Storage & Conveyance

D-001423

STATE OF CALIFORNIA
The Resources Agency
Department of Water Resources
NORTHERN DISTRICT

MAJOR SURFACE WATER DEVELOPMENT OPPORTUNITIES IN THE SACRAMENTO VALLEY

A Progress Report

FEBRUARY 1975

COMPARATIVE UNIT COSTS OF DRY PERIOD DELTA YIELD FROM VARIOUS NORTHERN CALIFORNIA PROJECTS

D-001425

	Tributary Storage	Tuscan Buttes	Glenn	Colusa	Enlarged Berryessa	Enlarged Shasta	Dos Rios (USCE Plan)
Sources of Data	a/	a/	a/	a/	b/	b/	c/
Capitalized cost (million $)	718	1,774	1,033	937	1,048	1,364	842
Price basis	1-75	1-75	1-75	1-75	1-75	1-75	1-72
Cost adjustment factor to 1977 prices	$\frac{2.11}{1.84}$	$\frac{2.11}{1.84}$	$\frac{2.11}{1.84}$	$\frac{2.11}{1.84}$	$\frac{2.11}{1.84}$	$\frac{2.11}{1.84}$	$\frac{2.11}{1.33}$
Capitalized cost (1977) (million $)	823	2,034	1,185	1,074	1,202	1,564	1,336
Estimated share allocated to water supply	90%	100%	99%	100%	99%	80%	93%
Capitalized cost allocated to water supply (million $)	741	2,034	1,173	1,074	1,190	1,251	1,242
Average annual cost to water supply (million $) d/	47.0	129.0	74.4	68.1	75.5	79.4	78.8
Nominal yield (MAF/yr.)	0.670	0.640	0.990	0.460	0.990	0.990	0.930
Demand buildup period @ 75 TAF/yr. (years)	8.9	8.5	13.2	6.1	13.2	13.2	12.4
Avg. annual equivalent yield (MAF/yr.)	0.531	0.512	0.695	0.395	0.695	0.695	0.668
Unit cost of Yield ($/AF)	89	252	107	172	109	114	118

a/ "Major Surface Water Development activities in the Sacramento Valley", February 1975.
b/ DWR Northern District file data.
c/ "Alternative Eel River Projects and Conveyance Routes, Appendix B, Supporting Engineering Studies", December 1972 (pp. 36-38).
d/ 6% interest, 50-year repayment.

FOREWORD

The recently published Department of Water Resources Bulletin No. 160-74, "The California Water Plan - Outlook in 1974", reached the following conclusion regarding new water supplies from surface water resources:

> "1. The location, character of streamflow and present stage of development of California's surface water resources are such that the only areas in the State where there is any substantial physical potential for development of additional water supplies are in the north coastal area and the Sacramento River Basin. More than 25 percent (18 million acre-feet) of the total stream runoff in California is set aside and not available for water supply development under existing law for wild and scenic rivers in the north coastal area (although the law does require the Department of Water Resources to report in 1985 on the need for water supply and flood control projects on the Eel River and its tributaries). There is a potential for additional development of water in the Sacramento Basin, although such development will be costly because the more economical sites have already been developed."

This progress report summarizes preliminary results of comparative studies of possible surface water development opportunities in the Sacramento Valley. The studies were conducted under the Northern California Investigation which is a part of the Department's continuing program to appraise the future needs and alternative sources of water supply in California. Sacramento Valley surface water developments are but one potential source of supply for meeting future statewide water requirements. The Department is currently studying other sources of water supply such as waste water reclamation, geothermal water, weather modification, ground water, desalting of brackish water, and possible surface water developments in some other areas of the State.

The four possible surface water developments presented in this report could augment present water supplies and provide other benefits such as flood control, recreation, and hydroelectric power. All of these possibilities would depend to varying degrees on the same surplus water available in the Sacramento River system. Therefore, their water supply capabilities are not additive, but are essentially alternative.

The studies described by this progress report represent an overall appraisal of physical possibilities and they do not constitute, therefore, a proposal for construction. The costs presented are preliminary estimates intended only to allow comparison of the plans. Any proposals for construction which may develop in the future would require more extensive investigation of designs, costs, institutional arrangements, service areas, environmental effects, economics, and financing.

Albert J. Dolcini
District Engineer
Northern District

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INTRODUCTION

The Department's Bulletin No. 160-74, "The California Water Plan, Outlook in 1974", compares projected future water demands and supplies under a variety of growth conditions. The bulletin shows that statewide water needs are expected to exceed presently foreseen supplies by from 1,600,000 to 3,800,000 acre-feet per year by 1990.

The Department is currently analyzing a number of possible water sources to meet future needs, as well as means of reducing those needs through more efficient use of existing facilities and supplies. The sources under consideration include waste water reclamation, geothermal water, weather modification, ground water, desalting of brackish water, and conventional surface water developments.

This progress report describes studies of major surface water development opportunities within the Sacramento Valley, which are being conducted under the Department's Northern California Investigation. Separate studies of Sacramento Valley ground water which are presently under way may permit future investigation of conjunctive operation of surface reservoirs and ground water.

The Sacramento River Basin

The Sacramento River drains an area of almost 27,000 square miles. It is the State's largest river, with a natural runoff averaging 22,000,000 acre-feet per year. The largest tributaries are the Feather, Pit, and American Rivers, with mean natural runoffs of about 7,000,000, 3,000,000, and 3,000,000 acre-feet per year, respectively. Total present reservoir storage capacity within the Sacramento River Basin is nearly 17,000,000 acre-feet. The basin's largest reservoirs are Shasta (4,500,000 acre-feet), Oroville (3,500,000 acre-feet), Berryessa (1,600,000 acre-feet), Almanor (1,300,000 acre-feet), and Folsom (1,000,000 acre-feet). Auburn Reservoir, when completed, will store 2,500,000 acre-feet of water.

The average annual flow passing Shasta Dam is almost 6,000,000 acre-feet and approximately 5,000,000 acre-feet per year originate in the intermediate tributary areas between Shasta Dam and the Feather River. In addition, about 1,000,000 acre-feet per year are imported to the upper Sacramento River via the Trinity River Division of the Central Valley Project.

The principal Sacramento River tributaries between Shasta Dam and the Feather River, in descending order of average natural runoff, are: Cottonwood, Cow, Stony, Battle, Clear, Butte, Mill, Deer, and Thomes Creeks. The average annual runoff of these tributaries totals about 2,800,000 acre-feet and ranges from approximately 500,000 acre-feet at Cottonwood Creek to near 200,000 acre-feet at Thomes Creek. Only a small portion of the intermediate tributary runoff is controlled; the only sizable storage facilities are Whiskeytown Reservoir on Clear Creek (250,000 acre-feet), and Black Butte, East Park, and Stony Gorge Reservoirs on Stony Creek (160,000, 51,000, and 50,000 acre-feet). However, a substantial part of the flow within the area of study is already put to use through direct diversion from the tributary streams, the Sacramento River, or the Sacramento-San Joaquin Delta.

Potential Developments

Part of the presently unused Sacramento River and tributary flows between Shasta Dam and the Feather River could be developed with any of three basic approaches to conventional surface water projects. All would involve long-term reservoir storage of flows surplus to all other requirements, and later, release during periods of need.

One approach would be construction of a series of reservoirs on the tributary streams. This approach has been investigated before during the past 30 years. If enough reservoirs were constructed, substantial water supply and flood control could be provided.

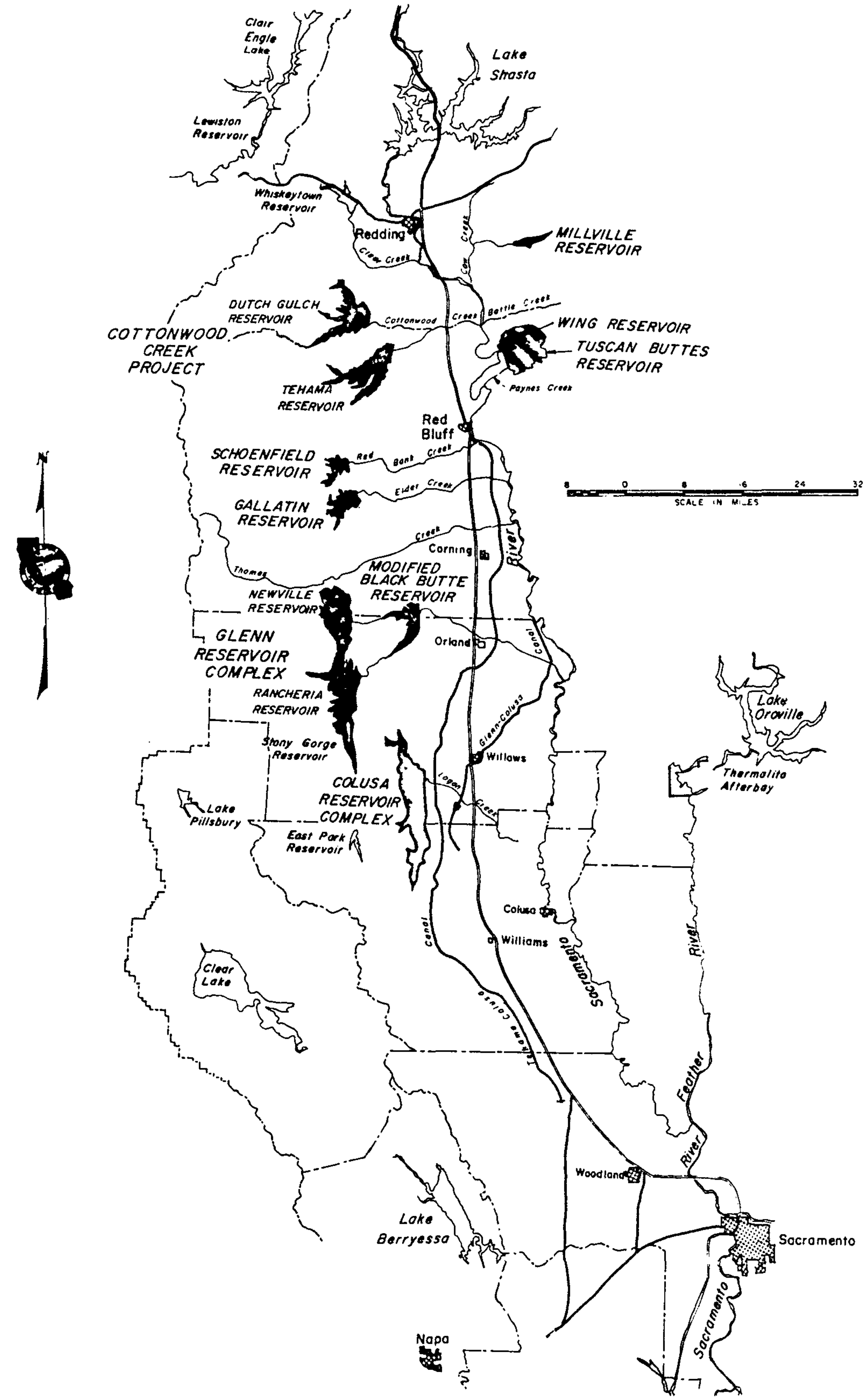
A second type of development would be a new reservoir on the Sacramento River itself. This approach, which could also provide substantial flood control and hydroelectric power benefits, was thoroughly explored in the past. A dam at the Iron Canyon site near Red Bluff was authorized by Congress in 1944, but for various reasons was never constructed. Due to potential detrimental environmental effects, construction of new reservoirs on the main Sacramento River is no longer considered a viable possibility.

The third approach to surface water development would involve construction of a large tributary reservoir for offstream storage of surplus water pumped from the Sacramento River. The potential for flood control of such a plan would be limited.

Four plans for potential surface water developments are described in separate sections of this report. The various features of these plans are shown on Figure 1. The first of the plans presented is representative of the tributary reservoir approach to development. The other three plans involve the concept of offstream storage of water pumped from the Sacramento River.

Direct comparison of the plans is very difficult with the data which have been developed thus far. The illustrated plans incorporate varying amounts of pumped-storage hydroelectric power, so that direct economic comparisons are very sensitive to the assumed power values and operating criteria. However, from the standpoint of cost of water supply, the Colusa and Tuscan Buttes Reservoir Plans would appear significantly less attractive than the Tributary Storage and Glenn Reservoir Plans.

A final section of the report discusses additional potential developments which would depend on enlargement of existing reservoirs.



POSSIBLE FUTURE SACRAMENTO VALLEY WATER DEVELOPMENTS

D-001431

Investigation Guidelines

The studies summarized by this report are largely based upon previous work by the Department of Water Resources, the Bureau of Reclamation, and the Corps of Engineers. Most key features of the plans have been covered by other studies within the past few years. These previous plans were reexamined and reformulated as necessary to meet the needs of the present investigation. Original plans were devised for the Colusa Reservoir development, which had not been studied before. This section describes the guidelines by which this investigation was conducted.

Water Supply

The water supply capability of each plan was evaluated by determining its contribution to the overall statewide water supply. From this viewpoint, a new reservoir could store only those flows which would be in excess of downstream Sacramento Valley and Delta requirements for diversion, navigation, or water quality control. To identify periods of surplus flows, the Department made coordinated operation studies of the State Water Project, the federal Central Valley Project, and all local developments projected to exist in the Central Valley in 2015. These studies identified both the timing and amounts of surplus water in the Sacramento River. On the average, surplus water would be available during about 3 months per year; however, during dry periods, surplus water might not be available for several years. Surplus water would usually be abundant when available, so the analysis of the plans is not particularly sensitive to the assumptions built into the coordinated operation studies.

The Department's coordinated operation studies also revealed that essentially no surplus water would be available within the basin during a repetition of the 1928 through 1934 critical dry period. The overall water supply capability of a plan was evaluated as the average annual increase in critical period supply made possible by the plan. This was derived from the amount of water in reservoir storage at the beginning of the critical period, with deductions for reservoir evaporation and credits for return flows from stored water releases used for irrigation upstream from the Sacramento-San Joaquin Delta.

Monthly operation studies of each plan were performed for the 1916 to 1966 hydrologic period, with adjustments to reflect projected 2015 water development in California. The studies allowed first for meeting projected local water demands on an irrigation schedule (without deficiencies) and then for release of the remainder of the new water supply on a pattern tailored to projected needs in the Sacramento-San Joaquin Delta. Under this method of operation, the long-term average annual need for supplemental water in the Delta would be slightly less than half of the average annual critical period need. Use of this schedule presupposes that any plans under study would be operated integrally with the State Water Project or the Central Valley Project and would be the next addition to one of those projects. If another plan (such as an Eel River development) were integrated first, the ratio of long-term to critical period demands on a Sacramento Valley development would be greater; this would tend to reduce the potential water supply capability of developments in the valley.

