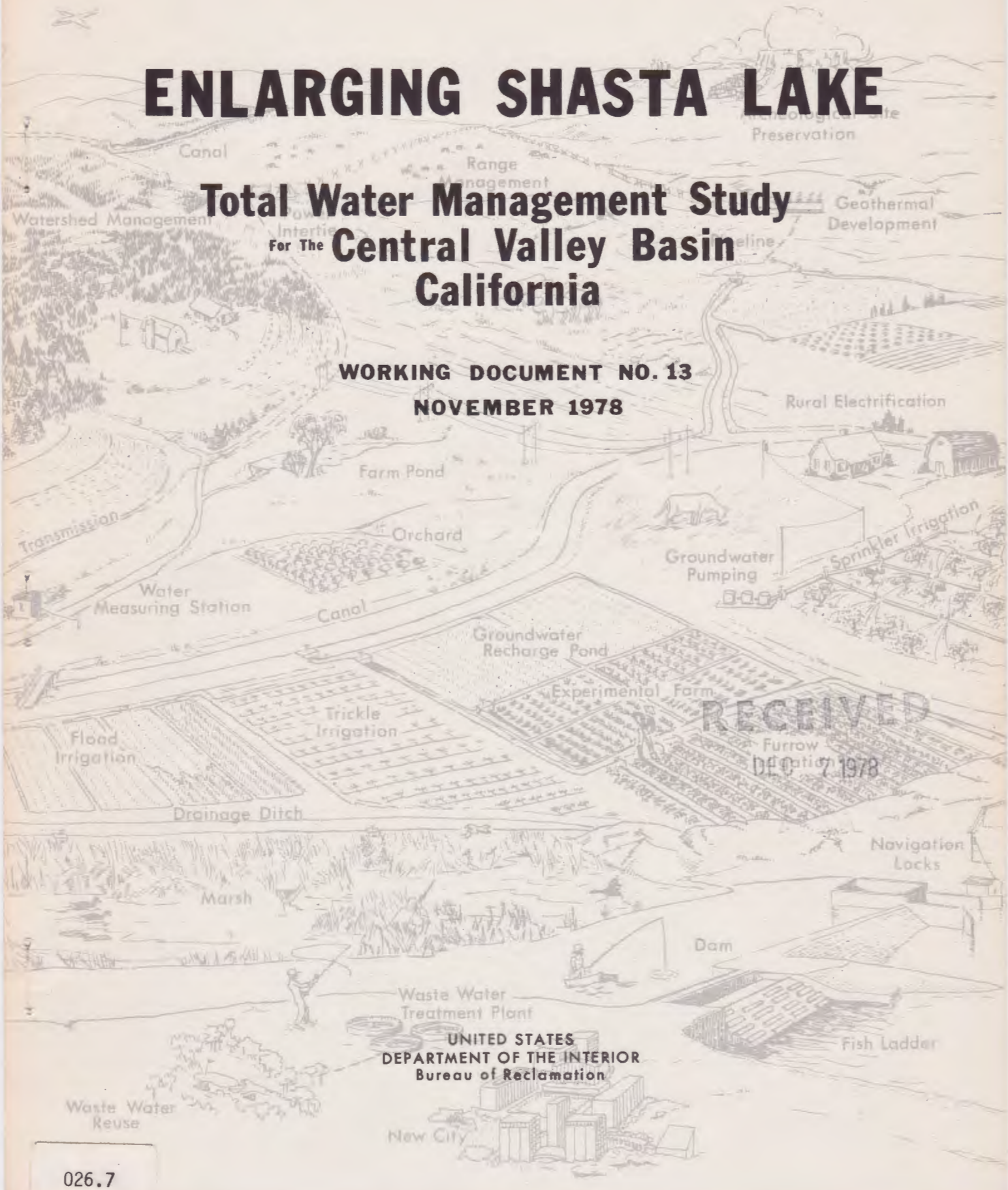
ENLARGING SHASTA LAKE

Total Water Management Study For The Central Valley Basin California

WORKING DOCUMENT NO. 13

NOVEMBER 1978



UNITED STATES
DEPARTMENT OF THE INTERIOR
Bureau of Reclamation

TOTAL WATER MANAGEMENT STUDY
FOR THE
CENTRAL VALLEY BASIN, CALIFORNIA

ENLARGING SHASTA LAKE

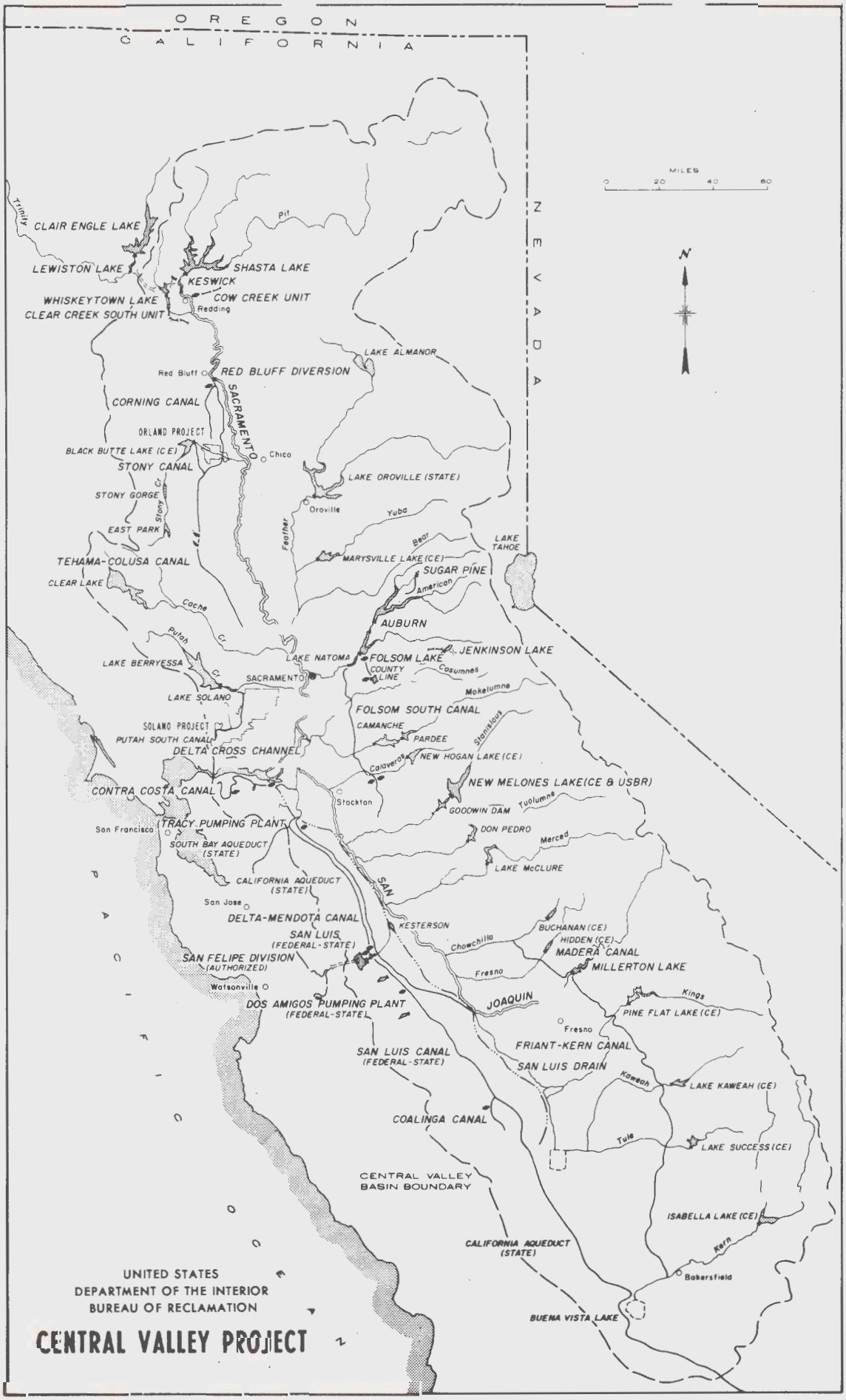
WORKING DOCUMENT NO. 13

November 1978

THIS REPORT WAS PREPARED PURSUANT TO FEDERAL RECLAMATION LAWS (ACT OF JUNE 17, 1902, 32 STAT. 388 AND ACTS AMENDATORY THEREOF OR SUPPLEMENTARY THERETO). PUBLICATION OF THE FINDINGS AND RECOMMENDATIONS HEREIN SHOULD NOT BE CONSTRUED AS REPRESENTING EITHER THE APPROVAL OR DISAPPROVAL OF THE SECRETARY OF THE INTERIOR. THE PURPOSE OF THIS REPORT IS TO PROVIDE INFORMATION AND ALTERNATIVES FOR FURTHER CONSIDERATION BY THE BUREAU OF RECLAMATION, THE SECRETARY OF THE INTERIOR, AND OTHER FEDERAL AGENCIES.

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

FIGURE 1


OREGON
CALIFORNIA
NEVADA
MILES
0 20 40 60
N
Trinity
CLAIR ENGLE LAKE
LEWISTON LAKE
Trinity R.
WHISKEYTOWN LAKE
CLEAR CREEK SOUTH UNIT
Pit
SHASTA LAKE
KESWICK
COW CREEK UNIT
Redding
LAKE ALMANOR
Red Bluff
RED BLUFF DIVERSION
CORNING CANAL
SACRAMENTO
ORLAND PROJECT
BLACK BUTTE LAKE (CE)
STONY CANAL
Chico
