

Fish Slough contains carp and possibly other undesirable fishes. It would be essential that these fishes, particularly carp, be completely eliminated prior to water storage in the proposed reservoir.

The costs of chemically treating the slough are estimated as follows:

Salaries and Wages	
One Fishery Biologist III	$ 400
One Fishery Biologist II	325
Two Fish and Game Seasonal Aids	325
Operating Expenses	
Helicopter rental	960
Emulsifiable rotenone	900
Miscellaneous supplies	200
TOTAL	$3,110

Department of Fish and Game personnel would undertake this work. However, it should be understood that funds would have to be budgeted by the Department of Water Resources.

Means of Preventing Entry of Undesirable Fishes into the Reservoir

Unless carp can be prevented from entering the reservoir from the Owens River, the sport fishery potential of the reservoir will be very low. There are two possibilities of preventing contamination of the reservoir with rough fish, both of which will require more study. First, it may be feasibile to divert the water supply from a point immediately below Pleasant Valley Dam, in which case the water would be free of undesirable species. If the diversion is located downstream, some type of electric screen that would be operative during possible power failures would have to be installed.

Such a screen would probably cost in the neighborhood of $30,000.

Costs of Establishing a Game Fish Population

An initial stocking of largemouth bass and a species of sunfish would be required to establish a desirable fish population. Approximately 100 largemouth bass fingerlings and 200 sunfish fingerlings would be planted for each surface acre. Assuming a cost of $100 per thousand fish and a surface area of 2,220 acres, the cost would be $66,600.

Costs of Controlling Aquatic Vegetation

Due to the shallowness of the extensive littoral zone of the proposed reservoir, growths of aquatic vegetation would become a serious problem. A continuing program of chemical weed control would be essential.

The annual costs of such a program cannot be satisfactorily estimated at this time. It probably would not be over $1,000 per annum.

Funds for weed control, fish planting, and any other essential management operations would have to be budgeted by the Department of Water Resources from the General Fund.

Costs of Management Surveys

Annual inventories of the Fish Slough Reservoir fish population and fishery would be necessary for proper management. This would cost about $1,500 per annum.

APPENDIX C

STATEMENT OF DR. HUGO BENIOFF
REGARDING
EARTHQUAKE HAZARDS AT FISH SLOUGH

CALIFORNIA INSTITUTE OF TECHNOLOGY
Division of the Geological Sciences

SEISMOLOGICAL LABORATORY
Pasadena

Address:
Seismological Laboratory
220 North San Rafael Ave.
Pasadena, California

September 2, 1963

Mr. Alfred Golze, Chief Engineer
Department of Water Resources
P. O. Box 388
Sacramento 2, California

Dear Mr. Golze:

In accordance with Mr. Lawrence James' request, I submit herewith an evaluation of the earthquake hazard associated with the site of the proposed Fish Slough dam located a few miles north of the town of Bishop.

The site falls along the northward extension of the Sierra Nevada Fault Zone or system in which the great Owens Valley earthquake of 1857* occurred. This earthquake was one of the three great earthquakes that have occurred in California since the coming of the White Man. The maximum vertical and horizontal fault displacements were approximately 23 feet and 18 feet respectively. The break extended northward from Lone Pine for a distance of more than 45 miles with cracks visible at Bishop. The fault system which lies along the eastern boundary of the Sierra Nevada Mountains is an expression of the continuing rise of these mountains. Farther north along the same zone another fault scarp is visible running through the town of Genoa, Nevada. Although the earthquake associated with this scarp occurred before the advent of White Man, it is clearly very recent, geologically speaking. The displacement of this fault was 47 feet vertically which equals the largest single fault break observed anywhere on earth.

From 1932 to 1960 some 87 earthquakes of magnitude 4 or greater have occurred within a 20 mile radius of the damsite.

The available evidence thus indicates that the proposed site is located in one of the two most active earthquake zones of California. Great earthquakes have occurred in the vicinity in the past and most certainly will recur in the future. A dam constructed on this site should be able to withstand horizontal and vertical ground displacements of 10 feet or more and accelerations of one half gravity or greater, which will be difficult in view of the excessive weak character of the ground. Failure of a dam at this site would be a very serious matter in view of the location downstream of the town of Bishop.

Very truly yours,

/s/ Hugo Benioff
Hugo Benioff
Professor of Seismology

*Editor's Note: Should be 1872.