Three of the four plans described by this report would depend on off-stream storage of surplus water pumped from the Sacramento River. For these plans, an analysis of daily river flows was conducted to determine the portions of monthly surplus flows which could be captured with various pumping capacities.

Water supply allocations for local use were derived principally from federal studies of the Cottonwood Creek and Paskenta-Newville Projects. Future studies may indicate additional local demands for water and, under the California Water Code, local users would have first priority. Within reasonable bounds, the water supply allocation for local use could be increased without significant effect on the indicated overall water supply capabilities of the plans.

For comparison purposes, construction of the features of each plan was assumed to be staged to meet assumed water supply needs which would increase at an annual rate of 75,000 acre-feet per year.

Flood Control

Shasta Dam has greatly reduced flooding along the upper Sacramento River, but serious damages still result from uncontrolled runoff originating downstream from the dam. The six major post-Shasta floods and the estimated flood damages between Shasta Dam and Colusa are shown in the following tabulation:

Storm	Peak Inflow to Shasta (cfs)	Release From Shasta at Time of Peak (cfs)	Peak Flow at Ord Ferry (cfs)	Primary[1/] Flood Damage (Dollars)
December 1955	201,000	3,000	165,000[2/]	2,200,000
February 1958	116,000	12,000	232,000	6,100,000
December 1964	187,000	6,000	220,000	9,800,000
January 1970	210,000	15,000	275,000	18,500,000
January 1974	215,000	6,500	212,000	unavailable
March 1974	164,000	45,000	156,000	unavailable

1/ From USCE flood damage reports. Price levels for time of occurrence.

2/ Exceeded by a secondary crest in January 1956.

The average annual flood damages in this reach will increase in the future if development in the floodplain continues and no new flood control features are constructed in the basin. Because new reservoirs within the reach have the potential to reduce flood damages, flood control has been included as a project purpose in most of the plans presented in this report. The amount of reservoir storage capacity dedicated to flood control was based on past Corps of Engineers studies and the Department's Bulletin No. 150-1, "Upper Sacramento River Basin Investigation", February 1969.

However, reservoir construction alone cannot provide complete protection during major storms. As Bulletin No. 150-1 concluded, the best solution to flood problems in the upper Sacramento River Basin (north of Colusa) would be a carefully integrated complex of reservoir projects, levee and bypass systems, channel maintenance, and floodplain management.

Recreation

The Sacramento Valley area presently has an abundance of reservoir recreation opportunities. A theoretical upper limit exists as to the amount of time a given population can devote to outdoor recreation. As this limit is approached, adding new opportunities can cause a redistribution of local use rather than a net increase in use. Conversely, construction of a complex of reservoirs and the variety of recreational activities they make available may attract additional recreationists from distant areas.

Estimates made for the State-Federal Type I Framework Studies suggest that the present upper Sacramento Valley population may generate about 2,000,000 to 3,000,000 recreation days annually for all recreation away from home. Attendance data from existing reservoirs in the area indicate that about half of the recreation use originates within 50 miles. This local use already exceeds 1,000,000 recreation days, thus suggesting the local market for reservoir recreation may be near saturation.

For these reasons, a significant part of attendance at any proposed new reservoir in the upper Sacramento Valley may be at the expense of other existing or planned projects in the area. However, since the distant market is by no means saturated, major new reservoirs would draw some new users. With several new reservoirs under consideration for the upper Sacramento Valley, a reasonable method of allocating future recreation use among the competing projects is needed. For this report, a judgment was made concerning this factor in estimating future recreation use at a potential reservoir project.

Fish and Wildlife

The Sacramento River system supports an excellent inland salmon and steelhead sport fishery. An average of about 400,000 king salmon and 25,000 steelhead spawn in the Sacramento River Basin each year, mostly upstream from Red Bluff. Approximately 100,000 angler-days of use are expended by salmon fishermen and 40,000 angler-days by steelhead fishermen per year. This represents about 45 and 13 percent, respectively, of the total statewide angling effort for salmon and steelhead in inland waters. Present sport landings in the Sacramento River system are estimated at 20,000 salmon and 10,000 steelhead annually.

The upper Sacramento River provides good rainbow trout fishing during the summer. In the spring, striped bass, shad, and sturgeon are landed as far upstream as Red Bluff. The upper Sacramento River also supports populations of sunfish, black bass, catfish, and nongame species such as carp, suckers, and squawfish.

The Sacramento River Basin supports a large variety of game and nongame species. Big game animals include blacktailed deer, black bear, and mountain lion. Valley quail, mountain quail, mourning dove, band-tailed pigeon, pheasant, turkey, sooty grouse, gray squirrel, Douglas squirrel, black-tailed jack rabbit, and brush rabbit are the common species of upland game. Furbearers include badger, beaver, bobcat, coyote, ermine, fisher, gray fox, red fox, marten, mink, muskrat, opossum, river otter, raccoon, ring-tailed cat, striped skunk, spotted skunk, and weasel. The Sacramento Valley also supports millions of wintering waterfowl. Almost any water development in the upper Sacramento River Basin would have an impact on the fish and wildlife resources of the basin. Some of the plans presented in this report would block salmon and steelhead from upstream spawning areas and most would inundate valuable wildlife habitat. Increased flood control could have a significant effect on wildlife in the Butte Basin, in the riparian habitat along the river, and in the seasonal wetlands provided by flooding in the Sutter and Yolo Bypasses.

The Butte Basin provides vital winter habitat for waterfowl and associated wildlife species in the various overflow channels. The riparian habitat along the river supports a wide variety of game and nongame wildlife species. Reduction in floodflows by upstream reservoirs could permit additional land reclamation and land use changes to allow more intensive agriculture. This would result in reduced wildlife habitat, especially in the streamside riparian and marshland areas. Marshland and riparian habitat support a wider variety and denser populations of wildlife species than do any of the other habitat types in this study area, and both of these habitat types are identified in the California Fish and Wildlife Plan as being in short supply.

Hydroelectric Power

The plans covered by this report represent only a small fraction of the potential for development of new conventional hydroelectric power within the Sacramento River Basin. The potential of all plans, and particularly the Tributary Storage Plan, is limited by the irregular pattern of demands for water.

However, except for the Tributary Storage Plan, the plans described by this report would have some potential for pumped-storage hydroelectric power development since they would already incorporate pumping and conveyance facilities and/or reservoirs with favorable differences in elevation. Under the pumped-storage mode of operation, off-peak energy would be used to pump water to an upper reservoir for subsequent release for generation during periods of peak electrical power demand. The net efficiency of the pumped-storage cycle is such that only about two-thirds of the energy consumed by pumping can be recovered; therefore a pure pumped-storage hydroelectric development is a net consumer of energy. Nevertheless, increased use of pumped-storage developments is foreseen to meet peak demands in the future, when greater reliance will be placed on thermal electric plants which operate most efficiently at near-uniform load and which are capable of producing surplus energy for pumping during off-peak periods.

The various plans were formulated to incorporate pumped-storage hydroelectric power generation where practical. The vexing problem of pumped-storage project formulation at the reconnaissance planning level is to decide how much pumping-generating capacity to include. In the absence of definite physical constraints, the power features could be expanded until they totally dominate the other functions. Accordingly, the general approach used in this study was that pumped-storage power would be included only to the extent that it could be accomplished by using reversible pump-turbine units in place of pump units which would be required anyway.

Determination of dependable pumped-storage hydroelectric generating capacity was based on the assumptions that the reservoir would be at minimum pool level and that maximum pumping for water supply would be under way. It was further assumed that off-peak energy for pumping would be available during 96 hours of the critical week and that power would have to be generated for 40 hours of the week.

Water Quality

Both surface and ground waters of the Sacramento River Basin are generally of good to excellent quality at present. As part of a statewide program to protect and enhance water quality, the Central Valley Regional Water Quality Control Board is preparing to adopt a water quality control plan which includes the Sacramento River Basin. This plan will be adopted in 1975; meanwhile, the Regional Board is depending on an interim water quality control plan which was completed in 1971.

The interim plan establishes specific water quality objectives for the main stem of the Sacramento River, its principal tributaries, and all minor tributaries above an elevation of 1,000 feet. However, it does not establish specific objectives for the lower reaches of any of the tributaries which would be affected by the plans described by this report. The 1975 water quality control plan will probably continue with essentially the same water quality objectives established by the interim plan, but also include objectives for all other waters of the basin.

The following Sacramento River water quality objectives of the Regional Board's interim plan could have substantial impact on additional water development projects:

1. There shall be no significant increase in turbidity beyond background levels.

2. There shall be no adverse changes in water temperature due to waste discharges or other activities of man. Temperatures shall be maintained at historic levels since 1960 and normal seasonal and daily variations shall be maintained. Temperature shall not be increased by more than 3^{o} F. During periods when temperature increases will be detrimental to the fishery, temperature shall not be elevated above 56^{o} F. from Keswick Dam to Hamilton City nor above 68^{o} F. from Hamilton City to Sacramento.

3. Dissolved oxygen levels shall be maintained at or near established seasonal levels. Waste discharges shall not cause the dissolved oxygen concentration to fall below 5.0 mg/l or, during June, July, and August, below 9.0 mg/l from Keswick Dam to Hamilton City or 7.0 mg/l between Hamilton City and Sacramento.

These objectives may be difficult to meet, and more detailed studies would be needed to draw firm conclusions concerning the impact of the various plans on river water quality. Some of the plans presented in this report could prove quite beneficial in helping to preserve the high quality of water in the Sacramento River. Water quality control was one of the motivating factors in the selection of the large minimum pools used in many of the reservoirs included in this study.

THE TRIBUTARY STORAGE PLAN

This plan would involve a composite of eight new reservoirs on streams tributary to the Sacramento River between Redding and Colusa. All eight reservoirs would not necessarily have to be constructed in a package as this plan illustrates.

Sites used in this plan were selected from over a dozen previously studied reservoir sites in the same area. Probably the best known of the sites selected are those of the Corps of Engineers' Cottonwood Creek Project, which has been authorized for construction.

The Corps of Engineers is currently studying a Millville Reservoir Project on the South Fork of Cow Creek. Its studies, based on federal formulation criteria, may indicate a somewhat different reservoir size than shown in the plan described here.

The Newville Reservoir included in this plan is a smaller version of the reservoir investigated by the Bureau of Reclamation as a part of a potential Paskenta-Newville unit of the Central Valley Project. The reservoir size selected by the Bureau was based on coordinated operation with other reservoirs of the Central Valley Project.

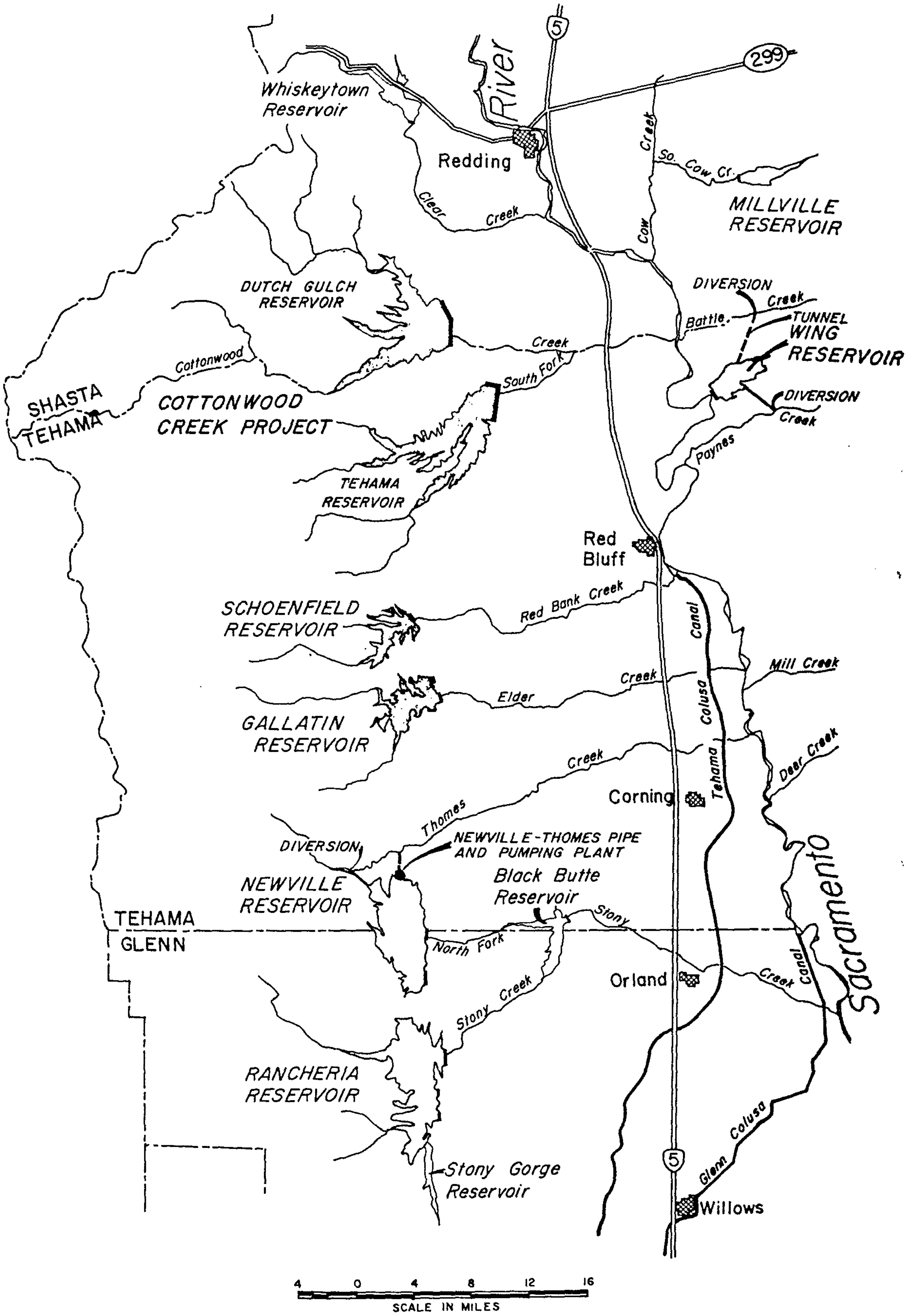
Tables 1 through 4, located at the end of the section, present pertinent data on the Tributary Storage Plan.

Project Description

As shown by Figure 2, the eight reservoirs selected for this plan are: Dutch Gulch 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. Two of the reservoirs would rely on diversions from other watersheds for their principal water supply.