STONY GORGE
Stony Cr.
EAST PARK
LAKE OROVILLE (STATE)
Oroville
Feather
Yuba
Bear
MARYSVILLE LAKE (CE)
LAKE TAHOE
SUGAR PINE
American
TEHAMA-COLUSA CANAL
CLEAR LAKE
Cache
Putah Cr.
AUBURN
LAKE BERRYESSA
LAKE NATOMA
FOLSOM LAKE
JENKINSON LAKE
COUNTY LINE
Cosumnes
SACRAMENTO
LAKE SOLANO
Mokelumne
FOLSOM SOUTH CANAL
SOLANO PROJECT
PUTAH SOUTH CANAL
CAMANCHE
PARDEE
Stanislaus
DELTA CROSS CHANNEL
Calaveras
NEW HOGAN LAKE (CE)
NEW MELONES LAKE (CE & USBR)
CONTRA COSTA CANAL
Stockton
GOODWIN DAM
Tuolumne
San Francisco
TRACY PUMPING PLANT
DON PEDRO
Merced
SOUTH BAY AQUEDUCT (STATE)
LAKE McCLURE
CALIFORNIA AQUEDUCT (STATE)
SAN
San Jose
DELTA-MENDOTA CANAL
KESTERSON
BUCHANAN (CE)
HIDDEN (CE)
Chowchilla
SAN LUIS (FEDERAL-STATE)
MADERA CANAL
SAN FELIPE DIVISION (AUTHORIZED)
Fresno
MILLERTON LAKE
Watsonville
DOS AMIGOS PUMPING PLANT (FEDERAL-STATE)
JOAQUIN
Kings
PINE FLAT LAKE (CE)
Fresno
FRIANT-KERN CANAL
SAN LUIS CANAL (FEDERAL-STATE)
SAN LUIS DRAIN
Kaweah
LAKE KAWEAH (CE)
COALINGA CANAL
Tule
LAKE SUCCESS (CE)
CENTRAL VALLEY BASIN BOUNDARY
ISABELLA LAKE (CE)
Kern
CALIFORNIA AQUEDUCT (STATE)
Bakersfield
BUENA VISTA LAKE
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT

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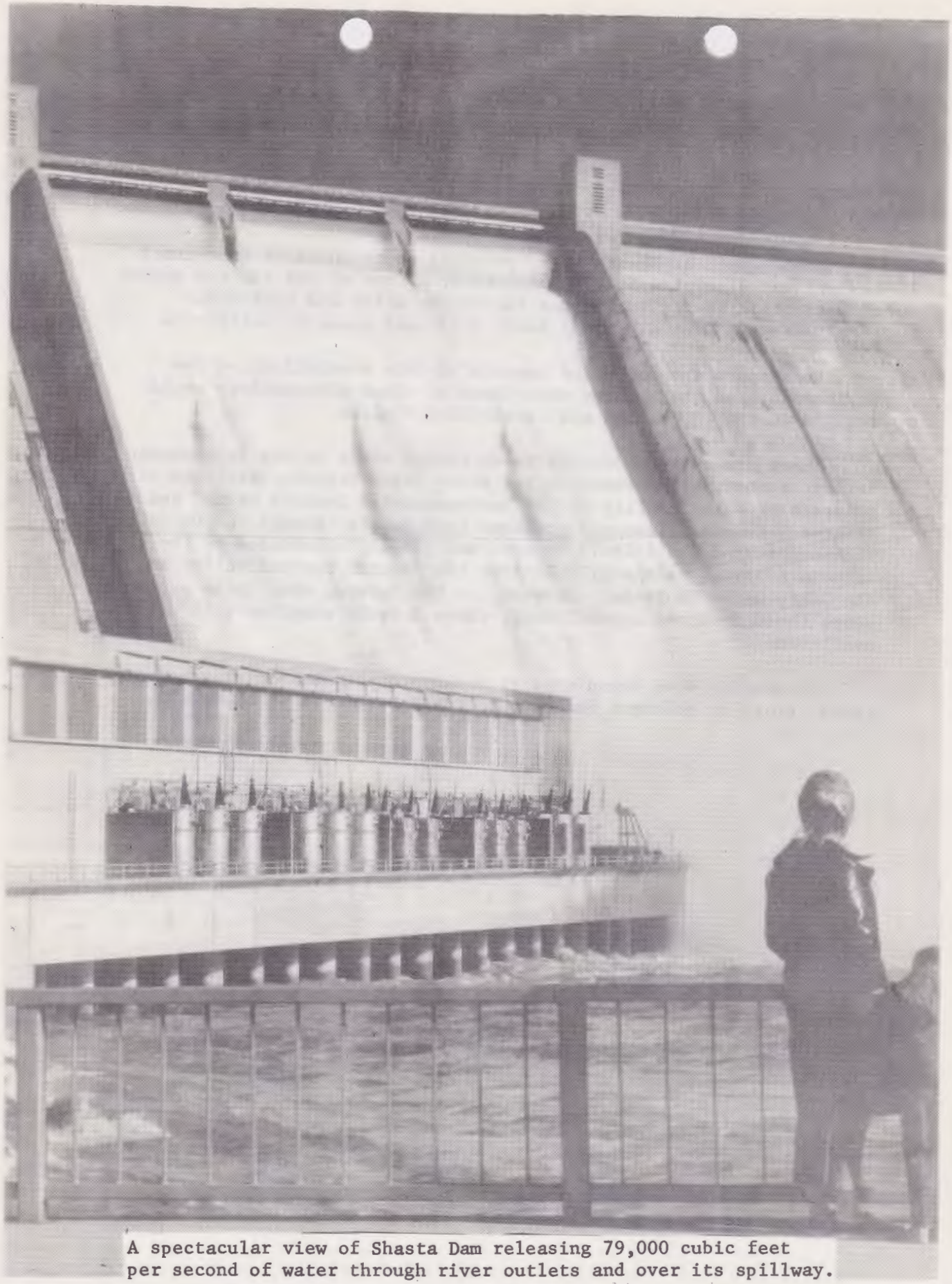
SUMMARY