A diversion dam on Thomes Creek and a 2.4-mile canal would provide Newville Reservoir with its principal water supply. Flows which would be surplus to both local and downstream needs would be diverted, with the provision that the remaining Thomes Creek flow would not be reduced below 100 cfs. The diversion canal would carry up to 67,000 cfs in order to provide flood protection along Thomes Creek. Water for local use along lower Thomes Creek would be pumped from the north end of Newville Reservoir when necessary.

Wing Reservoir would receive surplus water from Paynes and Battle Creeks. Surplus flows in excess of 50 cfs would be diverted from Paynes Creek through a 1.8-mile canal and those in excess of 400 cfs



TRIBUTARY STORAGE

would be diverted from Battle Creek through a 2.7-mile tunnel. The capacity of these conduits would be 500 cfs and 2,000 cfs, respectively.

As presently envisioned, releases from all reservoirs would reach the Sacramento River via natural channels. As an alternative, releases from some reservoirs could be delivered to existing irrigation canals in exchange for reduction of their diversions from the river.

Project Sizing

The illustrated sizes of Dutch Gulch and Tehama Reservoirs are those proposed by the Corps of Engineers. Either water supply or topography limited the sizes of the other dams used in the plan. The sizes of Schoenfield, Gallatin, Wing, and Millville Reservoirs would represent essentially full development of the topographic potential of the sites. However, the sizes of Schoenfield and Gallatin, along with Rancheria and Newville, are limited by their water supplies. Schoenfield and Newville Reservoirs may be somewhat oversized and further study is needed of their sizing.

Project Costs

The first cost of the eight reservoirs in this plan would be about $660,000,000. The total capitalized cost, including allowances for interest during construction, operation, maintenance, and replacement, would be about $720,000,000, based on 6 percent interest and a 100-year period of analysis. The staging plan used in the calculation of capitalized cost and the breakdown of cost by feature are shown in Tables 3 and 4.

Project Accomplishments

Coordinated operation of the eight reservoirs included in this plan could increase net usable water supplies during a repetition of the 1928-34 critical dry period by an average of 670,000 acre-feet per year. Demand projections indicate that about 60,000 acre-feet per year of the new supply could be used locally and the remainder would be available for use in other areas.

Allowances for water for local use were based on meeting total projected demands of 40,000 acre-feet per year along Cottonwood Creek and 20,000 acre-feet per year along Thomes Creek. Changes in the amount or location of local water use to accommodate local desires could be made without appreciable effect on the total project water supply capability.

The Corps of Engineers has studied the flood control potential of most of these reservoirs. Based on a review of these past studies and on studies conducted for the Department's Bulletin No. 150-1, "Upper Sacramento River Basin Investigation", the following allowances for primary flood control reservations have been included in these reservoirs:

Reservoir	Flood Control Storage in Acre-Feet
Dutch Gulch	240,000
Tehama	240,000
Schoenfield	10,000
Gallatin	20,000
Newville	100,000
Rancheria	100,000
Wing	None
Millville	20,000
Total	730,000

These reservoirs, with the indicated flood control storage, would provide essentially complete flood protection for Stony, Thomes, and Cottonwood Creeks and would provide substantial reductions in floodpeaks on Elder Creek, Red Bank Creek, and the South Fork of Cow Creek. In combination, the reservoirs would reduce typical peak floodflows on the Sacramento River by approximately 20 percent at both Red Bluff and Ord Ferry.

Initial water-oriented recreation use at the reservoirs of this plan is estimated as about 1,300,000 recreation days per year. Maximum use of about 4,500,000 recreation days per year would be expected in 55 to 100 years. Estimates of recreation use at the individual reservoirs are presented in Table 1.

As formulated here, the Tributary Storage Plan would incorporate no facilities for hydroelectric power generation or for pumping; therefore, the plan would neither produce nor consume electrical energy. Increased values of energy could make power generation economically attractive and the possibility should be considered in any future studies.

Project Detriments

The eight reservoirs in this plan would inundate about 68,000 acres in Shasta, Tehama, and Glenn Counties (including the existing 1,300-acre Stony Gorge Reservoir). This land presently supports (1) about 550 people living in and around the reservoir areas; (2) 4,000 acres of agricultural crops, including 2,000 acres of irrigated crops and 2,000 acres of dry-farmed crops; (3) numerous game and nongame wildlife species; (4) about 65 miles of year-round natural streams and attendant riparian habitat; (5) about 70 miles of secondary roads, and (6) significant numbers of archaeological sites. In addition to the inundated areas, over 40,000 acres of land would be required for other purposes, including public access, recreation developments, and wildlife areas. Nearly all of the land that would be dedicated to project purposes would be acquired from the private sector and thus removed from county tax rolls.

Together, the dams included in this plan would block annual fish runs averaging over 3,300 salmon and 1,700 steelhead. Tehama, Dutch Gulch, and Millville Dams would account for most of the blocked fish runs; the Corps of Engineers' plans for Tehama and Dutch Gulch Reservoirs call for fishery improvement flow releases to compensate for most spawning habitat above the damsites. Mitigative measures for all reservoirs will require additional study.

The overall impact of the tributary reservoirs could be detrimental to the Sacramento River fisheries. This could occur through alteration of gravel movement patterns, aquatic and riparian vegetation, and water temperatures. Because of their relatively small storage capacities, some of the reservoirs might exhaust their reserves of cold water early in the fall and be forced to release warmer water during critical fish migration or spawning periods.

The benefits derived from the relatively high degree of flood control provided by this plan could be accompanied by some objectionable environmental effects. Reservoir fluctuation, particularly that needed for flood control operation, would sometimes expose mudflats. Operation of the reservoirs for flood control could extend the length of periods of high turbidity levels in the Sacramento River. Also, flood control without adequate local regulation frequently encourages agricultural, residential, and industrial encroachment along streams; this not only reduces or eliminates the wild characteristic of the stream and its floodplain, but also creates other potential problems, such as loss of wildlife habitat and increased risk of flood damage.

Collectively, the reservoirs of this plan would inundate a comparatively large amount of wildlife habitat, including over 1,000 acres of riparian vegetation. The lands which would be flooded presently support about 2,500 deer.

Level of Planning Knowledge

The extent of current knowledge of individual potential reservoirs in the Tributary Storage Plan is quite varied. Some prior planning work was available on all the reservoirs included in this plan. Past studies provide fairly detailed geologic and cost data for Dutch Gulch, Tehama, Newville, and Rancheria Reservoirs. These studies included surface and subsurface geologic investigations, borrow area location and exploration, fill materials testing, and sufficient planning to provide a reasonable degree of confidence in the engineering feasibility of these sites.

Knowledge of the Millville, Wing, Schoenfield, and Gallatin sites is of a lower level than for the four sites listed above. Surface geologic mapping has been performed at all four sites, but foundation drilling has been done only at the Millville and Gallatin sites. Borrow areas have been mapped, but very little materials testing has been done. Present indications are that any of these features could be built essentially as envisioned.

Any future studies of this plan should place considerable emphasis on local water supply, flood control, and environmental effects. A detailed consideration of these factors could result in size changes for the individual reservoirs included here. As noted, the Corps of Engineers' current studies of a Millville Reservoir Project may indicate a different reservoir size than shown in this plan.

TABLE 1

TRIBUTARY STORAGE PLAN
DAM AND RESERVOIR DATA SUMMARY

	Cottonwood Creek Project				
	Dutch Gulch Dam and Reservoir	Tehama Dam and Reservoir	Schoenfield Dam and Reservoir	Gallatin Dam and Reservoir	Newville Dam and Reservoir
Drainage area, square miles	392	382	47	96	231 1/
Mean annual flows, acre-feet					
Runoff at damsite (1916-66)	313,000	184,000	24,000	55,000	216,000 1/
Storable inflow	192,000	113,000	14,000	26,000	149,000 1/
Elevations, feet					
Dam crest	778	735	1,012	1,000	904
Maximum pool	773	730	1,000	990	895
Top of flood reservation	757	715	992	980	885
Top of conservation pool	735	692	976	966	877
Minimum pool	635	608	867	847	730
Streambed	510	497	730	720	600
Dam height, feet	268	238	282	280	304
Dam construction time, years	4	4	2	3	4
Capacities, acre-feet					
Flood reservation, maximum	240,000	240,000	10,000	20,000	100,000
Conservation storage	710,000	540,000	147,000	310,000	1,320,000
Inactive, dead, sediment	150,000	120,000	20,000	40,000	200,000
Gross	1,100,000	900,000	177,000	370,000	1,620,000
Area, acres					
Reservoir at gross storage	12,700	12,200	2,300	4,300	13,300
Total land required	24,000	22,000	4,200	7,200	18,000
eservoir shoreline, miles	130	136	42	56	86
ive streams inundated, miles	20	20	0	8	0
opulation displaced, 1970	50	60	10	10	50
1990	80	100	10	10	50
verage fish runs at damsite					
Salmon, fish per year	500	1,800	few	few	few 1/
Steelhead, fish per year	400	1,100	few	few	200 1/
ecreation days per year					
Initial use	205,000	175,000	35,000	60,000	310,000
Maximum use	700,000	500,000	130,000	210,000	800,000
Years to reach maximum use	85	75	100	100	55
er displaced	200	200	100	300	800+

Includes Thomes Creek diversion.

TABLE 1 (continued)

TRIBUTARY STORAGE PLAN
DAM AND RESERVOIR DATA SUMMARY

	Rancheria Dam and Reservoir	Wing Dam and Reservoir	Paynes Creek Diversion	Battle Creek Diversion	Millville Dam and Reservoir
Drainage area, square miles	599	23	69	300	80
Mean annual flows, acre-feet					
Runoff at damsite (1916-66)	322,000	11,000	37,000	329,000 1/	71,000
Storable inflow	135,000	7,000	20,000 2/	78,000 3/	23,000
Elevations, feet					
Dam crest	864	565			830
Maximum pool	857	558			825
Top of flood reservation	845	--			815
Top of conservation pool	830	550			807
Minimum pool	742	415			678
Streambed	590	318			570
Dam height, feet	274	247			260
Dam construction time, years	3	3			3
Capacities, acre-feet					
Flood reservation	100,000	0			20,000
Conservation storage	900,000	425,000			200,000
Inactive, dead, sediment	200,000	40,000			20,000
Gross	1,200,000	465,000			240,000
Areas, acres					
Reservoir at gross storage	15,200 4/	5,200			2,500
Total land required	21,600	7,400			4,000
Reservoir shoreline, miles	113	24			17
Live streams inundated, miles	11	1			5
Population displaced, 1970	330	10			30
1990	330	10			50
Average fish runs at damsite					
Salmon, fish per year	0	0	few	few 5/	1,000
Steelhead, fish per year	0	0	few	few 5/	few
Recreation use, visitor-days/yr.					
Initial use	350,000	140,000			70,000
Maximum use	1,380,000	540,000			280,000
Years to reach maximum use	60	100			100
Deer displaced	500	300+	unknown	unknown	100

1/ Flow at gage near mouth.

2/ Storable flow in excess of 50 cfs.

3/ Storable flow in excess of 400 cfs.

4/ Includes existing Stony Gorge Reservoir (1,300 acres).

5/ Could have an adverse impact on spawning downstream.

TABLE 2

TRIBUTARY STORAGE PLAN
CONVEYANCE FACILITY DATA

Thomes-Newville Canal	
Type	Unlined
Length, miles	2.4
Capacity, cfs	67,000
Newville-Thomes Pipe and Pumping Plant 1/	
Length, miles	5
Capacity, cfs	100
Installed horsepower	4,000
Maximum lift, feet	300
Paynes-Wing Canal	
Type	Concrete-lined
Length, miles	1.8
Capacity, cfs	500
Battle Creek Tunnel	
Diameter, feet	13
Length, miles	2.7
Capacity, cfs	2,000

1/ Newville-Thomes Pipe and Pumping Plant would be primarily for supplying water for local irrigation and fish maintenance along Thomes Creek.

TABLE 3

TRIBUTARY STORAGE PLAN
ILLUSTRATIVE STAGING PLAN

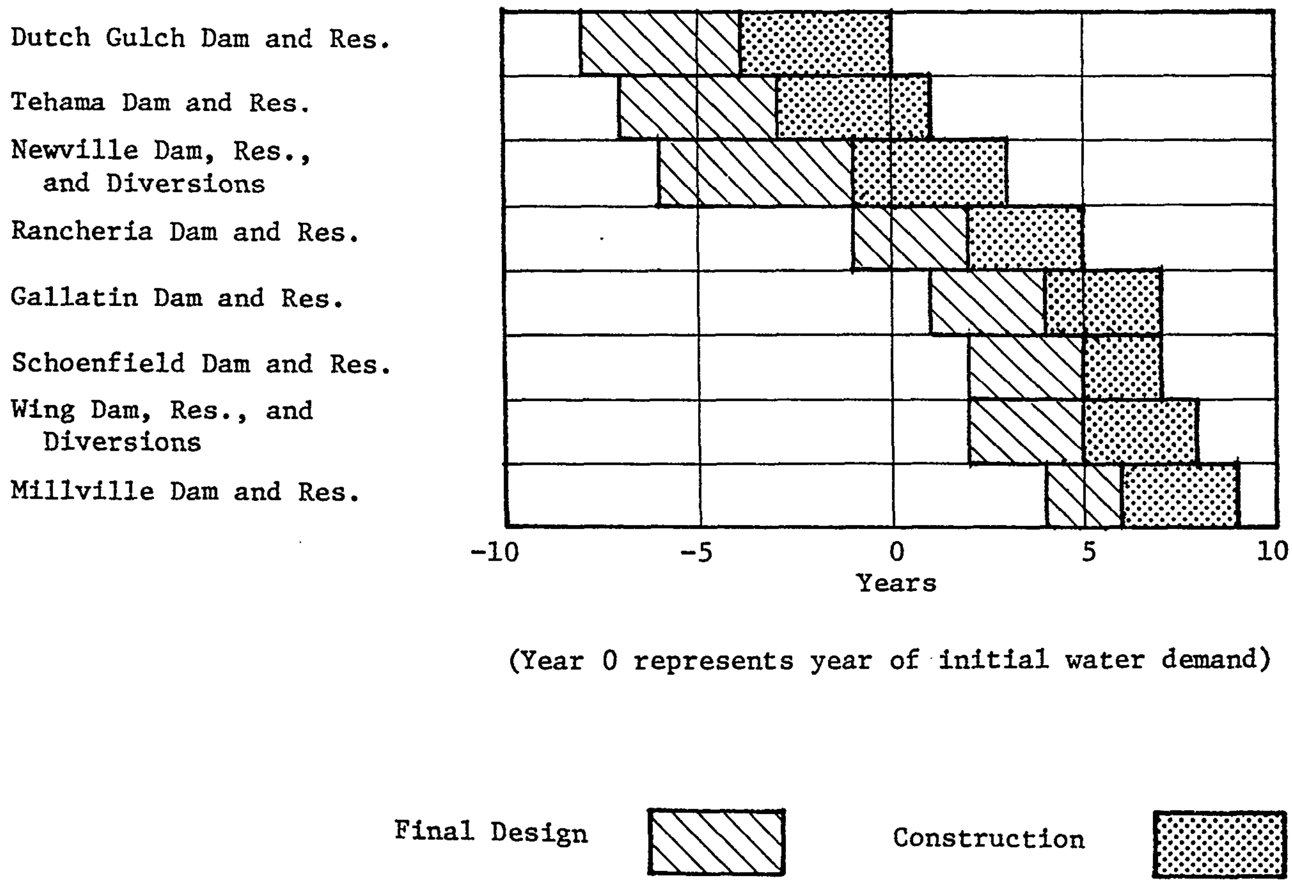


TABLE 4

TRIBUTARY STORAGE PLAN
COST SUMMARY

(Price basis, Jan. 1975. Period of analysis, 100 years. Interest rate, 6%)

Feature	Construction Completion Year 1/	Construction Time (Years)	Costs, in Millions of Dollars: First Cost (includes Engr. and Contingencies)	Construction Cost Capitalized to Year 0	OM&R Cost Capitalized to Year 0	Total Cost Capitalized to Year 0
Dutch Gulch Dam and Reservoir	0	4	162	182	27	209
Tehama Dam and Reservoir	1	4	107	113	15	128
Newville Dam, Reservoir, and Diversion Facilities	3	4	104	97	8	105
Rancheria Dam and Reservoir	5	3	133	111	10	121
Gallatin Dam and Reservoir	7	3	33	24	2	26
Schoenfield Dam and Reservoir	7	2	21	15	2	17
Wing Dam, Reservoir, and Diversion Facilities	8	3	58	40	3	43
Millville Dam and Reservoir	9	3	28	18	2	20
Recreation Facilities 2/			19	21	28	49
TOTAL COST			665	621	97	718

1/ Year 0 represents year of initial water demand.

2/ First cost includes initial recreation facilities only; capitalized costs include all future stage recreation development.

TUSCAN BUTTES RESERVOIR-RIVER DIVERSION PLAN

The Tuscan Buttes Reservoir-River Diversion Plan would store surplus Sacramento River flows by pumping to a large off-stream reservoir on Inks and Paynes Creeks in Tehama County. As formulated for this study, the plan would include reversible pumping-generating units to produce pumped-storage hydroelectric power. The plan described herein incorporates a 5,500,000-acre-foot Tuscan Buttes Reservoir and facilities to divert up to 5,000 cfs from the Sacramento River. Tables 5 through 8, located at the end of the section, summarize numerical data.

The concept of the Tuscan Buttes Reservoir-River Diversion Plan was developed by the Bureau of Reclamation in the late 1960s. The Bureau's 1972 reconnaissance report, "Tuscan Buttes Unit, Central Valley Project", describes a 3,675,000-acre-foot reservoir with a 4,000-cfs river diversion capacity. Operated as a unit of the Central Valley Project, the Bureau's Tuscan Buttes Reservoir Plan would provide firm annual water supply of 535,000 acre-feet and 80 megawatts of firm hydroelectric power. The Bureau of Reclamation report concludes that the Tuscan Buttes plan merits further study and consideration, but the Bureau has not yet begun additional studies.

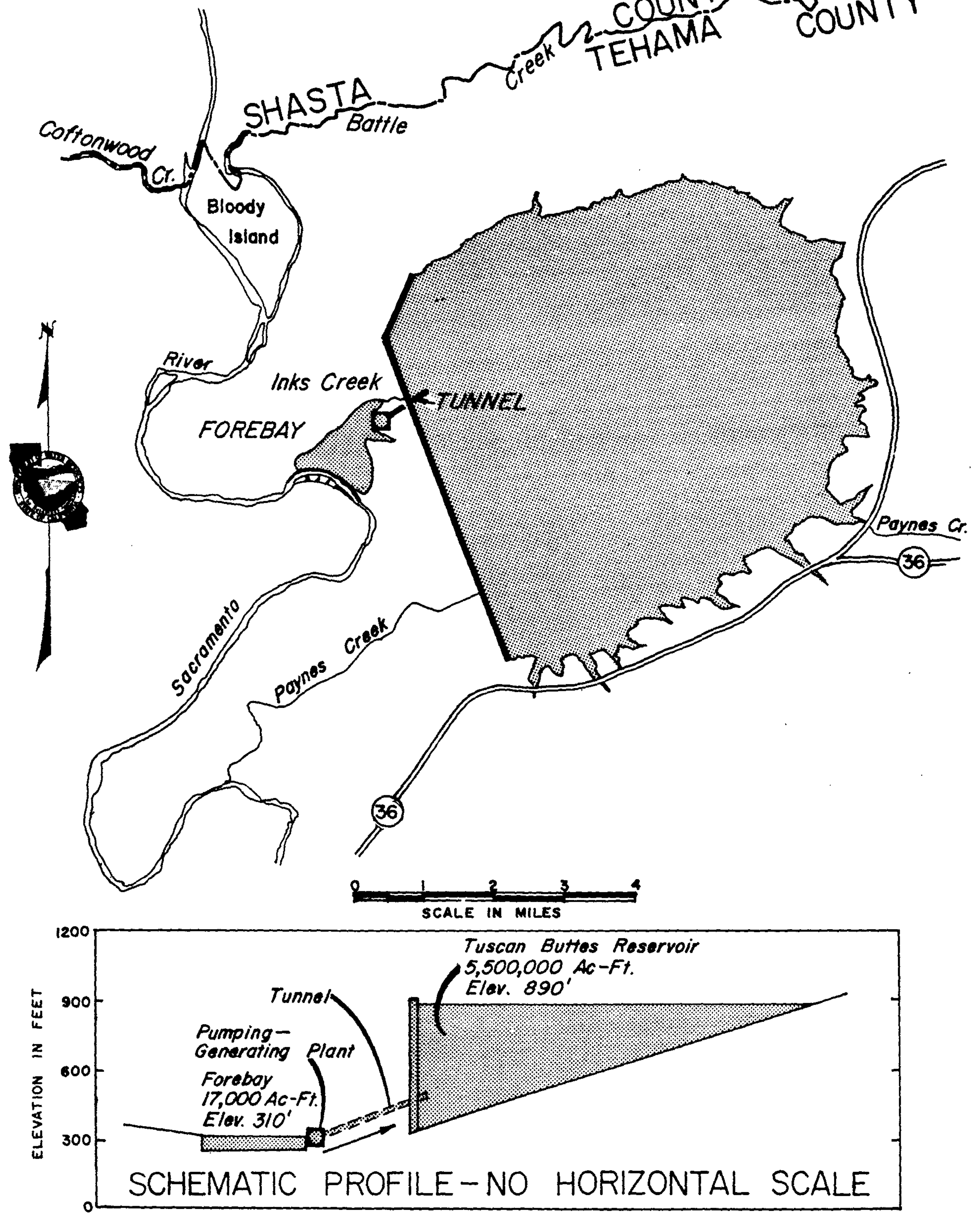
Project Description

As shown on Figure 3, the key feature of this plan would be a 5,500,000-acre-foot reservoir formed by Tuscan Buttes Dam. The dam would have a crest length of 6 miles and a maximum height of 585 feet and require embankment volume of 500,000,000 cubic yards. This volume of fill would be almost three times that of the current world record holder, Pakistan's 186,000,000-cubic yard Tarbela Dam.

Up to 5,000 cfs of surplus Sacramento River water would be diverted by gravity to a 17,000-acre-foot pumping forebay. The forebay would be formed by excavation in a natural bend of the Sacramento River and would involve relocation of the river through a 0.9-mile excavated channel. Water would be pumped on an off-peak basis from the forebay through two 25-foot-diameter tunnels to Tuscan Buttes Reservoir. The maximum rate of pumping would be 10,000 cfs and the maximum pump lift would be about 580 feet.

As the plan is presently formulated, the pumping plant would be operated for pumped-storage hydroelectric power generation. The plant depicted would have a dependable power capacity of 71 megawatts.

Reservoir releases would travel back through the diversion facilities to the Sacramento River. Multiple-level intake structures in Tuscan Buttes Reservoir would allow control of the temperatures and turbidity of releases.



TUSCAN BUTTES RESERVOIR —RIVER DIVERSION

D-001449

Project Sizing

The 5,500,000-acre-foot Tuscan Buttes Reservoir capacity was selected to agree with the size then being studied by the Bureau of Reclamation. (The Bureau subsequently reported upon a smaller reservoir.) The relatively large 1,200,000-acre-foot dead storage was incorporated in the plan to facilitate hydroelectric power generation and control of the water quality of reservoir releases.

The diversion system capacity of 5,000 cfs was chosen to provide a good hydraulic balance between the divertible water supply and the reservoir active storage capacity. A greater diversion capacity would increase the project water supply and permit inclusion of greater reservoir storage capacity.

The forebay would be sized to regulate the peaking power releases from the pumping-generating plant and the continuous Sacramento River diversions to conform to the off-peak mode of operation. The forebay is topographically limited and very little opportunity exists for enlargement. The dependable power generation capacity of 71 megawatts is controlled by the forebay capacity and the minimum pool elevation of Tuscan Buttes Reservoir. Greater dependable pumped-storage generating capacity could be achieved only by increasing the minimum pool elevation of Tuscan Buttes Reservoir.

Project Costs

The first cost of the Tuscan Buttes Reservoir-River Diversion Plan would be about $1,500,000,000. The total capitalized cost, including allowances for interest during construction, operation, maintenance, replacement, and pumping power, would be about $1,800,000,000, based on 6 percent interest and a 100-year period of analysis. The staging plan used in the calculation of capitalized cost and the breakdown of cost by feature are shown in Tables 7 and 8. Under the demand buildup used to develop this plan, Tuscan Buttes Dam would not have to be completed before use could be made of some of the storage potential.

Project Accomplishments

The Tuscan Buttes Reservoir-River Diversion Plan could increase usable water supplies during a repetition of the 1928-34 critical dry period by an average of 640,000 acre-feet per year.

The pumped-storage power operation described would provide a dependable generating capacity of 71 megawatts, which would produce net annual revenues of around $3,000,000. The pumped-storage power operation would result in net use of approximately 100,000,000 kilowatt-hours per year. (The pumping of Sacramento River water to the reservoir for long-term storage and subsequent power recovery through generation with the reservoir releases would consume a net average of an additional 100,000,000 kilowatt-hours annually.)

Flood protection potential would occur from (1) pumping as much as 5,000 cfs from the Sacramento River for water supply conservation and (2) impounding Paynes and Inks Creeks. These would reduce river stages slightly.

Total water-oriented recreation use at Tuscan Buttes Reservoir is estimated as 225,000 recreation days per year initially and 400,000 recreation days per year when capacity is reached in 35 years.

Project Detriments

Tuscan Buttes Reservoir would inundate 22,000 acres of important deer-wintering area which supports over 1,700 deer. This would be of major impact to wildlife since there is little or no opportunity to offset the losses.

The most serious fishery problem associated with this plan would be created by diversion of flows from the Sacramento River at a location where active spawning of steelhead and salmon occurs. The intake screening problem is aggravated by the fact that the river would often be transporting large quantities of debris during the diversion time. A fine mesh screen necessary to exclude small fish from the forebay would rapidly choke with debris. A high efficiency screen design to overcome this problem has not yet been developed.

A total of about 30,000 acres of land would be required for Tuscan Buttes Reservoir and associated facilities. Approximately 27,000 acres would be acquired from private owners and thus removed from Tehama County tax rolls. The land which would be acquired is used primarily for grazing; about 300 acres are cultivated and about 50 people presently live within the area.

Level of Planning Knowledge

Investigation of the Tuscan Buttes Reservoir-River Diversion Plan has been relatively limited. Surface geologic studies were conducted jointly by the Bureau of Reclamation and the Department, but no subsurface exploratory work was done. Cost estimates and project formulation studies were brief. Further consideration of this plan would require substantial additional investigation, with particular attention to engineering feasibility, fish screening problems, wildlife impacts, and hydroelectric power potential.

TABLE 5

TUSCAN BUTTES RESERVOIR-RIVER DIVERSION PLAN
DAM AND RESERVOIR DATA SUMMARY

	Tuscan Buttes Dam and Reservoir
Drainage area, square miles	121
Mean annual flows, acre-feet	
Runoff at damsite (1916-66)	54,000 1/
Storable inflow	27,000 1/
Elevations, feet	
Dam crest	915
Maximum pool	900
Top of flood reservation	890
Top of conservation pool	890
Minimum pool	640
Streambed	330
Dam height, feet	585
Dam construction time, years	7
Capacities, acre-feet	
Flood reservation	0
Conservation storage	4,300,000
Inactive, dead, sediment	1,200,000
Gross	5,500,000
Area, acres	
Reservoir at gross storage	22,000
Total land required	28,000 2/
Reservoir shoreline, miles	40
Live streams inundated, miles	7
Population displaced, 1970	50
1990	100
Average fish runs at damsite	
Salmon, fish per year	Few
Steelhead, fish per year	Few
Recreation days per year	
Initial use	225,000
Maximum use	400,000
Years to reach maximum use	35
Deer displaced	1,700+

1/ This is the combined runoff of Inks and Paynes Creeks.

2/ Total project including the diversion system would require 30,000 acres.