Enlargement of Shasta Lake, possibly up to three or four times its present size of 4,552,000 acre-feet, is one of the limited number of possibilities for increasing the future water and hydropower supply for the Central Valley Basin and other areas in California.

To compare the costs and impacts of this possibility on the environment and the economy with those of other alternatives would require further appraisal and feasibility studies.

There are current overdrafts on ground water in the San Joaquin Valley, a shortage of water in the State Water Project, problems of maintaining water quality in the Sacramento-San Joaquin Delta, and water-related fish resource problems from Shasta through the Delta. The severity of the 1976-77 drought was greatly alleviated by the interim supplies made available from the Federal Central Valley and the State Water Projects. However, in the future, when these projects reach their designed capabilities, these interim supplies will not be available.

If studies were begun now, it would probably be a minimum of 20 years before an enlarged Shasta Lake could be placed in operation.



A spectacular view of Shasta Dam releasing 79,000 cubic feet per second of water through river outlets and over its spillway.

INTRODUCTION

GENERAL

This working document is one of a series on total water management for the Central Valley Basin. The study was one of those recommended in the August 1972 report by the Mid-Pacific Region on "An Appraisal of Total Water Management in the Central Valley Basin, California." It is listed in table 4 of that report on page 45 under category C, increase water and energy supply with additional construction projects, as item 1, Central Valley Basin Storage. Proposals for additional basin storage development were reviewed and updated with the objectives of increasing water supply, and providing flood control, recreation, and other services.

This study summarizes the considerations which enter into a decision as to whether or not to undertake feasibility studies of the possibilities of enlarging Shasta Lake of the Central Valley Project. Project features are shown on figure 1. The purpose of the enlargement would be to increase water supplies and power generation for the Central Valley Basin, to improve fishery and recreation conditions, and to provide additional flood control along the Sacramento River.

This document is the initial step in a planning, authorization, and construction process, which, if carried to completion, would result in an enlarged reservoir possibly 20 years from now.

Shasta Dam was constructed from 1938 to 1945 to a capacity of 4,493,000 acre-feet, with a later modification of the spillway gates to increase the capacity to 4,552,000 acre-feet. When completed, it was the second highest and second largest concrete dam in the world, being exceeded only by Boulder in height and by Grand Coulee in volume, but many dams now rank above it.

In 1937, when the original capacity for Shasta (then called Kennett) Lake was chosen, it was considered that ultimately 7 to 8 million acre-feet of storage capacity would be needed on the upper Sacramento River. Budget limitations, economic conditions, and technical limitations of the time governed the decision to build Shasta to a lesser capacity. The planners hoped that the additional storage needed could be obtained later at the Table Mountain site downstream.

Because of fishery problems and opposition to the extensive flooding of the lands within the Table Mountain reservoir site, this

hope was not realized. Studies showed that a high dam at the Table Mountain site would block migrating salmon and steelhead trout from their upper river spawning grounds. Although a low-level dam (500,000 acre-foot capacity) was authorized by Congress in 1944 at Table Mountain or at its alternate, the nearby Iron Canyon damsite, a reservoir was never constructed. In 1977 the authorization was rescinded.

In addition to plans for storage on the main river, early plans for the Central Valley Basin included storage on the river's tributaries and a diversion from the Trinity River. These plans were actively pursued, thus delaying the need for further main river storage. Folsom Lake was built on the American River, Oroville on the Feather, Black Butte on Stony Creek, and Whiskeytown on Clear Creek, as well as the Trinity River system to supply water to the Central Valley.

With these potentialities achieved, attention has again turned to the possibility of increasing main river storage. Enlarging Shasta Lake is one of the more promising of these possibilities.

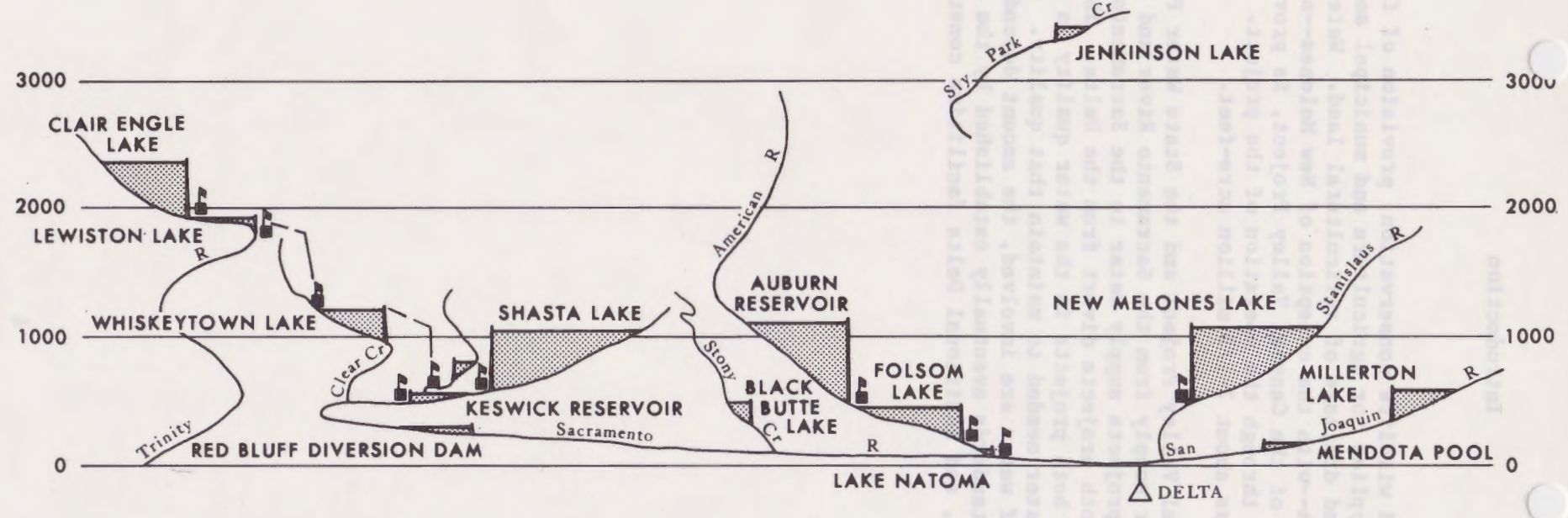
Previous reports of the California Department of Water Resources and the Bureau of Reclamation have provided the basic material for this document. Their principal reports consulted are listed in the "References." Comments on environmental impacts have been supplied by the U.S. Fish and Wildlife Service and the U.S. Forest Service.