TABLE 6

TUSCAN BUTTES RESERVOIR-RIVER DIVERSION PLAN
CONVEYANCE FACILITY DATA

Forebay	
Capacity, acre-feet	17,000
Pumping-Generating Plant	
Operating mode	Pump off-peak, generate on-peak
Design flow, cfs	10,000
Maximum static head, feet	580
Pumping capacity, megawatts	580
River Bypass Channel	
Type	Unlined
Length, miles	0.9
Capacity, cfs	250,000
Tunnels	
Type	2 - Concrete-lined
Length, feet (each)	1,410
Capacity, cfs (each)	5,000
Diameter, feet (each)	25

TABLE 7

TUSCAN BUTTES RESERVOIR-RIVER DIVERSION PLAN
ILLUSTRATIVE STAGING PLAN

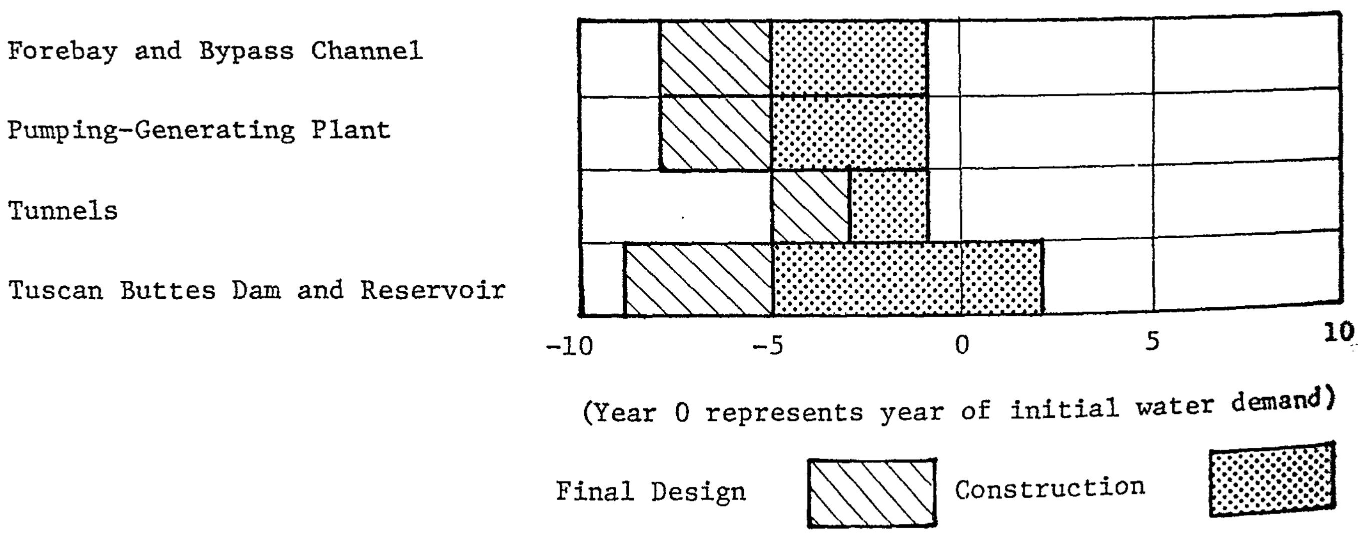


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TABLE 8

TUSCAN BUTTES RESERVOIR-RIVER DIVERSION PLAN
COST SUMMARY
(Price basis, Jan. 1975. Period of analysis, 100 years. Interest rate, 6%)

Feature	Construction Completion Year 1/	Construction Time (Years)	Costs, in Millions of Dollars			
			First Cost (includes engr. & contingencies)	Construction Cost Capitalized to Year 0	OM&R and Power Cost Capitalized to Year 0	Total Cost Capitalized to Year 0
Forebay and Bypass Channel	-1	4	30	36	8	44
Pumping-Generating Plant	-1	4	105	125	80	205
Tunnels	-1	2	25	29	-	29
Tuscan Buttes Dam & Res.	2	7	1,299	1,399	90	1,489
Recreation Facilities 2/			4	3	4	7
TOTAL COST			1,463	1,592	182	1,774

1/ Year 0 represents year of initial water demand.

2/ First cost includes initial recreation facilities only; capitalized costs include all future staged recreation development.

GLENN RESERVOIR-RIVER DIVERSION PLAN

The Glenn Reservoir-River Diversion Plan would store surplus Sacramento River flows in a large offstream reservoir complex within the Stony Creek drainage area in Tehama and Glenn Counties. Additional water supply would be obtained from local runoff and by diversion from Thomes Creek. Tables 9 through 12, located at the end of the section, summarize numerical data.

Glenn Reservoir has long been recognized as an economically attractive potential storage site; it has been considered for about 15 years as a component of various plans to divert water from the north coastal area to the Sacramento River Basin. The plan described herein is the first formal appraisal of a Glenn Reservoir development which would depend entirely on water supplies from within the Sacramento River Basin.

Project Description

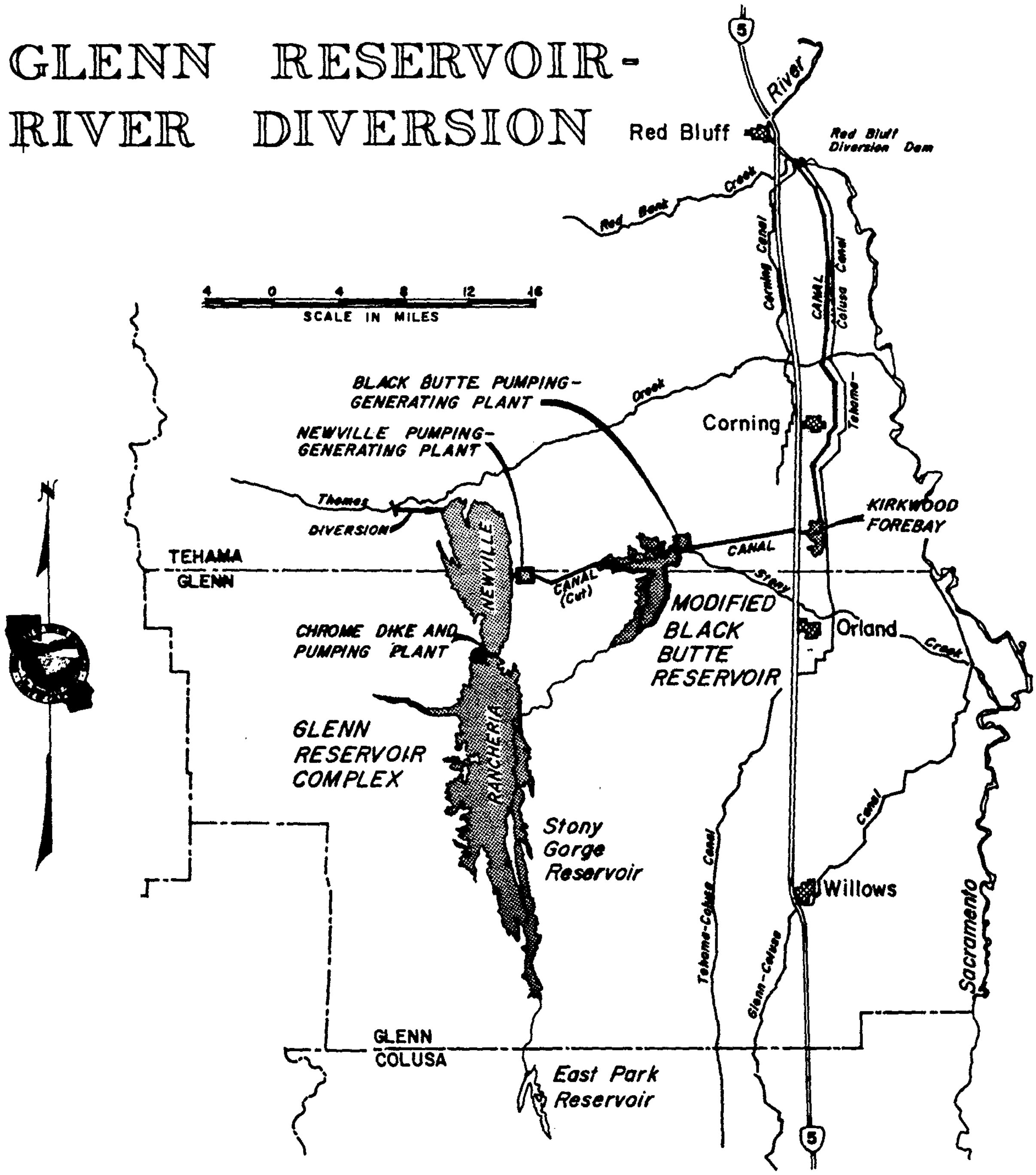
As shown on Figure 4, the key feature of this plan would be an 8,700,000-acre-foot reservoir complex formed by Rancheria Dam on Stony Creek and Newville Dam on North Fork Stony Creek. The Newville compartment of the Glenn Reservoir Complex would be separated from the Rancheria compartment by a 105-foot-high dike. At their maximum levels, Rancheria Reservoir would be 25 feet higher than Newville Reservoir; Chrome Pumping Plant would lift water from Newville to Rancheria Reservoir when necessary.

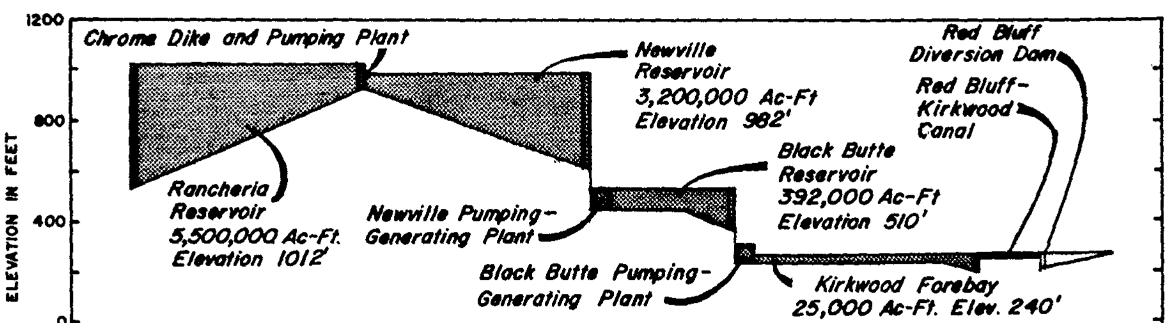
Surplus water would be diverted from Thomes Creek to Newville Reservoir through a 2.4-mile canal which would be sized to handle flood peaks of up to 67,000 cfs. This arrangement would substitute a small diversion dam for the Paskenta Dam used in earlier studies, in order to reduce the amount of deer habitat inundated.

Diversions of up to 5,000 cfs of surplus Sacramento River water would enter the Red Bluff-Kirkwood Canal through new intake facilities at the existing Red Bluff Diversion Dam. This canal would parallel the existing Tehama-Colusa Canal for 24.9 miles to the 25,000-acre-foot Kirkwood Forebay. An 8.1-mile canal would connect Kirkwood Forebay to the Black Butte Pumping-Generating Plant, which would lift as much as 10,000 cfs (off-peak pumping) about 270 to 290 feet to Modified Black Butte Reservoir. Storage in the modified version of the existing Black Butte Reservoir would be maintained at an essentially constant elevation at or near the present maximum pool level; this would increase the normal storage capacity of Black Butte Reservoir from 160,000 acre-feet to 392,000 acre-feet.

A 4.2-mile canal would connect Black Butte Reservoir to the Newville Pumping-Generating Plant near the toe of Newville Dam; using off-peak pumping energy, this plant would pump as much as 10,000 cfs to Newville Reservoir, a maximum lift of about 475 feet.

GLENN RESERVOIR-RIVER DIVERSION





SCHEMATIC PROFILE — NO HORIZONTAL SCALE

As the plan is presently formulated, both the Newville and Black Butte Pumping-Generating Plants would be operated in conjunction with Newville Reservoir and Kirkwood Forebay for pumped-storage hydroelectric power generation. The two plants would have a combined dependable power capacity of 140 megawatts; greater dependable pumped-storage generating capacity could be achieved if the pumping facilities, canals, and Kirkwood Forebay were enlarged.

Water for local use along lower Thomes Creek would be pumped from the north end of Newville Reservoir when necessary. As presently envisioned, reservoir releases would travel back through the diversion system to Kirkwood Forebay and then down about 6 miles of improved creek channels to reach the Sacramento River at the mouth of Burch Creek. An alternative to direct releases would be water exchanges with the Glenn-Colusa and Tehama-Colusa Canals, whereby their diversions from the river would be reduced in exchange for direct service from the Glenn Reservoir Complex.

Project Sizing

The sizes of project features illustrated in this plan were originally selected to meet projected critical period deficiencies of the State Water Project. This criterion determined the total active storage capacity needed in the Glenn Reservoir Complex. The facilities for diversion from the Sacramento River were sized to provide a water supply in balance with the reservoir storage. A greater diversion capacity from the Sacramento River would increase the project water supply and permit the inclusion of somewhat more reservoir storage capacity; however, the illustrated plan would develop a substantial portion of the water available to it and would realize a reasonable portion of the potential of the storage sites involved.

The 3,200,000-acre-foot Newville Reservoir included in this plan is near the maximum size feasible due to topographic and geologic limitations of the natural ridge forming the east reservoir rim. The relatively high minimum pool storage in Newville Reservoir (1,800,000 acre-feet) was primarily established to facilitate hydroelectric power generation. The 5,500,000-acre-foot Rancheria Reservoir was sized to obtain the desired total system storage for water conservation (after allowance was made for flood control storage reservations).

The modification of Black Butte Reservoir would involve adding spillway gates to raise the normal water surface as high as possible without raising the dam; this would minimize the channel excavation required for the canal connecting Black Butte Reservoir and the Newville Pumping-Generating Plant. An even higher pool level in Black Butte Reservoir would be desirable; however, the reservoir topography is unfavorable for any plan to raise the dam.

Kirkwood Forebay would be sized to regulate the on-peak power releases from the upstream plants and the continuous Sacramento River diversions to conform to the off-peak pumping mode of operation.

Project Costs

The first cost of the Glenn Reservoir-River Diversion Plan would be about $990,000,000. The total capitalized cost, including allowances for interest during construction, operation, maintenance, replacement, and pumping power, would be about $1,030,000,000, based on 6 percent interest and a 100-year period of analysis. The staging plan used to calculate capitalized cost and the breakdown of cost by feature are shown in Tables 11 and 12.

Under the relatively slow demand buildup used to develop this plan, Newville Reservoir and the diversion facilities from Thomes Creek would be constructed first. The Black Butte Reservoir modifications and the first stage of the Newville Pumping-Generating Plant would be added next, to gain access to the flows of Stony Creek. Then, Kirkwood Forebay, the Kirkwood-Black Butte Canal, and the Black Butte Pumping-Generating Plant would be added, along with a temporary intertie to the Tehama-Colusa Canal. The final stage of project construction would add Rancheria Reservoir and the facilities for direct diversion from the Sacramento River.

Project Accomplishments

The illustrated Glenn Reservoir-River Diversion Plan could increase net usable water supplies during a repetition of the 1928-34 critical dry period by an average of 990,000 acre-feet per year. Demand projections indicate that about 20,000 acre-feet per year of the new supply could be used locally and the remainder would be available for use in other areas.

The pumped-storage power operation described would provide a dependable generating capacity of 140 megawatts; net annual revenues from power operations would be around $6,000,000. (Power costs for pumping for water supply are not included in this calculation of net power revenue.)

If they were operated only for pumping water from the river to the reservoir and generating during periods of reservoir release, the described pumping-generating facilities could produce a net excess of about 100,000,000 kilowatt-hours of electrical energy each year. (The net positive energy balance would result from generation with the natural reservoir inflow as well as with releases of water pumped in from the Sacramento River.) Operation of the facilities for pumped-storage power generation, as described, would consume a net of about 100,000,000 kilowatt-hours annually, so the total plan would be essentially in balance from the standpoint of energy.

Black Butte Reservoir presently affords substantial flood protection along Stony Creek and contributes to the control of Sacramento river flooding. The Glenn Reservoir-River Diversion Plan would improve the protection provided along Stony Creek and the Sacramento River and add a high degree of flood control on Thomes Creek.

Total water-oriented recreation use at the plan's reservoirs is estimated as 1,290,000 recreation days per year initially and 3,960,000 recreation days per year when capacity is reached in 60 to 100 years. The net impact of the plan on recreation use would be as shown on the following tabulation.

Item	Recreation Days per Year		Years to Reach Maximum
	Initial	Maximum	
Gross use at plan reservoirs	1,290,000	3,960,000	60 to 100
Less use at existing reservoirs			
Stony Gorge (inundated)	-35,000	-145,000	100
Black Butte (present operation)	-130,000	-540,000	100
East Park (present operation)	-45,000	-195,000	100
Plus use at			
East Park (stabilized)	+110,000	+420,000	100
Net new use due to plan	1,190,000	3,500,000	

A significant portion of the recreation use at Glenn Reservoir would be supported by a moderately productive warm water fishery. Glenn Reservoir would also have a zone of cold water suitable for trout, but such a fishery would have to be supported almost entirely by planting of hatchery-reared fish.

Project Detriments

Glenn Reservoir would inundate approximately 54,000 acres in Glenn and Tehama Counties (including the existing 1,300-acre Stony Gorge Reservoir). Modification of Black Butte Reservoir would permanently inundate about 3,900 acres that are presently subject only to rare flooding and Kirkwood Forebay would inundate an additional 1,200 acres. The total land area required for all features of the plan would be about 90,000 acres. Much of the required area is rolling foothill land used primarily for grazing. About 300 acres of the Glenn Reservoir site lands are presently irrigated (pasture, alfalfa, and field crops) while another 1,700 acres are devoted to dry-farmed grain.

Most of the land needed for the Glenn Reservoir-River Diversion Plan would be acquired from private owners and thus removed from the tax rolls of the two counties involved. Approximately 420 permanent residents would be displaced by the project, including those in the community of Elk Creek and the residents of the 80-acre Grindstone Indian Rancheria.

Glenn Reservoir would have a moderate impact on wildlife; approximately 200 acres of riparian habitat supporting upland and non-game animals would be inundated and over 2,200 deer would be displaced.

The illustrated plan could have a major impact on Sacramento River salmon and steelhead, many of which spawn upstream from Red Bluff. Millions of the young salmonids migrate downstream from December to May, when diversions would often be made into the Red Bluff-Kirkwood Canal. Major screening facilities would be required to prevent drawing the young fish into the canal. Most such screens have been only partly effective and the added difficulty of dealing with high debris loads makes screening a definite problem.

The project could have additional adverse impact on Sacramento River salmon and steelhead if releases from Glenn Reservoir warmed excessively before reaching the river. If additional study reveals water temperature problems, modifications of the project configuration and operation methods could probably be made to overcome them.

The Thomes Creek Diversion Dam would block a steelhead run of about 200 fish per year and some spring-run king salmon may summer in the headwaters of Thomes Creek. If these fish were passed over the diversion dam, their progeny would probably be diverted to Newville Reservoir and lost. Therefore, either a trap and salvage operation at the diversion dam or a fish barrier at the mouth of Thomes Creek would be needed.

Level of Planning Knowledge

Previous studies of the components of Glenn Reservoir were more extensive than those for most of the other potential features described in this report. Studies of Newville Dam were conducted to feasibility-level standards by the Bureau of Reclamation as a part of a possible Paskenta-Newville Unit of the Central Valley Project. A potential Rancheria Dam was studied in comparable detail by the Department of Water Resources as a part of its Eel River investigations. Studies at both damsites included geological mapping, foundation exploration, borrow area exploration, materials testing, and detailed cost estimating. As a result, the engineering feasibility of both Newville and Rancheria Dam has been established.

The level of planning knowledge on all other features of the Glenn Reservoir-River Diversion Plan is considerably lower. No previous work has been performed on the conveyance or power features; they were investigated at the reconnaissance level as a part of studies leading to this report. Substantial additional work should be devoted to fish screening, power and pumping facilities and operations, reservoir water quality, wildlife, and temperatures of water which might be returned to the Sacramento River.

TABLE 9

GLENN RESERVOIR-RIVER DIVERSION PLAN
DAM AND RESERVOIR DATA SUMMARY

	Thomes Creek Diversion Dam and Reservoir	Glenn Reservoir		Modified Black Butte Reservoir
		Newville Dam and Reservoir	Rancheria Dam and Reservoir	
Drainage area, square miles	176 1/	55	599	87 2/
Mean annual flows, acre-feet				
Runoff at damsite (1916-66)	191,000	25,000	322,000	31,000 2/
Storable inflow	138,000	11,000	135,000	12,000 2/
Elevations, feet				
Dam crest	1,065	997	1,025	515 3/
Maximum pool	1,057	992	1,017	510 3/
Top of flood reservation	1,026	987	1,012	510 4/
Top of conservation pool	1,026	982	1,006	510 4/
Minimum pool	1,026	898	706	425 4/
Streambed	955	610	590	375 3/
Dam height, feet	110	387	435	140 3/
Dam construction time, years	2	4	5	--
Capacities, acre-feet				
Flood reservation	0	80,000	220,000	0
Conservation storage	0	1,320,000	5,180,000	372,000
Inactive, dead, sediment	5/	1,800,000	100,000	20,000
Gross	5/	3,200,000	5,500,000	392,000
Area, acres				
Reservoir at gross storage	5/	16,900	37,000 6/	8,500 7/
Total land required 8/	5/	23,000	51,000	11,500
Reservoir shoreline, miles	5/	93	141	45
Live streams inundated, miles	1	0	22	2 9/
Population displaced, 1970	0	50	370	0
1990	0	50	370	0
Average fish runs at damsite				
Salmon, fish per year	few	0	0	0
Steelhead, fish per year	200	0	0	0
Recreation days per year 10/				
Initial use	Negligible	350,000	560,000	380,000
Maximum use	Negligible	1,000,000	1,500,000	1,460,000
Years to reach maximum use		65	60	100
Deer displaced	unknown	1,000+	1,200	unknown

1/ Includes 6 square miles tributary to Thomes-Newville Canal.
2/ Excludes area and runoff tributary to Glenn Reservoir.
3/ No change from existing Black Butte Reservoir.
4/ Existing Black Butte Reservoir operating levels are: top of joint use flood control-conservation storage = elevation 474 (160,000 acre-feet gross storage); minimum pool = elevation 415 (10,000 acre-feet storage).
5/ Not calculated.
6/ Includes existing Stony Gorge Reservoir (1,300 acres).
7/ Existing Black Butte Reservoir area = 4,560 acres.
8/ Total land required (including diversion system) = 90,000 acres.
9/ Increase over miles inundated by existing Black Butte Reservoir.
10/ These are gross use projections for the reservoirs in the plan. See text for discussion of overall net impact on recreation use.

TABLE 10

GLENN RESERVOIR-RIVER DIVERSION PLAN
CONVEYANCE FACILITY DATA

Kirkwood Forebay	
Capacity, acre-feet	25,000
Canals	
Red Bluff-Kirkwood Canal	
Type	Concrete-lined
Length, miles	24.9
Capacity, cfs	5,000
Kirkwood-Black Butte Canal	
Type	Concrete-lined
Length, miles	8.1
Capacity, cfs	10,000
Black Butte-Newville Canal	
Type	Unlined
Length, miles	4.2
Capacity, cfs	10,000
Thomes-Newville Canal	
Type	Unlined
Length, miles	2.4
Capacity, cfs	67,000
Pumping and Power Facilities	
Black Butte Pumping-Generating Plant	
Operating mode	Pump off-peak, generate on-peak
Design flow, cfs	10,000
Maximum static head, feet	290
Pumping capacity, megawatts	290
Newville Pumping-Generating Plant	
Operating mode	Pump off-peak, generate on-peak
Design pumping flow at maximum head	10,000
Maximum static head, feet	475
Pumping capacity, megawatts	475
Chrome Pumping Plant	
Operating mode	Pump off-peak
Design flow, cfs	5,000
Maximum static head, feet	40
Pumping capacity, megawatts	20

TABLE 11

GLENN RESERVOIR-RIVER DIVERSION PLAN
ILLUSTRATIVE STAGING PLAN

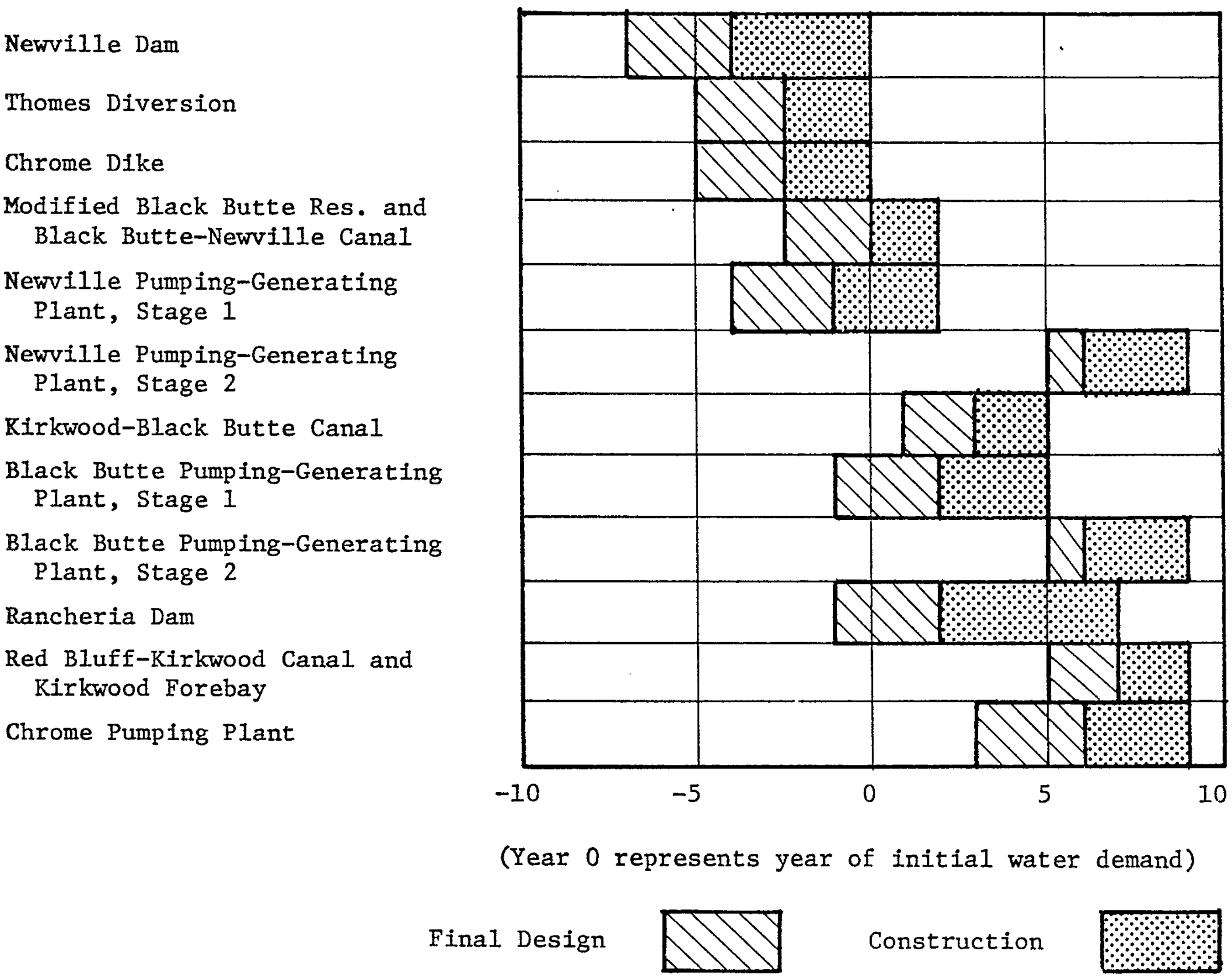


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TABLE 12

GLENN RESERVOIR-RIVER DIVERSION PLAN
COST SUMMARY

(Price basis, Jan. 1975. Period of analysis, 100 years. Interest rate, 6%)

Feature	Construction Completion Year 1/	Construction Time (Years)	Costs, in Millions of Dollars: First Cost (includes Engr. & Contingencies)	Construction Cost Capitalized to Year 0	OM&R and Power Cost Capitalized to Year 0	Total Cost Capitalized to Year 0
Newville Dam and Reservoir	0	4	225	252	24	276
Thomes Creek Diversion and Local Water Supply Facilities	0	2	19	20	5	25
Chrome Dike	0	2	37	39	2	41
Modified Black Butte Reservoir and Black Butte-Newville Canal	2	2	26	25	6	31
Newville Pumping-Generating Plant, First Stage	2	3	22	21	13	34
Kirkwood-Black Butte Canal and Tehama-Colusa Intertie	5	2	72	57	13	70
Black Butte Pumping-Generating Plant, First Stage	5	3	17	14	10	24
Rancheria Dam and Reservoir	7	5	322	246	21	267
Red Bluff-Kirkwood Canal	9	2	47	30	7	37
Kirkwood Forebay	9	2	18	11	1	12
Chrome Pumping Plant	9	3	13	8	5	13
Newville Pumping-Generating Plant, Second Stage	9	3	87	56	33	89
Black Butte Pumping-Generating Plant, Second Stage	9	3	69	44	26	70
Recreation Facilities 2/			17	17	27	44
TOTAL COST			991	840	193	1,033

1/ Year 0 represents year of initial water demand.
2/ First cost includes initial recreation facilities only; capitalized costs include all future staged recreation developments.