SHASTA LAKE AND THE CENTRAL VALLEY PROJECT

Shasta Lake, the subject of this working document, is a key feature of the Federal Central Valley Project. This multipurpose project consists of a series of storage, conveyance, and power facilities in operation, under construction, or planned, to make optimum use of the water supplies developed and controlled by those facilities.

The main existing storage reservoirs are Shasta, Clair Engle, Whiskeytown, Millerton, Black Butte, Folsom, and San Luis. As shown on figure 2, others currently under construction are Auburn and New Melones; Marysville is authorized but construction has not yet started. Minor reservoirs in operation beginning in 1977-78 that will soon be transferred to the Central Valley Project are those for Hidden and Buchanan Dams in the San Joaquin Valley.

Project functions are: Flood control, power, navigation,



POWERPLANT

SCHEMATIC PROFILE

CENTRAL VALLEY PROJECT RESERVOIRS

FIGURE 2

recreation, fish and wildlife conservation, provision of firm or dependable water supplies for agriculture and municipal and industrial (M&I) uses, and drainage of agricultural land. Water quality maintenance, although--with the exception of New Melones--not an authorized function of the Central Valley Project, is provided to the extent possible through the operation of the project. In 1974 project water use was about 7-1/2 million acre-feet.

Both the Central Valley Project and the State Water Project share a common water supply from the Sacramento River and its tributaries. Both projects supply water to the Sacramento-San Joaquin Delta and both projects divert from the Delta. Thus a pivotal problem for both projects is the water quality in the Delta and the amount of water needed to maintain that quality. Several million acre-feet of water are involved, the amount depending upon the water quality standards eventually established by the State and Federal governments, and additional Delta facilities constructed.

NEED FOR ENLARGEMENT

The two-year drought of 1976 and 1977 has again focused attention upon the long-range water needs of California. This drought drastically curtailed water supplies, increased oil consumption for power generation, and created severe fishery problems along the Sacramento River and severe water quality problems in the Sacramento-San Joaquin Delta. The drought also severely curtailed recreation at water storage facilities.

The impact of the drought was considerably lessened by water which the Federal Central Valley Project and the State Water Project were able to supply. This source of relief was only possible, however, because water requirements of these projects had not yet developed to their ultimate or full usage. By then the State will be short 2 million acre-feet of meeting its contract commitments.

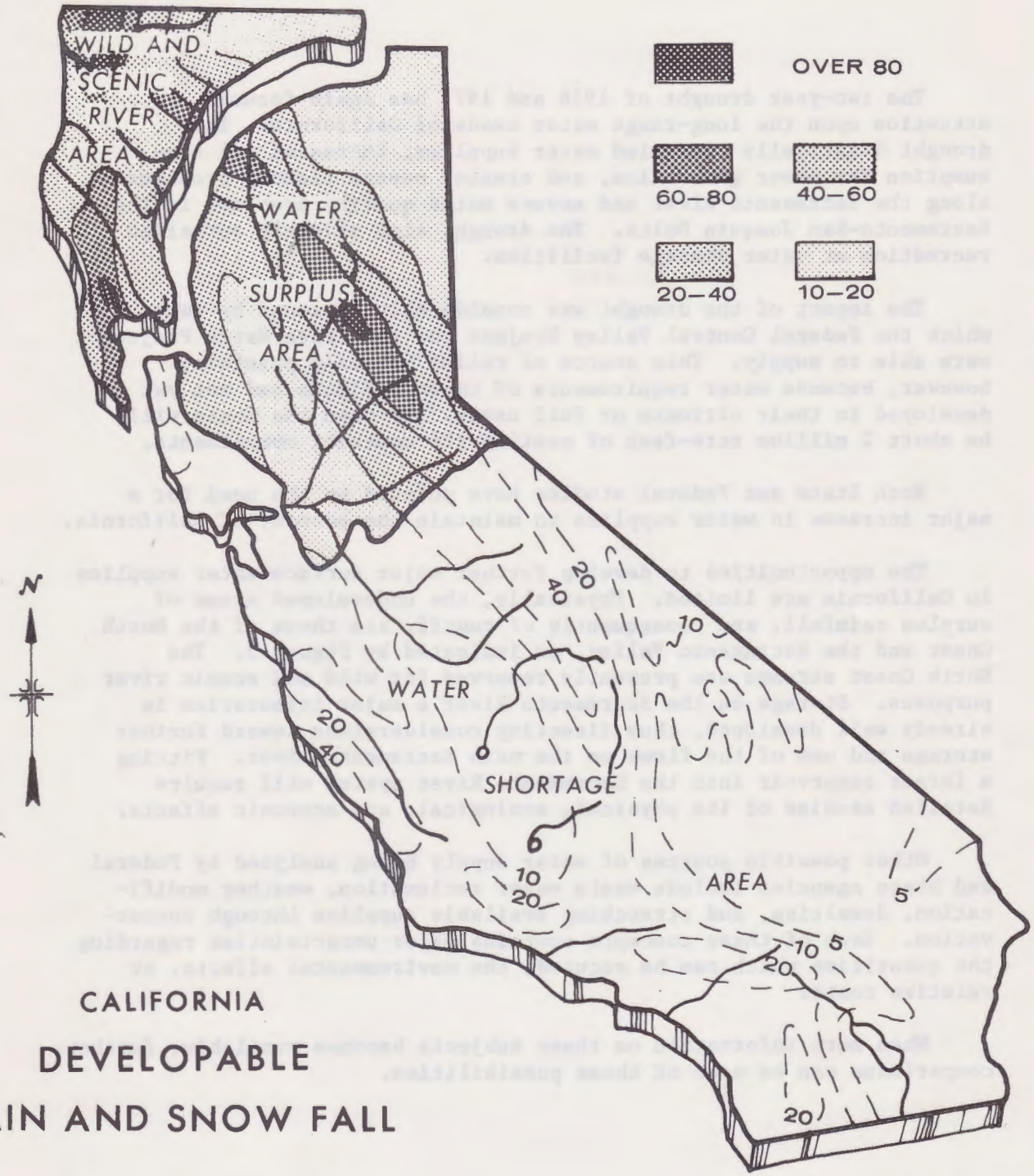
Both State and Federal studies have pointed to the need for a major increase in water supplies to maintain the economy of California.

The opportunities to develop further major surface-water supplies in California are limited. Physically, the undeveloped areas of surplus rainfall, and consequently of runoff, are those of the North Coast and the Sacramento Valley, as indicated by figure 3. The North Coast streams are presently reserved for wild and scenic river purposes. Storage on the Sacramento River's major tributaries is already well developed, thus directing consideration toward further storage and use of the flows on the main Sacramento River. Fitting a larger reservoir into the Sacramento River system will require detailed studies of its physical, ecological, and economic effects.

Other possible sources of water supply being analyzed by Federal and State agencies include waste water reclamation, weather modification, desalting, and stretching available supplies through conservation. Each of these concepts contains major uncertainties regarding the quantities which can be secured, the environmental effects, or relative costs.

When more information on these subjects becomes available, further comparisons can be made of these possibilities.

FIGURE 3



CALIFORNIA

DEVELOPABLE

RAIN AND SNOW FALL

DESIGN FEATURES AND MAJOR COSTS

Shasta Lake might be enlarged either by adding to the height of the existing concrete dam, or by constructing a new earth and rockfill dam immediately downstream. The choice between the two possibilities would be made after further, more detailed studies.

The height of the existing dam is just under 500 feet, and the top of the spillway gates is at elevation 1067 feet. This provides a reservoir capacity of 4,552,000 acre-feet. Raising the dam about 200 feet and the water surface to an elevation of 1270 feet would increase the reservoir capacity to about 14 million acre-feet. This would double the area covered by the reservoir, increasing it from about 30,000 to about 60,000 acres.

The increased heights and area of the reservoir water surface would require relocation of the present transportation routes, including the Southern Pacific Railroad and Interstate Highway 5, which now cross the reservoir. Other roads, the resorts, and other business and recreation facilities which now fringe the reservoir shores would likewise require relocation. Increasing the water surface elevation to 1270 would completely inundate the Pacific Gas and Electric Company's Pit River #7 Powerplant, and would adversely affect the operation of Pit River #6 Powerplant.

Based on a cursory evaluation, possible alternative costs of enlarging Shasta Lake to about 14 million acre-feet, based on July 1978 prices, are:

Raising the existing concrete dam	$1.4 billion
New earth and rockfill dam downstream	$2.6 billion

Both of these alternatives include relocation costs of $480 million.

EFFECTS OF ENLARGEMENT

WATER SUPPLY

Preliminary estimates of the increases in water supply obtainable by enlarging Shasta Lake are:

Reservoir size (acre-feet)	Elevation (feet)	Additional yield (acre-feet per year)	Critical period
4,552,000	1067	-	-
5,600,000	1100	250,000	May 1928-Oct 1934
10,000,000	1200	1,000,000	May 1928-Oct 1937
14,000,000	1270	1,400,000	Apr 1923-Oct 1937
27,000,000	1440	2,500,000	May 1922-Oct 1937

The critical period given in the tabulation is based on the historical record of riverflows. The tabulation shows the time during which the reservoir storage drops from full to a minimum stage of 500,000 acre-feet.

POWER

The existing Shasta Powerplant has five main generating units and two station service units. Two of the main generating units are being rewound to increase their capacities. With this modification the total installed capacity of the powerplant will be 539,000 kilowatts. Average annual generation is about 2 billion kilowatthours (kWh) per year.

An enlarged reservoir would provide the opportunity to increase average annual generation by up to 80 percent, depending upon the minimum reservoir stage adopted. The enlarged reservoir would both increase the average head on the powerplant and permit more water to be passed through it.

A rough preliminary evaluation indicates enlarging Shasta could provide the following potential power develoments and benefits:

Effects of Enlargement

Reservoir size (millions of acre-feet)	Potential increase in Capacity (MW)[a]	Average annual energy (GWh)[b]	Annual power benefits ($1,000)
10	360	300	15,000
14	460	600	29,000
27	860	1,600	75,000

[a] Megawatts
[b] Gigawatthours

Further appraisal and feasibility studies would be required to determine the optimum powerplant size, number of units, and method of operation. These studies would also explore the possibility of pump-storage for peaking power or a combination of conventional peaking and baseload operation.

Increasing the Shasta power capability would necessitate enlarging the downstream Keswick Afterbay to reregulate the additional power releases. An enlarged Keswick would also provide opportunities to increase the Central Valley Project power potential. The reregulation space required at Keswick would necessarily be based on the size of the enlarged Shasta Powerplant and its method of operation. This can be more fully explored in a detailed feasibility study.

FISH AND WILDLIFE

The Division of Ecological Services of the U.S. Fish and Wildlife Service at Sacramento has made a preliminary or "threshold" evaluation of possible effects on fish and wildlife resources. It notes that enlargement of Shasta Lake would have an extremely significant impact on the immediate project area, the Sacramento River, the Central Valley, and the entire Sacramento-San Joaquin estuarine complex.

The evaluation notes that the enlargement would present significant environmental problems as well as considerable opportunities. If operated for fish and wildlife purposes as well as other uses, the enlargement could be one of the least damaging alternatives for additional water development.

The evaluation points out that the terrestrial and aquatic ecosystems both above and below Shasta Lake would be altered by the enlargement. Among the effects would be the flooding of 42 miles of live streams by raising the reservoir to elevation 1270 feet, and the flooding of 30,000 to 40,000 acres of terrestrial wildlife habitat, including that of the endangered bald eagle and the State-designated rare Shasta salamander. Downstream effects would include the effect of changes in flows on fish and riparian habitat, and also the effects of increased water use on wildlife in the areas to which the water is supplied.

A summary prepared by the U.S. Fish and Wildlife Service of its "threshold evaluation" is attached to this document. The Service has suggested extensive studies will be required. This subject is discussed in this document under "Schedule for Future Work."

RECREATION

Shasta Lake is presently extensively developed for recreation. In 1975 visitation amounted to 4.4 million visitor-days. The main attraction is water-oriented recreation, including boating, swimming, fishing, and water skiing. In 1976, with lower lake levels caused by drought, visitation dropped to 2.7 million visitor-days.

With an enlarged reservoir at elevation 1270, the maximum reservoir area would be about doubled from 30,000 to 60,000 acres. However, there would be greater fluctuations in the reservoir stages.

Further studies would be needed to determine how the recreational opportunities provided by the increased maximum lake surface would balance against greater fluctuations in lake levels and the possibilities and advantages of establishing a larger minimum pool.

FLOOD CONTROL

Shasta Lake is operated for flood control during the flood season, October to April, according to criteria established by the U.S. Army Corps of Engineers. The maximum storage reservation for this purpose is 1,300,000 acre-feet. The maximum allowable release from Keswick is 79,000 cubic feet per second.