COLUSA RESERVOIR-RIVER DIVERSION PLAN

This plan involves the diversion of surplus flows from the Sacramento River to an off-stream storage reservoir. The plan would use the existing Glenn-Colusa Irrigation District Canal and the Tehama-Colusa Canal (under construction) to make deliveries during non-irrigation periods to a new reservoir on the west side of the Sacramento Valley about 10 miles southwest of Willows. To the maximum degree possible, water would be released directly back to the canals for use in their service areas. Water which these canals would have taken from the river would be allowed to remain in the river and would provide water for use in other areas. Tables 13 through 16, located at the end of this section, present pertinent data.

Project Description

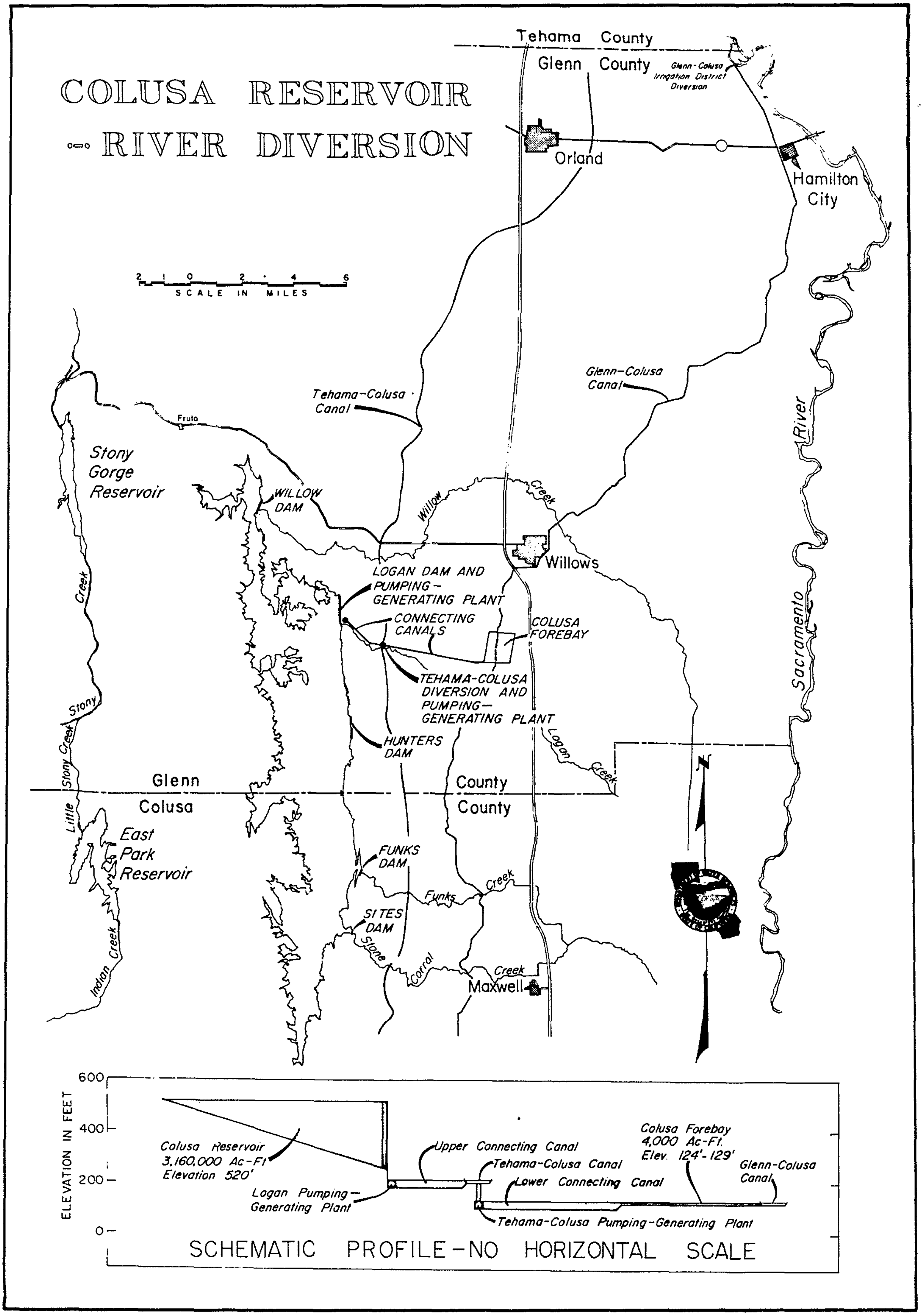
Colusa Reservoir would be formed by a series of dams along a ridge of the foothills in western Glenn and Colusa Counties. The reservoir would be 24 miles long and up to 4 miles wide. Major dams would be located on Willow, Logan, Hunters, Funks, and Stone Corral Creeks. In addition, many smaller dams and extensions of the ridges would be required. The total volume of dam fill would be 86,000,000 cubic yards. The reservoir created by these dams would hold 3,160,000 acre-feet and have an area of 30,000 acres at a water surface elevation of 520 feet.

As shown by Figure 5, the conveyance system would consist of the Glenn-Colusa and Tehama-Colusa Canals with their diversion works, a forebay located along the Glenn-Colusa Canal, and two canals and pumping facilities to connect with Colusa Reservoir. All pumping would use off-peak energy. During on-peak hours, the flow of both supply canals would be stored in the forebay reservoir on the Glenn-Colusa Canal. During the hours when off-peak energy was available, the stored water and the continuing flow of the supply canals would be pumped in two lifts to Colusa Reservoir.

The first pumping facility would lift water from the forebay from 81 to 86 feet to the level of the Tehama-Colusa Canal. The pumping facility would be located near the Tehama-Colusa Canal diversion point and connected to the forebay by a 3.8-mile unlined canal. Since the Tehama-Colusa Canal flow would be dropped through this plant during on-peak hours, reversible pump-turbine units are shown in the plan; this would allow the plant to generate incidental on-peak energy on a non-dependable basis.

The second pumping lift would be one of 110 to 310 feet from the level of the Tehama-Colusa Canal to Colusa Reservoir. The pumping facilities would be near the toe of Logan Dam and would be served by a 1.9-mile canal connection from the Tehama-Colusa Canal. This plant is also shown to incorporate reversible units in order to generate incidental energy with reservoir water supply releases.

Figure 5


COLUSA RESERVOIR
RIVER DIVERSION
Tehama County
Glenn County
Glenn-Colusa Irrigation District Diversion
Orland
Hamilton City
SCALE IN MILES
Glenn-Colusa Canal
Tehama-Colusa Canal
Fruto
Stony Gorge Reservoir
WILLOW DAM
Willow
Creek
Willows
LOGAN DAM AND PUMPING-GENERATING PLANT
CONNECTING CANALS
COLUSA FOREBAY
TEHAMA-COLUSA DIVERSION AND PUMPING-GENERATING PLANT
HUNTERS DAM
Logan Creek
Sacramento River
Stony Creek
Little Stony Creek
Glenn County
Colusa County
East Park Reservoir
FUNKS DAM
Funks Creek
SITES DAM
Stone Corral Creek
Maxwell
Indian Creek
N
600
400
200
0
ELEVATION IN FEET
Colusa Reservoir 3,160,000 Ac-Ft Elevation 520'
Logan Pumping-Generating Plant
Upper Connecting Canal
Tehama-Colusa Canal
Lower Connecting Canal
Colusa Forebay 4,000 Ac-Ft. Elev. 124'-129'
Glenn-Colusa Canal
Tehama-Colusa Pumping-Generating Plant
SCHEMATIC PROFILE-NO HORIZONTAL SCALE

Alternative project formulations which would incorporate pumped-storage hydroelectric power were studied but found impractical due to the low heads and wide variations in head. Another possible project variation would involve separate forebays on the Glenn-Colusa and Tehama-Colusa Canals; this would reduce project energy consumption and might prove economical.

Water would be diverted from the Sacramento River to Colusa Reservoir only in those months when the Glenn-Colusa and Tehama-Colusa Canals would not otherwise be in use. During the irrigation season, releases from Colusa Reservoir would be made back to the canals in exchange for water which they would otherwise have removed from the Sacramento River. Outside the irrigation season, reservoir releases could be made through the Colusa Basin drainage system.

Project Sizing

The plan presented extends to the approximate topographic limit for the reservoir and would make full use of the capacities of the Glenn-Colusa and Tehama-Colusa Canals. The 520-foot-elevation Colusa Reservoir would be an expansion of the Sites Reservoir which was studied by the Bureau of Reclamation as a part of the West Sacramento Canal Unit of the Central Valley Project. Sites Reservoir would utilize the Sites and Funks Dam sites and would have a storage capacity of 1,200,000 acre-feet at a water surface elevation of 480 feet.

Improvements planned by the Glenn-Colusa Irrigation District were assumed to be completed by the time this project would be built. At that time, the Glenn-Colusa Canal will carry 3,000 cfs at the river and about 2,100 cfs at the point where it would flow into the pumping forebay. The Tehama-Colusa Canal will have a capacity of over 2,100 cfs at the intersection with the project canal. This would permit a total of up to 4,200 cfs to be diverted from the Sacramento River.

Project Costs

The first cost of this plan would be about $790,000,000. The total capitalized cost, including allowances for interest during construction, operation, maintenance, replacement, and net energy costs, would be about $940,000,000, based on 6 percent interest and a 100-year period of analysis. The staging plan used in the calculation of capitalized cost and the breakdown of cost by feature are shown in Tables 15 and 16.

Project Accomplishments

The Colusa Reservoir-River Diversion Plan could increase usable water supplies during a repetition of the 1928-34 critical dry period by an average of 460,000 acre-feet per year. Pumping from the river to achieve this water supply capability and subsequent power recovery through generation with reservoir releases would consume a net average of about 50,000,000 kilowatt-hours of electrical energy each year.

Colusa Reservoir would provide new water-associated recreation opportunities and should ultimately support a use of 2,200,000 recreation days per year. Further, the project would provide some incidental flood control benefits to Willows and to the Colusa Basin. Further study may reveal that a specific flood control storage allowance should be included in Colusa Reservoir.

Substitution of Colusa Reservoir releases for water otherwise diverted from the river would increase the flow of high quality water in the river and further dilute irrigation return flows. This would result in lower mineral concentrations and, possibly, lower temperatures during the irrigation season. By using multiple-level outlet works, warm water could be released from Colusa Reservoir during the summer months, which might benefit rice growers.

Project Detriments

Colusa Reservoir would flood about 30,000 acres of land in western Glenn and Colusa Counties. This area has only a minimal amount of improvements. The area supports little irrigated agriculture but does include about 10,000 acres of dry-farmed crops. Most of the reservoir area is good rangeland, used extensively in winter and spring for grazing cattle and sheep. In 1970 about 60 people lived in the reservoir area. No state roads pass through the reservoir area, but the main county road connecting Maxwell with the town of Stonyford would have to be relocated. The reservoir area is probably of very limited archaeological and paleontological value.

In addition to the lands flooded by the reservoir, another 10,000 acres would be purchased by the project for rights-of-way, the conveyance system, and recreation developments. A total of about 40,000 acres of land and improvements would be acquired from the private sector and thus removed from tax rolls in Glenn and Colusa Counties.

The reservoir area supports numerous game and nongame wildlife species. However, wildlife population densities are very low and the overall direct impact on wildlife would be relatively small. Colusa Reservoir could alter the winter distribution of waterfowl in the nearby Colusa and Butte Basins; this is a subject which warrants additional consideration.

Due to the relatively small capacity and the timing of the diversions from the Sacramento River, adverse effects on the quality and character of the river would be minimal. However, the plan could have a major impact on salmon and steelhead, most of which spawn upstream from the diversion points. A majority of the young salmon and steelhead migrate downstream during the months when diversions would be made to Colusa Reservoir. Both the Glenn-Colusa and Tehama-Colusa Canal intakes incorporate screening facilities to prevent drawing fish into the canals, but these facilities are designed for controlled summer flows in the river. Development of efficient screens for use during periods of high flow and heavy debris loads would be a significant problem.

Level of Planning Knowledge

Colusa Reservoir has been included in past studies by the Department. Subsurface geologic exploration has been conducted by the Bureau of Reclamation for the Sites and Funks Dam sites and for some quarry sites. Surface geologic mapping has been done by the Bureau and by the Department for most of the other damsites. Some material testing has been done by various agencies. A review of these past studies indicates that no unusual problems should be encountered in building the dams needed to form Colusa Reservoir.

Items that should be covered in any future studies of this plan include: development of a hydroelectric pumped-storage operation, inclusion of a specific flood control reservation, water quality, potential impacts on waterfowl, staging of the component parts, screening of water diverted from the river to the Tehama-Colusa and Glenn-Colusa Canals, coordinated operations with the two canals, capacities of the natural and man-made channels draining away from Colusa Reservoir, and better definition of the route that reservoir releases should follow back to the river or to the Delta.

TABLE 13

COLUSA RESERVOIR-RIVER DIVERSION PLAN
DAM AND RESERVOIR DATA SUMMARY

	Colusa Reservoir
Drainage area, square miles	148
Mean annual flows, acre-feet Runoff at damsite (1916-66)	Operation studies for this plan used flows from the Sacramento River only. The natural inflow to this reservoir is negligible.
Elevations, feet	
Dam crest	535
Maximum pool	520
Top of flood reservation	--
Top of conservation pool	520
Minimum pool	320
Streambed 1/	375, 279, 265, 240, 240
Dam height, feet 1/	160, 256, 270, 295, 295
Dam construction time, years	6
Capacities, acre-feet	
Flood reservation	0
Conservation storage	3,000,000
Inactive, dead, sediment 2/	60,000
Gross	3,160,000
Area, acres	
Reservoir @ gross storage	30,000
Total land required	40,000
Reservoir shoreline, miles	210
Live streams inundated, miles	0
Population displaced, 1970	60
1990	100
Average fish runs at damsite	
Salmon, fish per year	0
Steelhead, fish per year	0
Recreation use, days per year	
Initial use	650,000
Maximum use	2,200,000
Years to reach maximum use	100
Deer displaced	Negligible impact

1/ Willow, Logan, Hunters, Funks, and Sites Dams.

2/ Total of all impoundments.