The objective of the operation is to limit the flow in the Redding area to 80,000 cubic feet per second and at Bend Bridge to 100,000 cubic feet per second. Bend Bridge is 35 miles below Keswick. At times it is physically impossible to keep the flows at these points within these

limits due to substantial unregulated tributary inflows below Keswick and releases necessary to maintain flood control space in the reservoirs.

Further studies would be needed to determine whether more flood control space should be provided in an enlarged reservoir, and how much incidental flood control the enlargement would provide with the present flood control reservation.

CULTURAL RESOURCES

Pursuant to Executive Order 11596 and the Historic and Archeologic Preservation Act of 1974, cultural resource surveys and evaluations would be necessary. The existing reservoir area was only partially surveyed in 1941-42. Because of World War II, surveys were very limited, and by 1945, inundation of the reservoir had begun, thereby precluding further surveys. On the McCloud Arm of the reservoir, 37 sites were discovered. They consisted of house pits, dance pits, burials, and associated midden deposits. The information provided by researchers infers that many of the sites found were significant. Additional required surveys, therefore, would probably produce a number of cultural resource sites with National Register significance.

WATER RIGHTS

The enlargement of Shasta Lake or any of the alternatives which modify the regime of the Sacramento River will affect water users along the river and in the Delta. Resolution of water rights will be a complex and lengthy process.

ALTERNATIVES TO SHASTA LAKE ENLARGEMENT

GENERAL CONSIDERATIONS

When the water resources of the State of California are viewed as a whole, as previously mentioned, the only major undeveloped sources are the Sacramento River and the North Coast streams. Assuming that the North Coast streams are reserved for wild and scenic river purposes, consideration is limited to the Sacramento River.

In addition to the enlargement of Shasta Lake, locations for further development of the Sacramento, shown on figure 4, fall into three general categories:

1. Main river storage
    a. Above Shasta Lake
    b. Below Shasta Lake
2. Tributary stream storage
3. Off-channel storage (filled by pumping from the main river)
    a. Surface storage
    b. Subsurface or ground-water storage

Data on reservoir capacities, water yield, power considerations, and reservoir acreage are summarized in table 1. The cost estimates are intended only to give a very general idea of relative costs.

MAIN RIVER STORAGE

Storage above Shasta Lake

Storage possibilities above the reservoir were the subject of a 1962 reconnaissance report "Storage Above Shasta Lake" by the Mid-Pacific Region of the Bureau of Reclamation. Only two possibilities for multiple-purpose storage at capacities greater than 200,000 acre-feet appeared practicable. These were the Squaw Valley site on Squaw Valley Creek and the Kosk site on the Pit River. The combined storage capacity of the two reservoirs was 1,200,000 acre-feet with an irrigation yield of 140,000 acre-feet. Dependable capacity for power (energy) was about 50,000 kilowatts and average annual generation, including the increase at the Pacific Gas and Electric Company plant, was about 27 million

FIGURE 4


OREGON
CALIFORNIA
NEVADA
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
LOCATION MAP
TOTAL WATER MANAGEMENT STUDY
CENTRAL VALLEY BASIN
SEPTEMBER 1978
MILES
0 20 40 60
0 20 40 60 80 100
KILOMETERS
N
SQUAW VALLEY
Pit
KOSK
Trinity
CLAIR ENGLE LAKE
LEWISTON LAKE
SHASTA LAKE
KESWICK
COW CREEK UNIT
MILLVILLE
WHISKEYTOWN LAKE
Redding
CLEAR CREEK SOUTH UNIT
DUTCH GULCH
WING
TUSCAN BUTTES
LAKE ALMANOR
TEHAMA
Red Bluff
RED BLUFF DIVERSION
SCHOENFIELD
GALLATIN
CORNING CANAL
BLACK BUTTE LAKE (CE)
Cr.
SACRAMENTO
NEWVILLE
Chico
GLENN RES COMPLEX
RANCHERIA
STONY GORGE
Stony
COLUSA RES COMPLEX
LAKE OROVILLE (STATE)
Oroville
Yuba
Feather
EAST PARK
Bear
LAKE TAHOE
MARYSVILLE LAKE (CE)
SUGAR PINE
TEHAMA-COLUSA CANAL
American
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JENKINSON LAKE
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COUNTY LINE
Cosumnes
SACRAMENTO
Mokelumne
LAKE SOLANO
FOLSOM SOUTH CANAL
CAMANCHE
SOLANO PROJECT
PUTAH SOUTH CANAL
PARDEE
Stanislaus
DELTA CROSS CHANNEL
Calaveras
NEW HOGAN LAKE (CE)
1258-208-41

Table 1. Summary of data on Shasta Lake enlargement and alternatives

	Reservoir capacity (millions of acre-feet)	Additional water yield (millions of acre-feet)	Cost ($millions)	Power (million kWh)	Acreage (1,000's)
Shasta enlargement	9.5 increase	1.4	1400 to 2600	+600	31 increase
Upstream storage (Squaw Valley and Kosk)	1.2	0.14	330	+27	9
Tributary stream storage (eight-reservoir plan)	6.1	0.67	440	None	68
Off-channel storage					
Tuscan Buttes	5.5	0.64	1,500	-100	30
Glenn	8.7	0.99	990	0	90
Colusa	3.2	0.46	790	- 50	40
Monticello enlargement	8.4 increase	+1	Not available	0	Not available

kilowatthours. The capital cost, indexed to October 1977 prices, is about $330 million.

Storage Below Shasta Lake

Below Shasta Dam, the Sacramento River flows through a broad valley and a few miles above Red Bluff enters a canyon section which contains the Iron Canyon and Table Mountain damsites. Storage at these sites, as mentioned previously, was deauthorized in 1977 under the provisions of Section 12 of the Water Resources Act of 1974 (P.L. 93-251, 88 Stat. 16, 17). Deauthorization was based on the U.S. Army Corps of Engineers' findings that the projects were no longer considered economically justified, had little local support, and had an impact on the natural environment which was considered to be adverse with little likelihood of adequate mitigation measures.

TRIBUTARY STREAM STORAGE

In many of the tributary streams below Shasta, including Feather and American Rivers, and Clear and Stony Creeks, sizable storage facilities have been constructed. A Cottonwood Creek Project has been authorized for construction by the U.S. Army Corps of Engineers.

Over the past 30 years, numerous plans for storage on tributary streams have been studied. A 1975 study by the California Department of Water Resources "Major Surface Water Development Opportunities in the Sacramento Valley: A Progress Report," summarizes information on an eight-reservoir plan. It includes Dutch Gulch Reservoir on Cottonwood Creek, Tehama on the south fork of Cottonwood Creek, Schoenfield on Red Bank Creek, Gallatin on Elder Creek, Newville on the north fork of Stony Creek, Rancheria on Stony Creek, Wing on Inks Creek, and Millville on the south fork of Cow Creek. The combined gross storage capacity of the eight reservoirs would be about 6,100,000 acre-feet, including about 730,000 acre-feet for flood control storage. Net usable supplies during the critical dry period (1928-34) would be increased about 670,000 acre-feet per year on the average. Power facilities were not included in the State plan.

The capital cost, based on January 1975 prices, was estimated as about $440 million.

The State report estimates that the eight reservoirs would inundate about 68,000 acres, and about 65 miles of year-round natural streams. In addition to the inundated areas, another 40,000 acres would be required for public access, wildlife, recreation, and other purposes.

OFF-CHANNEL STORAGE

Another alternative would be pumping from the Sacramento River to offstream surface or underground storage. A number of possibilities for pumping to surface reservoirs have been examined by the California Department of Water Resources and the Bureau of Reclamation. These possibilities include Tuscan Buttes, Glenn, and Colusa Reservoirs in the Sacramento Valley. Other possibilities under consideration by the Department of Water Resources include an enlarged Lake Berryessa of the Bureau's Solano Project, and possible offstream storage sites in the San Joaquin Valley.

The possibilities of ground-water storage are less well-defined, in part at least, because of physical and legal uncertainties in the operation of ground-water reservoirs.

Surface Storage Possibilities

The California Department of Water Resources 1975 progress report on "Major Surface Water Development Opportunities in the Sacramento Valley" outlined plans for an offstream storage reservoir filled by pumping from the Sacramento River. Data on three possible sites for such a reservoir are:

Site	Reservoir capacity (millions of acre-feet)	Yield (acre-feet)	Capital cost (millions)	Acreage required	Net power usage (millions of kWh)
Tuscan Buttes	5.5	640,000	$1500	30,000	100
Glenn	8.7	990,000	990	90,000	0
Colusa	3.2	460,000	790	40,000	50

To operate any of these reservoirs, large diversions from the Sacramento River would be required, with consequent impact upon the fishery. Two of the plans would consume large amounts of energy. In the Glenn plan, energy generation and energy consumption would balance, with no net gain.

The existing Lake Berryessa has a capacity of 1.6 million acre-feet. The 1975 State report noted the possibility of enlarging this reservoir to as much as 10 million acre-feet and operating it--in conjunction with diversions from Sacramento River--to increase the yield by more than 1 million acre-feet per year during the critical dry period. Fishery and energy problems would be generally similar to those for the other off-channel storage plans.

Ground-Water Storage

Use of underground storage has been practiced in the Central Valley Basin for many years. Water from the Central Valley Project as well as natural streamflow has been used for recharge purposes in the San Joaquin Valley. However, in normal years the San Joaquin Valley overdraft is estimated as about 1.5 million acre-feet, increasing in drought years.

To make further use of ground-water storage by recharge or replacement supply from the Sacramento River, conveyance canals and other facilities would be needed. Greater use of ground-water storage would also require solutions to possible legal and institutional problems of accommodating the present ground-water pumpers and rechargers within a larger scale operation.

Problems and costs of using ground-water storage are more complex technically and legally, and are less well defined than those of surface storage. With this uncertainty, the large-scale operation of an underground reservoir may or may not entail problems greater than those of providing surface storage. Studies would be required to compare alternative costs and benefits.

SCHEDULE FOR FUTURE WORK

If the decision is made to proceed, the next step would be a feasibility study. Such a study will require authorization by Congress. The first phase of a feasibility study would be the establishment of a public involvement program, appraisal of all potential major benefits including power possibilities, identification of major environmental impacts, and major cost items, such as road relocations, to determine the critical points of the investigation. Succeeding phases of the investigation would examine the physical and social impacts of the enlargement, and present this information in a feasibility report which would be accompanied by an environmental statement.

The feasibility report and environmental statement would be furnished to Federal, State, and local agencies, and to the general public for review and comment. The completed report and statement would then be submitted to the Congress, who would decide whether to authorize enlargement of Shasta Lake and appropriate funds for construction.

Following authorization would come preconstruction studies, preparation of designs and contract specifications, and right-of-way acquisition. Construction would then begin. Upon completion of construction, the enlarged reservoir would be filled and become operational.

A provisional timetable for this process is:

Program item	Years
Feasibility investigation, including an 18-month appraisal phase	4
Review and Congressional consideration	2
Preconstruction studies	4
Construction	6
Reservoir filling to operating level	4
Total number of years required	20

The first step in the process, the feasibility study, is estimated to require a total of about $3,840,000 over a period of 4 years. A schedule for the study is shown in figure 5.

FIGURE 5

SCHEDULE OF ACTIVITIES FOR SHASTA ENLARGEMENT STUDY

(THOUSANDS OF DOLLARS)

PROGRAM ITEM	FISCAL YEARS 1	2	3	4	TOTAL
PUBLIC INVOLVEMENT	20	15	15	15	65
PLAN FORMULATION	135	50	25	15	225
ENGINEERING DATA AND ANALYSIS	330	545	200	20	1095
ENVIRONMENTAL STUDIES	480	845	675	105	2105
SOCIO-ECONOMIC STUDIES	25	110	15	5	155
REPORT AND ENVIRONMENTAL STATEMENT	—	—	85	110	195
TOTAL	990	1565	1015	270	3840

NOTES:

Progress Report:

Feasibility Report and Environmental Statement:
Draft:
Final:

Public Involvement includes public meetings, onsite inspections, and other means to facilitate public understanding of the planning process and to actively solicit public views and preferences.

Plan Formulation Studies define the principal planning elements and constraints which form the subject of more detailed studies. The results would be presented in a progress report.

Engineering Data and Analysis include gathering and analyzing information on topography, geology (including geologic mapping, drilling, and seismic studies), hydrology, water rights, sedimentation, seepage, water quality, land classification and drainage, power production and marketing, and design and cost estimates.

Environmental Studies include studies of fish and wildlife, recreation, forest impacts and environmental effects, including an archeological survey and data for an environmental impact statement.

Socio-Economic Studies analyze the social and economic impacts of reservoir enlargement, presenting benefits and costs in monetary and non-monetary terms.

The Feasibility Report and Environmental Statement present the results of the investigation, including appendixes on each of the principal topics.

Schedule for Future Work

The schedule includes $1,800,000 for fish and wildlife studies within the $2,105,000 Environmental Studies item. The U.S. Fish and Wildlife Sevice has suggested $6 million be included as a minimum for fish and wildlife studies in the Shasta Enlargement Study to address new adverse impacts or existing problems which would be accentuated by a larger project. This would include major ecological studies of the distribution, abundance, feeding, movements and production of freshwater and estuarine aquatic resources.

This Shasta Enlargement Study schedule is based on the premise that the additional funds required for the more extensive studies desired by the U.S. Fish and Wildlife Service would be beyond the scope of the enlargement studies and would be justified and funded separately.

U.S. FISH AND WILDLIFE SERVICE SUMMARY

Excerpt from a letter of June 16, 1978 from the Division of Ecological Services, U.S. Fish and Wildlife Service, Sacramento, subject: Central Valley Project Total Water Managment Study - Enlarged Shasta Lake - Preliminary Evaluation of Possible Effects on Fish and Wildlife Resources:

"SUMMARY

We believe that the enlarged Shasta project will present significant environmental problems as well as considerable opportunities. Recognizing that additional water development is planned for the Central Valley we believe that this project, if operated for fish and wildlife purposes as well as other uses, could be the one of the least damaging alternatives.