TABLE 14

COLUSA RESERVOIR-RIVER DIVERSION PLAN
CONVEYANCE FACILITY DATA

Tehama-Colusa Canal (Under construction)	
Type	Concrete-lined
Length, Red Bluff to project diversion, miles	56
Capacity at project diversion, cfs	2,100
Maximum water surface elevation at project diversion, feet	210
Glenn-Colusa Irrigation District Canal (Existing)	
Type	Unlined
Length, Sacramento River to project forebay, miles	23
Capacity at forebay (with planned improvements), cfs	2,100
Maximum water surface elevation at forebay	129
Colusa Forebay	
Active storage capacity, acre-feet	4,200
Operating water surface elevation, feet	124 to 129
Maximum area, acres	840
Lower Connecting Canal (Forebay to Tehama-Colusa Canal)	
Type	Unlined, level bottom
Length, miles	3.8
Capacity, cfs	6,300
Upper Connecting Canal (Tehama-Colusa Canal to Logan Dam)	
Type	Unlined, level bottom
Length, miles	1.9
Capacity, cfs	8,400
Tehama-Colusa Pumping-Generating Plant	
Maximum static head, feet	86
Minimum static head, feet	81
Maximum pumping rate, cfs	6,300
Maximum generating flow, cfs	2,100
Pumping capacity, megawatts	56
Installed generating capacity, megawatts	39
Dependable generating capacity, megawatts	0
Logan Pumping-Generating Plant	
Maximum static head, feet	310
Minimum static head, feet	110
Maximum pumping rate, cfs	8,400
Maximum generating flow, cfs	2,600
Pumping capacity, megawatts	265
Installed generating capacity, megawatts	185
Dependable generating capacity, megawatts	0

TABLE 15

COLUSA RESERVOIR-RIVER DIVERSION PLAN
ILLUSTRATIVE STAGING PLAN

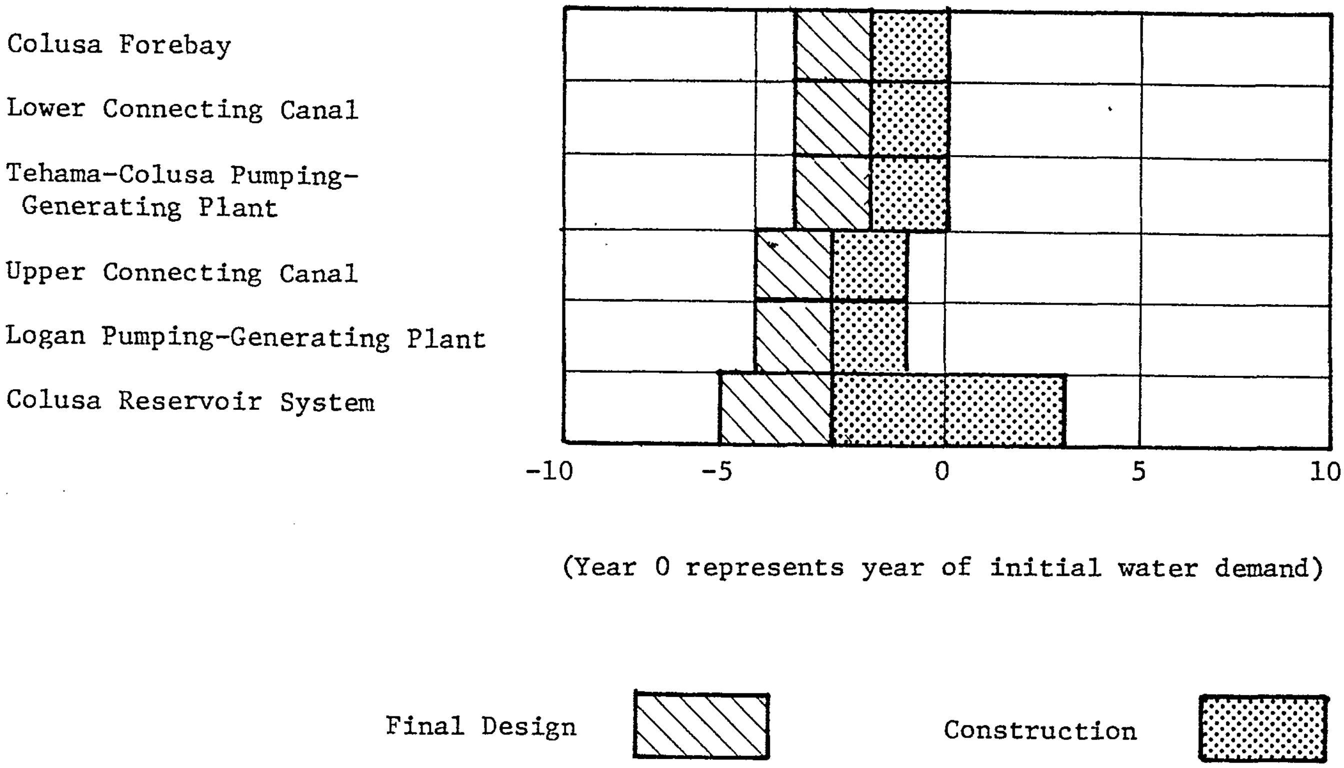


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TABLE 16

COLUSA RESERVOIR-RIVER DIVERSION PLAN
COST SUMMARY

(Price basis, Jan. 1975. Period of analysis, 100 years. Interest Rate, 6%)

Feature	Construction Completion Year 1/	Construction Time (Years)	Costs, in Millions of Dollars			
			First Cost (Includes Engr. & Contingencies)	Construction Cost Capitalized to Year 0	OM&R and Power Cost Capitalized to Year 0	Total Cost Capitalized to Year 0
Colusa Forebay	0	2	6	6	-	6
Lower Connecting Canal	0	2	20	21	5	26
Tehama-Colusa Pumping-Generating Plant	0	2	52	55	18	73
Upper Connecting Canal	-1	2	10	12	3	15
Logan Pumping-Generating Plant	-1	2	136	153	52	205
Colusa Reservoir System 3/	3	6	558	553	37	590
Recreation Facilities 4/			5	9	13	22
TOTAL COST			787	809	128	937

1/ Year 0 represents year of initial water demand.
2/ Includes pumping cost, less the value of incidental energy generated.
3/ Colusa Reservoir System would be constructed in units; no single contract would be over 2 years.
4/ First cost includes initial recreation facilities only; capitalized costs include all future staged recreation developments.

OTHER WATER DEVELOPMENT POSSIBILITIES

Two other major surface water development opportunities were also considered during the course of this investigation. Both would involve enlargement of existing projects which were constructed and are operated by the Bureau of Reclamation.

Because of the obvious institutional problems and disruptions which would be involved in enlargement of major existing projects, this section is restricted to general discussion of concepts rather than to details of specific potential plans. This section is presented in the spirit of examining the full range of physical options within the scope of the study.

Enlarged Shasta Reservoir

Shasta Dam, constructed by the Bureau of Reclamation during the late 1930s and early 1940s, is the keystone of the Central Valley Project. It is a gravity concrete dam, with a total height of 533 feet above the lowest point in the natural riverbed. Shasta Reservoir has a total storage capacity of 4,550,000 acre-feet at its maximum elevation of 1,067 feet. Active storage above the minimum pool elevation of 828 feet is 4,050,000 acre-feet. The reservoir is operated with a maximum flood reservation of 1,300,000 acre-feet.

Shasta Power Plant has a total installed generating capacity of 375 megawatts. Water released for power generation is reregulated by a 24,000 acre-foot afterbay reservoir which is formed by Keswick Dam, located about 10 miles downstream from Shasta Dam. Additional hydroelectric power is generated by a 75-megawatt base load power plant at Keswick Dam.

At the time of its completion, Shasta Dam was the world's second highest, exceeded only by Hoover Dam. However, the active storage capacity of Shasta Reservoir is only about three-fourths of the mean annual runoff of approximately 5,700,000 acre-feet. A substantial quantity of water must be relased in most years, solely to comply with flood operation criteria.

Therefore, as a part of an overall appraisal of the physical possibilities for water development in the Sacramento River Basin, it appears reasonable to appraise the general physical factors involved in obtaining additional storage in Shasta Reservoir.

Although no definitive studies have been made, an active reservoir storage on the order of 12,000,000 acre-feet would probably be needed to fully develop the runoff to Shasta Reservoir. This would require a gross reservoir storage capacity on the order of 15,000,000 acre-feet, depending on the amount of allowance for inactive storage. The following tabulation illustrates the reservoir area and storage capacity which could be developed by dams of various heights.

Reservoir Elevation (Feet)	Height Above Present Reservoir (Feet)	Approximate Dam Height (Feet)	Reservoir Area (Acres)	Gross Reservoir Storage (Acre-Feet)
1,067*	0	533	29,500	4,550,000
1,100	33	580	35,200	5,630,000
1,150	83	630	42,200	7,560,000
1,200	133	680	49,700	9,850,000
1,250	183	730	57,500	12,530,000
1,300	233	780	65,600	15,610,000

*Existing size

The height of dam which would be required for the larger reservoir sizes shown would be very notable, but within the range of current practice. Three auxiliary dams would be required along the southern rim of an enlarged reservoir; the lowest saddle is at elevation 1,120 feet and the other two are near elevation 1,200 feet.

Substantial enlargement of Shasta Reservoir could probably be accomplished most effectively by construction of an earth-rock embankment dam just downstream from the existing concrete dam. Much study would be required to establish the engineering feasibility of such a plan; however, geologic information gathered for construction of the existing dam and limited subsequent analyses reveal no obstacle to construction of a larger dam at the site.

Enlargement of Shasta Reservoir could increase critical period water supplies by an average of over 1,000,000 acre-feet per year. The increased storage capacity would allow much greater flexibility in flood control operations and would increase protection against the infrequent very large floods which tax the abilities of the existing reservoir. New hydroelectric power facilities would be required to replace the existing plant; if Keswick Reservoir were also enlarged, a major pumped-storage power installation could be incorporated.

An enlarged Shasta Reservoir plan would probably incorporate a large inactive storage reservation and multiple-level outlet works which would permit drawing water from any level within the reservoir. These would minimize the duration of turbid releases which are presently unavoidable following high flood inflows; they would also assure that cold water would be available for release during the most severe conditions of drawdown.

Enlargement of Shasta Reservoir would involve substantial drawbacks. Among the most serious would be the disruption of services provided by the existing project and the tremendous complex of public and private facilities which would have to be relocated if the project were built, including recreation facilities, railroads, highways, bridges, power plants, and small private businesses.

Raising the existing reservoir by 200 feet would flood about 32,000 acres of land which presently support (1) about 800 people living around the existing Shasta Reservoir; (2) substantial wildlife populations which include numerous deer and significant numbers of the rare Shasta salamander; (3) extensive transportation systems -- railroads, secondary roads, highways, and bridges; (4) an extensive recreation development; (5) the Pacific Gas and Electric Company's 112-megawatt Pit No. 7 Power Plant; (6) 42 miles of live streams including 17 miles of premium-quality trout streams; and (7) an unknown but significant number of archaeological and paleontological sites.

There would be a very slight increase in travel distance on Interstate 5 and the railroad, although both could be relocated at grade conditions at least as good as they are now. The greater length of some secondary roads could increase travel time between some points around the reservoir.

Operation of an enlarged Shasta Reservoir would have a significant effect on upper Sacramento River flows. In general, summer and early fall releases would often be larger, while the late fall and winter releases for evacuation of the flood control storage space would occur less often than with the existing reservoir. One drawback of reduced large flows could be lessened dilution of copper-polluted spills from Spring Creek Debris Dam, a problem which could probably be overcome by proper operation. Other possible detriments to the fishery could occur from alteration of the gravel movement patterns downstream or from a reduction in winter releases able to dilute turbid inflows from tributary streams.

Enlarged Lake Berryessa

Lake Berryessa is a 1,600,000 acre-foot reservoir formed by Monticello Dam on Putah Creek in Napa, Solano, and Yolo Counties. Monticello Dam is a 271-foot-high concrete arch dam, completed in 1957 as a feature of the Bureau of Reclamation's Solano Project. Lake Berryessa supplies the 960-cfs Putah South Canal with water for irrigation and municipal and industrial use. There are no hydroelectric power facilities associated with the project.

The basin occupied by Lake Berryessa is topographically the most suitable in California for storage of a very large quantity of water. The following tabulation illustrates the storage potential:

Reservoir Elevation (Feet)	Height Above Present Lake (Feet)	Approximate Dam Height (Feet)	Reservoir Area (Acres)	Gross Reservoir Storage (Acre-Feet)
440*	0	271	19,300	1,600,000
500	60	350	25,000	3,000,000
600	160	450	35,000	6,000,000
700	260	550	54,000	10,400,000
800	360	650	74,000	16,700,000
900	460	750	93,000	25,000,000

*Existing size

The existing Lake Berryessa develops essentially all of its natural inflow, which averages about 350,000 acre-feet per year. The only justification for enlargement of the lake would be for storage of water diverted from another watershed.

Enlargement of Lake Berryessa could provide offstream storage for surplus flows diverted from the Sacramento River. In one possible configuration, water could be taken from the river near Knights Landing and delivered to Lake Berryessa through a 33-mile conveyance system. At the point of diversion, the elevation of the Sacramento River would be only about 20 feet, so the maximum pumping lift would be approximately equal to the elevation of the enlarged lake.

The Department's earlier studies considered two ways to enlarge Lake Berryessa. One would involve a gravity concrete dam at the site of the existing dam; the other, a rockfill dam about a mile downstream. The rockfill dam was adopted as the basis for planning. A moderate amount of surface geologic study was devoted to the downstream damsite; more study would be necessary to evaluate the suitability of quarried rock for the dam and to evaluate possible landslides around the reservoir rim.

No detailed studies have been conducted of the maximum water supply potential of an enlarged Lake Berryessa operated in conjunction with diversions from the Sacramento River. The water supply available in the river is sufficient to justify a total reservoir capacity on the order of 10,000,000 acre-feet or more. Such a plan could increase the average water supply during a critical dry period by more than 1,000,000 acre-feet per year. The enlarged reservoir would provide only minor additional flood control benefits, primarily on Putah Creek.

A 10,000,000 acre-foot enlarged Lake Berryessa would require purchase of over 40,000 acres of land from private owners and rather extensive relocations of roads and facilities surrounding the existing lake. Over 3,000 acres of prime agricultural land would be inundated in Pope Valley. The present population which would be displaced is approximately 600 persons. Much of the land which would be inundated is prime deer habitat which presently supports over 3,000 deer. Conditions are unfavorable for increasing the carrying capacity of adjacent lands, so the displaced deer population would probably be lost.

The most serious fishery problem associated with enlarging Lake Berryessa would be intake screening. All of the Sacramento River salmon, steelhead, American shad, sturgeon, and many of the striped bass, spawn upstream from Knights Landing. The technology has yet to be developed for high-efficiency screening for large diversion works and small fish. The potential impact of such a diversion system on anadromous fish has not been adequately evaluated.

Pumping from the Sacramento River would consume substantial amounts of electrical energy. A considerable portion of the energy consumed could be recovered if reversible pump-turbine units were employed and the reservoir releases were made back through the diversion conveyance system. The diversion facilities might also be designed to operate for pure pumped-storage hydroelectric power generation.