For the purpose of brevity we have summarized the possible adverse effects and opportunities in the following paragraph. Undoubtedly there will be documents prepared which can utilize this summary.

Enlarging Shasta Lake to a capacity of about 14 million acre feet will have an extremely significant impact on the immediate project area, the Sacramento River, the Central Valley, and the entire Sacramento-San Joaquin estuarine complex.

The enlarged Shasta project would adversely impact fishery resources in the entire affected area. However, it appears substantial lessening of impacts and even restoration of fish resources are possible in some areas. Fish resources that will be adversely impacted and pose difficult problems in compensating for are those which are found in or utilize the lower Sacramento River and the delta and bay estuarine complex during all or portions of their life requirements. Regulating and removing an average of 1 million acre feet of flood flows annually from the river and estuarine system will effect changes in the ecosystem. These changes follow substantial prior water development and associated impacts. As water development progresses, management options and capabilities to compensate for resource losses are reduced. The area where potential improvement of fisheries resources may be possible is the

upper Sacramento River, from Keswick to Hamilton City. Improvements in water quality and possibly flow regimes appear highly practical and could substantially restore the salmon resource. Water quality considerations from the Spring Creek drainage are critical and should be a major concern of the project. Valuable stream fisheries will be lost by inundation and considerable lake fishing potential created.

The enlarged Shasta project would directly impact about 40,000 acres of land having moderate wildlife value lands: inundation will affect 32,000 acres and construction areas and project facilities perhaps another 8,000 acres. Downstream lands directly adjacent to the Sacramento River will be subject to possibly increased rates of erosion; the acreage affected will be relatively small but the riparian lands are extremely significant and valuable to the total riverine ecosystem. Adverse impacts on wildlife habitat in the Butte Basin could be significant. Wildlife resources in the San Joaquin Valley will be adversely impacted by intensified agriculture; perhaps second in impact only to the 40,000 acres directly impacted in the immediate project area. The magnitude of possible adverse impacts on wildlife resources in the estuarine portions of the project impact area are unknown at present. Only negligible opportunities for incidental improvement of wildlife resources appears possible. Compensation of wildlife resources adversely impacted by the project will be costly and for the most part require single purpose efforts. The endangered bald eagle and the State designated rare salamander will be directly impacted by the project and may present a serious restraint on the project."

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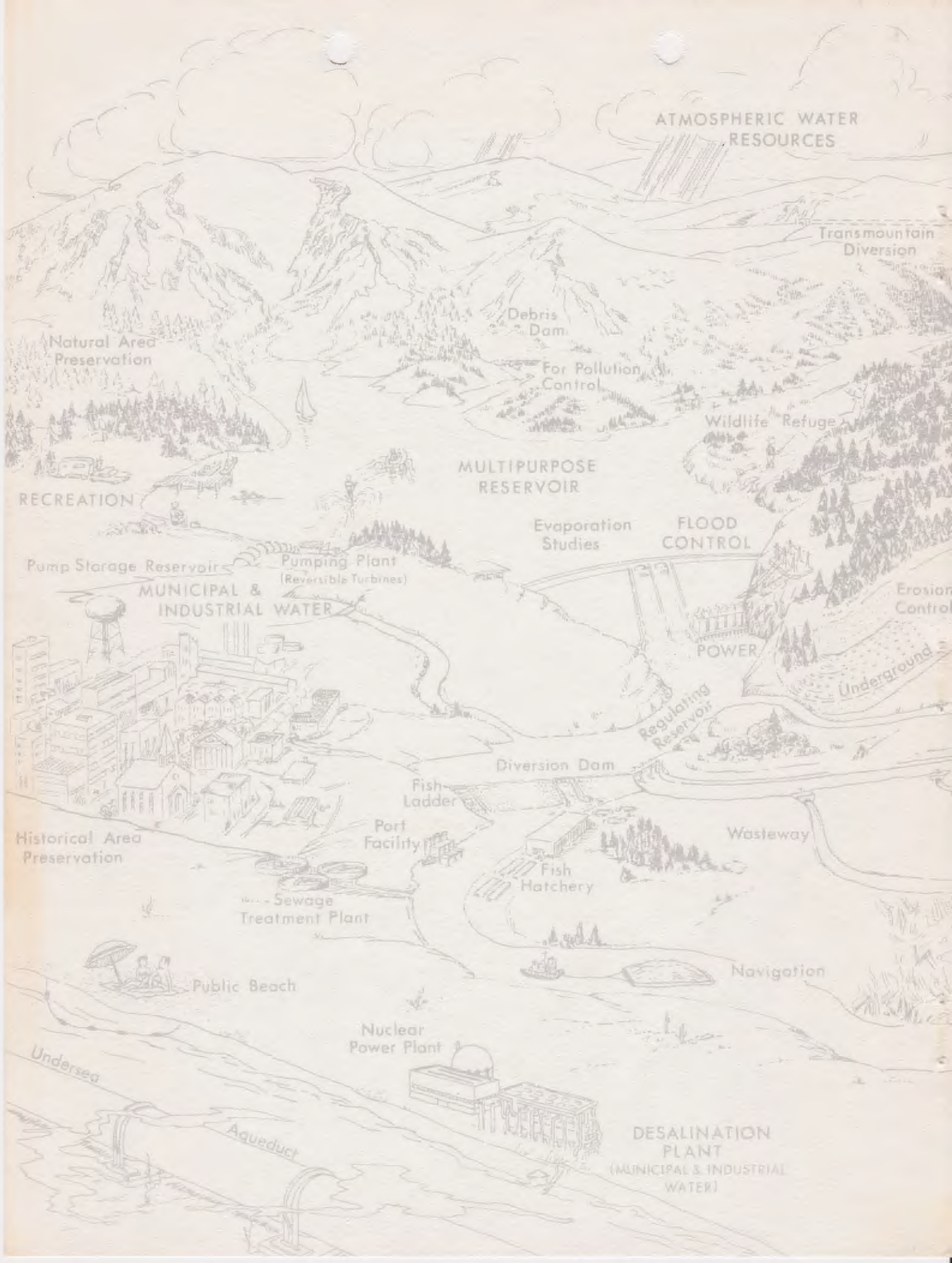
ATMOSPHERIC WATER RESOURCES
Transmountain Diversion
Debris Dam
For Pollution Control
Natural Area Preservation
Wildlife Refuge
MULTIPURPOSE RESERVOIR
RECREATION
Evaporation Studies
FLOOD CONTROL
Pump Storage Reservoir
Pumping Plant (Reversible Turbines)
MUNICIPAL & INDUSTRIAL WATER
Erosion Control
POWER
Underground
Regulating Reservoir
Diversion Dam
Fish Ladder
Port Facility
Historical Area Preservation
Wasteway
Fish Hatchery
Sewage Treatment Plant
Navigation
Public Beach
Nuclear Power Plant
Undersea Aqueduct
DESALINATION PLANT
(MUNICIPAL & INDUSTRIAL WATER)